THE 5TH WORLD CONSTRUCTION SYMPOSIUM - 2016

SYMPOSIUM PROCEEDINGS

29th – 31st | JULY 2016

Greening Environment, Eco Innovations & Entrepreneurship
29-31 July 2016 - Colombo

The 5th World Construction Symposium
Greening Environment, Eco-Innovations & Entrepreneurship

The 4th Construction Industry Investors Forum
Investment Opportunities in Megapolis Projects

HOTEL GALADARI, COLOMBO

The 3rd Green Building Awards Ceremony
RAMADA COLOMBO

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PROCEEDINGS

THE 5TH WORLD CONSTRUCTION SYMPOSIUM 2016

Theme:

Greening Environment, Eco-Innovations & Entrepreneurship

Editors

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We are very thankful to the authors who have submitted papers for this symposium, as if not for them, we could not hold this event. Our special thanks go to the eminent international and local scientific committee members for reviewing and offering constructive comments to make the papers more meaningful and contextual. We would like to extend our gratitude towards the chief guest, keynote speaker, session chairs, session coordinators, paper presenters, members of panel discussion and investor forum, awards selection committees, BEPAM Journal Editor-in-Chief, Emerald Publisher and the committee and other invitees for their commitment and contribution to the symposium.

We are also thankful for the organisations that have provided sponsorships. Last but not least, all our colleagues in the organising committee and symposium secretariat are especially thanked for devoting their time and effort to make ‘The 5th World Construction Symposium 2016’ a success.

Editors
The 5th World Construction Symposium 2016

Colombo, Sri Lanka
July 2016

PREFACE

The 5th World Construction Symposium jointly organised by the Ceylon Institute of Builders (CIOB) and Building Economics and Management Research Unit (BEMRU), Department of Building Economics, University of Moratuwa is held on 29-31 July 2016 in Colombo with the partnerships of Liverpool John Moores University, United Kingdom, Centre for Innovation in Construction and Infrastructure Development (CICID), The University of Hong Kong, Indian Institute of Technology Madras (IIT Madras), Auckland University of Technology (AUT), New Zealand and Northumbria University, United Kingdom, Robert Gordon University, United Kingdom and Colombo School of Construction Technology (CSCT), Sri Lanka. The symposium is co-sponsored by International Council for Research and Innovation in Building and Construction (CIB). The symposium provides a special forum for academic researchers and industry practitioners to share their knowledge, experience and research findings on the main theme of “Greening Environment, Eco-Innovations and Entrepreneurship”.

The sub themes of the symposium covers a wide spectrum of areas such as: Green Buildings; Sustainable Urbanisation; Sustainable Construction Practices; Procuring Sustainable Built Infrastructure; Cost Management; Process Improvement; Building Information Modelling and Information Management; Innovative Green Technologies; Sustainable Procurement Strategies; Public private partnerships (PPPs) and Green Innovation; PPPs for a Sustainable Built Environment; Environment Economics and Management; Affordable Sustainability; Socio-Economic Sustainability; Sustainable Materials/Green Building Materials; Green Rating and Certification; Energy Management; Legal Aspects Relating to Sustainable Construction; Sustainable Facilities; Education of Sustainable Construction; Linking Design and Construction to Operation and Maintenance; and Disaster Management.

We received number of abstracts and full papers for the symposium and all papers went through a rigorous double-blind peer-review process by locally and internationally renowned reviewers with respect to the originality, significance, reliability, quality of presentation and relevance, prior to selection. After the rigorous double blind review process, 58 papers were selected for publication, covering thirteen countries, i.e. Sri Lanka, India, United Kingdom, United States of America, Australia, New Zealand, Hong Kong, Malaysia, Turkey, Qatar, Oman, United Arab Emirates and Egypt. Priority was given to the quality and standard of papers rather than the number of papers presented at the symposium. It is our firm belief that the publication that emerged from this symposium is the result of the tireless effort of all authors, reviewers, symposium organising committee members, associate partners, sponsors and that it would pave way for advancement of knowledge in sustainable development in built environment.

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George Ofori received both his doctoral degree and a higher doctorate degree from the University of London. He is a Fellow of the Ghana Academy of Arts and Sciences. He is currently a Professor at the National University of Singapore, and Director of the multi-disciplinary MSc (Environmental Management) programme. He is also a Chair Professor at Tsinghua University, China. He is a Fellow of the Chartered Institute of Building, UK; Fellow of the Royal Institution of Chartered Surveyors, UK; and Fellow of the Society of Project Managers, Singapore. He is the Deputy Chairman of the International Board of the Construction Sector Transparency Initiative (CoST).

His main research area is strategic construction industry development, focusing on the improvement of the construction industries of developing countries. He has also undertaken research on sustainable construction, international construction, productivity and leadership development in construction. He has authored several papers which have been published in international refereed journal, conference papers, books, chapters in books, and published reports. He has been invited to deliver some keynote papers at many international conferences. He is a member of the editorial boards of many leading international peer-reviewed journals. He was the Founding Co-ordinator of the CIB Working Commission 107 (W107) on Construction in Developing Countries of the International Council for Research and Innovation in Building and Construction (CIB).

The subjects he has taught at the under-graduate and graduate levels include Construction and Development Economics, Development Management, Environmental Management, International Project Management, and Research Methods. His experience in the construction industry has been as a senior quantity surveyor, mainly in Ghana. He has also been a consultant on construction industry development to many governments and international agencies since 1978. The countries where he has undertaken assignments include: Bahrain, Ghana, Indonesia, Malawi, Malaysia, Myanmar, Singapore, South Africa, Swaziland and Tanzania.

ENTREPRENEURSHIP AND INNOVATION SUSTAINABLE BUILT ENVIRONMENT: A RESEARCH AGENDA

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ABSTRACT

What is new in "green built environment"? In considering this question, it is necessary to explore two others: why is it necessary to seek to attain a green built environment? What has been achieved in the efforts towards attaining it? What are the persisting challenges and problems? Thus, what else needs to be done? Again, in considering the question of what else needs to be done, it is necessary to investigate the full range of sustainability in the built environment - i.e., to go beyond 'green'. Such an investigation shows that whereas some headway has been made in formulating policies, strategies, regulations and actions in industry to enhance environmental performance in the built environment, much more needs to be done under that pillar of sustainable development. Moreover, the other elements of sustainability: economic, social and governance have not been given much attention. Focus has also been put on 'building' at the expense of other elements of the built environment. A more appropriate conceptualisation of the subject is explored.

After discussing key features of a sustainable built environment, entrepreneurship is considered. "Eco innovation" in building is next discussed. The definition of innovation is analysed, again, focusing on the current understanding. Innovation and entrepreneurship as they relate to a sustainable built environment is considered. The link between innovation and entrepreneurship is subsequently analysed. The relevance of these two processes to the process of planning, design, construction and management of the built environment today is discussed.

The main theme and each of the 23 sub-themes of the conference are then briefly considered individually. In each case, the current state of knowledge on, and special relevance of, the subject is discussed, followed by consideration of implications for further research. Some other points which are relevant to a sustainable built environment are also highlighted. It is found that there is scope for more work under each of the sub-themes, and that, together, the points highlighted constitute a research agenda for innovation and entrepreneurship in the built environment.

Keywords*: Innovation; Entrepreneurship; Sustainable Development; Built Environment; Research.*

1. INTRODUCTION

1.1 WHAT IS NEW IN GREEN BUILDING?

The theme of this conference is: "Greening Environment, Eco Innovations and Entrepreneurship". Some 23 sub-themes are outlined. It is pertinent to consider the need for a green built environment, and what has been achieved in this endeavour. If there is more to be done, and obstacles to overcome, then the role of innovation and entrepreneurship in the effort to make progress can be explored.

The creation of sustainable constructed items (which make up the built environment) is one of the key issues in all countries today. It is because it is recognised that construction plays a critical role in putting in place the foundation for sustainable socio-economic development by building place the needed physical assets (HM Treasury, 2011; National Infrastructure Unit, 2015). Considering sustainable development, it is pertinent to highlight the unique features of construction which make it possible that construction activity and constructed items can have a potentially negative impact on sustainable development (Ofori, 2015), and which also enable them to offer the possibility of making a significant positive contribution to efforts to address the effects of inappropriate economic development - for example, the Intergovernmental Panel on Climate Change (IPCC) (2007) suggested that the building stock offers the most cost-effective means of addressing climate change.

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Much has been achieved in many countries in the effort to attain a sustainable built environment (see, for example, a global survey of trends in green building McGraw-Hill Construction, 2013). Four examples from the arena of statutes and policies may be outlined. First, in some countries, laws and codes have been introduced which require appropriate action in attaining green construction. Second, a few countries, such as Singapore (BCA, 2014) have launched green building master plans. Third, in many other countries, such as Malaysia (CIDB, 2015) and the UK (HM Government, 2013), green building is a major element of national construction industry improvement strategies and subsequent policies. Finally, green building is a major component of the programmes in national sustainable development strategies - an example is Singapore where the target is to attain 80 percent green buildings in the building stock by 2030 (Inter-Ministerial Committee on Sustainable Development, 2009).

Developments in terms of the response of the industry (at the macro level) can also be outlined. The first is the formation of green building councils which bring parts of the industry together to pursue progress in green building. For example, the Singapore Green Building Council (SGBC), with membership from all sections of the construction industry, was formed in 2009. Its mission is "to propel the Singapore building and construction industry towards environmental sustainability by promoting green building design, practices and technologies, the integration of green building initiatives into mainstream design, construction and operation of buildings as well as building capability and professionalism to support wider adoption of green building development and practices in Singapore" (Singapore Green Building Council [SGBC], 2016). The vision of the Green Building Council of Sri Lanka (GBCSL) is: "to transform the construction industry in Sri Lanka with green building practices and to fully adopt sustainability as the means by which our environment flourishes, economy prospers and society grows to ensure the future wellbeing of our Motherland" (Green Building Council of Sri Lanka [GBCSL], 2016a).

Second, professional institutions and trade associations have formulated green building manifestos (such as Royal Institution of British Architects, 2000; Chartered Institute of Building (CIOB), 2013) and guides (such as Singapore Institute of Architects, 2013) for their members. Green building assessment and benchmarking tools have been developed in some countries by government agencies such as in Singapore (where the Building and Construction Authority (BCA) launched Green Mark (BCA, 2012)), by groupings in the industry such as in Malaysia (where the Green Building Index (GBI, 2009) was formulated by architects and consulting engineers and in Sri Lanka where the Green$^{SL®}$ Rating System for Existing and New Buildings was set up by the GBCSL (GBCSL, 2016b). At the company level, design and construction firms in many countries now use their capability and track records in green building as a strategic tool. An example of the periodic development of a UK company in the consideration of sustainability in corporate practices is provided by Whitehead (2015).

1.2. *AIM AND OBJECTIVES*

The aim of the study is to investigate the potential role of innovation and entrepreneurship in the effort to realise a green built environment. The discussion is focused on consideration of the main theme and sub-themes of this conference.

The objectives are to:

- consider the need for a green built environment, the progress which has been made in the effort to attain it, and the remaining issues, challenges and problems,
- consider the meaning of innovation and entrepreneurship today, and analyse their potential to facilitate the efforts towards creating and managing a sustainable built environment, and
- present a research agenda for a sustainable built environment by considering the 23 sub-themes of this conference.

2. SUSTAINABLE BUILT ENVIRONMENT

2.1. *WHY DOES MORE NEED TO BE DONE TO REALISE SUSTAINABLE BUILT ENVIRONMENT? WHAT REALLY NEEDS TO BE DONE?*

More needs to be done in the effort to attain a sustainable built environment, not only to ensure net-neutral impact of the process of creating and managing the built environment on sustainable development, but to maximise the potential positive impact. As a manifestation of the need for more work, some of the Sustainable Development Goals (SDGs), which outline what is to be achieved to bring about improvements in the quality of life of people around the world, relate directly to the expansion, improvement and better management of the built environment. These include (United Nations, 2015):

- Goal 6. Ensure availability and sustainable management of water and sanitation for all
- Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

(Goal 11, on cities, is considered below.)

Some examples of how the built environment can address all the pillars of sustainable development are now considered.

1. Environmental ... minimisation of land use change; conservation of resources - using fewest (in number) and least (in volume or weight), maximising recycling/reuse; minimising all forms of pollution
2. Economic ... creation of jobs, enhancing of incomes; integration of (and deriving synergies among inter-linkages among) elements of the built environment; enhancing productivity of production processes in organisations using the built items; saving of costs in built environment firms' own production; incentives
3. Social ... cultural suitability; lifestyle changes possibilities - examples include design for crime reduction and personal safety, and provision of leisure and sports facilities
4. Institutional … policies and programmes, regulation, enforcement, incentives and awards.

Another issue worth considering here is that of governance. In construction, corruption and mismanagement is responsible for the leakage of very high proportions of the funds which are meant to be invested in public construction projects (Transparency International, 2005; Hawkins and McKittrick, 2012). The factor of "project governance", as well as governance at the national level concerning the administration of projects are key in sustainable development (Ofori, 2016). Thus, it is possible to reconsider the concept of "project governance" in construction as the effort to attain sustainable development in the construction process, through the construction process, from the constructed item.

2.2. Why are Current Definitions Inadequate? What would an Appropriate Conceptualisation of the Subject be?

Viewed through the prism of sustainable development, the current focus on "green building" which has seen translation into policy and practice, and the formation of "Green Building Councils" and assessment systems in many countries, is inadequate. There is often some confusion on the subject. For example, the mission of the GBCSL is: "to develop the sustainability of the built environment by transforming the way it is planned, designed, constructed, maintained and operated and drive the adoption of green building practices through market-based solutions, while helping to forge a new partnership between government, industry and other stakeholders" (GBCSL, 2016a). Thus, the mission (which refers to "the built environment" is wider than the vision (which mentions "green building" and "the construction industry"). The attempt by some authors to equate green building with sustainable building, or to use expressions such as "green and sustainable construction" (Office of the Federal Environmental Executive, 2003) are not satisfactory. The existing definitions of "sustainable construction" do not go far enough; an example is that offered by the International Organisation for Standardisation (ISO) (2008). An attempt by the SIA (2013) to offer elements of a sustainable built environment goes much further than most of the existing ones.

Appropriate definitions of sustainable construction are needed. These should go beyond green building and consider the inter-linkages among the components of the built environment, well as the economic, social-cultural-historical and institutional-governance pillars of sustainable development. Ofori (2013) considers a sustainable building as:

> *"one which has been designed and constructed with due consideration of aspects relating to sustainable development including: preservation of land and effective decision making in answer to the fulfilment of the client's need for space (for example, is a new building needed?); resource conservation, and maximisation of utilisation of renewable resources; utilisation of existing natural factors such as daylight, wind direction and sunlight; prevention of pollution all types; protection*

and preservation of natural ecosystems; effective management of waste; enhancement of the durability of the built facilities including safeguarding the fabric of the built facilities in changing atmospheric conditions; promotion of the health and well-being of the workers building the items as well as occupants of nearby buildings (during construction), and of users of the built facilities (upon completion); and development of environmentally conscious lifestyles of the users".

It would be appropriate to consider, analyse and improve upon this definition. The appropriate definition would: consider all appropriate elements of sustainable development; seek to cover, and be relevant to, all types of constructed items; consider the lifecycle of the constructed item; seek to explore and exploit possible contributions of construction; and inspire and challenge the industry to perform to a higher level.

2.3. WHAT ARE SOME RECENT DEVELOPMENTS?

Some recent developments can be outlined. The Open Building Institute in the US has launched a crowd funding campaign to allow anyone the chance to create his or her own affordable eco-house. The open source platform has a free library designs for structures, furniture and utilities contributed by designers whose buildings met the (Quirke, 2016). However, many of the items have not been prototyped. The Low Emissions Intensity Lime and Cement consortium (LEILAC), which includes Heidelberg Cement of Germany, Mexico's Cemex, Tarmac of UK (a materials firm) and Calix of Australia (a mineral-processing and carbon capture technology company) was set up to exploit carbon capture technology developed by Calix, which may enable Europe's cement and lime industries to slash their carbon emissions without significantly increasing their costs (Rogers, 2016). The consortium is building a plant in Belgium which could capture more than 95percent of CO2 emissions from lime and cement manufacturing.

3. ENTREPRENEURSHIP AND ECO-INNOVATION

3.1. WHAT IS THE POSSIBLE RELATIONSHIP BETWEEN ENTREPRENEURSHIP AND SUSTAINABLE BUILT ENVIRONMENT?

There is a huge volume of literature on entrepreneurship (Shane and Venkataraman, 2000), and there are many myths, misunderstandings and arguments with entrenched positions on many aspects of entrepreneurship, and issues relating to it (Carlsson *et al*., 2013). There is general agreement that, as Schumpeter (1934) suggested many years go, entrepreneurship is important in all economies. For sustainable development, entrepreneurship could be considered to be crucial.

Today, the appropriate definition of "entrepreneurship" would have the following elements: (i) the ability to identify opportunities, often in a field or operating environment involving risks; (ii) the capability to assess the potential of these opportunities and determine that they are viable; (iii) the decision to enter into business or other activities to take advantage of these opportunities, a decision others might not have made; and (iv) the ability to build upon these opportunities to create other opportunities to apply, and hence, create additional wealth. Also, it is pertinent to state that there is a consensus today that entrepreneurship is not limited to business; it can be involved in any activity, and can also an involve individual, a group or an organisation.

The importance of entrepreneurship is even more evident today, with Schumpeterian disruption in many areas of endeavour which have taken many firms, including those which thought they were agile and competitive, by surprise and threatens to make whole segments of industries redundant. In the built environment field, it is necessary to pay attention to these possible developments in entrepreneurial disruption: (a) possible empowerment of small companies by easily available data and computer power (via the cloud); (b) rise of companies able to utilise new technologies such as BIM more effectively during development and in management of built items; (c)companies which will come up with the next technological innovation after BIM; (d) new production approaches and working methods such as greater automation; (e) new organisational working arrangements, lifestyles and shopping habits and their impact on the volumes of built items in different segments which will be needed; and (f) nature and volume of infrastructure which will be required to enable and support renewable energy, its basic unit of production and necessary aggregation, and the new methods of transportation.

Two other areas where disruptions will occur in the way the built environment is planned, designed, constructed and managed could be considered. First, there will be greater stakeholder involvement, as users and beneficiaries, empowered with computers and smart telephony, and emboldened by the social media, will show greater interest in the process of creating the components of the built environment. Thus, there will be the need for more effective stakeholder management in the planning and design process, in monitoring of projects, and in feedback during the operation of the facilities. The second disruption will be in the forms of ownership including community ownership of large-scale infrastructure. Thus, the local community could replace national government in public-private partnerships. These developments make a new understanding of entrepreneurship in the built environment necessary.

3.2. How Can Innovation Contribute to Attaining Sustainable Built Environment?

It is suggested that innovation and value creation are among the key sources of economic growth today. A committee set up by Singapore's government to formulate new strategies for the future highlighted this factor (Committee on the Future Economy Secretariat, 2015).

Innovation has many definitions. It can be considered as a new idea, method or item of equipment; a new way of using an existing idea, method or equipment; or the opening up of new ways of providing goods or services, and so on. An innovation should be of direct use, and should have an impact on society. It is helpful to consider Schumpeter's (1934) idea of creative destruction, and suggest that businesses, governments and individuals should continually find better ways of doing things, whether in the form of more effective processes, better inputs, better products (improved quality, durability, service, price), or better ways to reach the clientele (choice, waiting time, convenience). The link between entrepreneurship and innovation is often highlighted. For example, to Drucker (1985), "Entrepreneurship is the act of innovation involving endowing existing resources with new wealth-producing capacity". The strong link between entrepreneurship and innovation is evident in the many major global companies which were start-ups a few years ago.

It is pertinent to note that innovation does not only involve the application of new or more sophisticated technology. It includes new or smart ways of using existing or simple methods. Thus, it is often pertinent to explore traditional (old) approaches.

There are many possible areas where innovation is relevant to sustainable built environment. It should be noted that, in the context of sustainable development, the full range of innovation should be explored for possible application, rather than focusing on the 'eco' dimension, as in the theme of this conference. Some examples are: (a) planning and design approach - innovative planning to maximise use of space and preserve land; (b) passive design to create appropriate indoor environment with human comfort and productivity; (c) novel materials and their production methods; (d) high performing plant and equipment, installations and fittings; and (e) attention to social-community and personal-psychological aspects.

4. The Future

4.1. The Conference Themes as Further Research Agenda

The 23 sub-themes of this conference are presented below. Under each sub-theme, some comments are first made on its relevance and current state of knowledge on it. The implications for further research are then presented, with a focus on new considerations which will push the frontiers of knowledge and also lead to progress in the practice of sustainability in construction.

1. Green Buildings

As discussed above, the concept of "green building" should be extended beyond 'building' to cover 'construction' and ultimately, the entire built environment; and beyond 'green' to cover other elements of sustainable development other than the environmental module. It would be pertinent to study the concept of "sustainable construction" which includes "green building". Other relevant elements of this broad subject should also be institutionalised in order to set up appropriate headings for research. Arguably key among these is 'governance' (as discussed in section 2.1).

2. Sustainable Urbanisation

Urbanisation is a critical issue in many countries, especially in the developing nations. The merits and disadvantages of urban areas and their growth have been debated for several decades (Hall, 1996). It is now realised that cities offer possible arenas for developing and instituting solutions in sustainable development (Bouteligier, 2013**;** United Nations Human Settlements Programme, 2014). However, it is also evident that there are major problems in the cities in developing countries where millions of people live economically precarious lives in unsafe and unhealthy built environments (United Nations, 2015). A particular SDG, Goal 11, concerns cities, as it states: “Make cities and human settlements inclusive, safe, resilient and sustainable”. Making cities work, through effective planning and management, is a current major task in practice, administration and research. Sustainability across the urban area involves dealing with the inter-connection among built items. Much more work is needed in this important area.

3. Sustainable Construction Practices

The construction industry in each country has a range of practices, based on history, tradition and law. Reviews of the construction industries in many countries have found that the industries’ prevailing practices have a major impact on performance (Construction 21 Steering Committee, 1999; HM Government, 2013). For example, the allocation of the roles of the participants tends to constitute an obstacle to effective integration, co-ordination and value chain management. It is suggested that whole-industry approaches to establishing progressive and performance enhancing practices, procedures, contracts and relationships should be developed and instituted (Bernstein, 2003). It is also pertinent to consider the international variations in practices, sieve out good practices, and seek their effective dissemination for application, while recognising context specificity in each case.

4. Procuring Sustainable Built Infrastructure

Sustainable procurement has the potential to provide direction, guidance and incentives to practitioners and companies. Ofori (2000) suggests that procurement can be used to influence appropriate decision making in enterprises, and by individuals, throughout the value chain of construction firms. Some pertinent research questions include: (a) How different should the procurement arrangements for items of sustainable infrastructure be from those for 'regular' items? (b) What would be the appropriate assessment and bidder selection criteria for awarding these projects? (c) As environmental assessment is currently usually done at the design stage, what would be the relevant project success criteria? and (d) How can government set the example in procurement of sustainable built infrastructure, considering the differences in main considerations of public and private-sector clients during procurement.

5. Cost Management

‘Cost’ comes first when considering the performance parameters of construction projects, even in the so-called “iron triangle” (Association for Project Management, undated). The importance of the management of the cost of the constructed item is perhaps signified by the fact that a particular profession (Quantity Surveying or Cost Engineering) has been developed to practice it. Cost is also important in the context of sustainable development. It relates to the ‘economy’ pillar of the concept. It is necessary to progress from the persisting focus on cost in decision making on built environment projects. It is also necessary to enhance knowledge and application of life-cycle consideration of cost and related aspects of projects. This has relevance to sustainability with its stress on inter-generational equity and relevant considerations (Drexhage and Murphy, 2010). Studies are also needed on how best to balance cost with value, and then to relate cost to the other project performance parameters.

6. Process Improvement

Process improvement is important in the field of sustainable built environment as the industry uses massive volumes of materials. Thus, such concepts as Sustainable Consumption and Production (UNEP, 2015) are especially relevant to that field. Process improvement should be extended upward and downward beyond the construction process to include the extraction and production, transportation, storage and handling of materials; management or disposal of wastes during construction; continuous management of materials, components and installations in the facility during its operation, and appropriate reuse or recycling of its materials and components upon demolition.

7. Building Information Modelling and Information Management

From the perspective of a sustainable built environment, BIM offers the possibility of: effective collaboration in planning, design and construction; experimenting with various patterns and components; simulating the long-term performance of various materials and components; avoiding errors, rework and waste. Information management would help in the capturing, processing, dissemination and application of key information and data relating to aspects of the construction project and constructed items. Further research in BIM and information management should also consider the legal and other obstacles. Work is also required in integrating BIM with other technologies such as virtual reality and augmented reality, and the application of drones in various aspects of construction; and “the post-BIM era” in construction (Thasarathar, 2016).

8. Innovative Green Technologies

Innovation, in green technologies, in relation to the built environment, should not mean advanced, most mechanical technologies. Technologies should be explored and applied in construction in the most fundamental and widest sense, including equipment, methods, materials, processes, procedures, and so on. The technologies explored should be on the entire continuum, from the most advanced such as nanotechnology in the study of materials, and non-mechanical technologies as in passive methods. Contextual local relevance is key. Also worth exploring are the life-cycle cost implications of the new materials, components, techniques and tools.

9. Sustainable Procurement Strategies

The comments on this sub-theme are the same as on sub-theme 3.

The adoption of a strategic approach to procurement would be most useful. Sustainability here also refers to long-term, continuous development of strategies, policies and approaches, with stakeholder feedback.

10. Public Private Partnerships (PPPs) and Green Innovation

PPP is being increasingly used for various projects. It has merits and demerits, and while it has led to the realisation of some critical projects around the world, it has also resulted in projects which have involved problems and failures (European PPP Expertise Centre, 2015). It is appropriate to continuously innovate in the effort to apply PPP to constructed items and the urban infrastructure and rural built environment.

11. PPPs for a Sustainable Built Environment

Considering the increasing importance of PPP in the realisation of the elements of the built environment, further study of the effective application of PPP in this segment is necessary. Community level (instead of national level) PPP application is worth exploring.

12. Environmental Economics and Management

The subject of Environmental Economics and Management has not yet become established as a research area in construction. This requires key attention.Some possible topics in Environmental Economics with respect to the built environment include: (a) modelling life cycle assessment incorporating all dimensions of sustainability; (b) valuation of the priceless in built items; (c) what price premium to charge reasonably; and (d) what should the value of relevant incentives be, and for what duration. The possible research topics in Management are: (a) sustainability management as a project management knowledge area; and (b) managing the delivery of the sustainable built item.

13. Affordable Sustainability

Affordability is not given sufficient attention in construction. It is applied in practice without much analysis. This is a fertile area for further research.

14. Socio-Economic Sustainability

The focus on the ‘environmental’ pillar of sustainable development in built environment practice has been discussed above. This fixation even exists in research. Work on the other pillars is required. The expression “socio-economic” should be rendered more appropriately in its two component parts ‘social’ and ‘economic’, in addition to their combination to determine possible synergies.

15. Entrepreneurship

Entrepreneurship is relevant to the effort to pursue sustainable development, as discussed above. However, it should be reiterated that entrepreneurship should not only relate to individuals and businesses; it should also be applied to administrators, and organisations outside the business sector.

16. Sustainable Materials/Green Building Materials

Research on materials from the perspective of sustainable development should go beyond ‘green’ to cover the other pillars, in order to explore the full range of sustainable development in the development, production, installation or fixing and maintenance of construction materials. Affordability is also a relevant aspect to study in these respects.

17. Green Rating and Certification

The development of rating and benchmarking tools, and their application in certification is considered an important step in the pursuit of “green building”. These tools require further development in many regards, including: the contextual appropriateness of the tool; the theoretical basis of the segments of the tool; and the “further development during use” of the tools. Most important is the extension of the tools from ‘green’ to ‘sustainable’ (see, for example, CEEQUAL (ICE, undated)), and from ‘building’ to the entire range of constructed items. Other issues to consider are: (a) the stage at which the assessment should be done - design stage versus post-completion, and one-off assessment versus periodic re-assessment; and possibility of involvement of clients and users in the evaluation of performance. Finally, studies into the theoretical bases of the indicators and scores of assessment tools are required (Jayawickrama, Ofori and Low, 2014).

18. Energy Management

It is estimated that energy management in buildings can make a major contribution to the efforts to mitigate against climate change. In many countries, such as Singapore and the UK, reducing energy consumption in buildings is the main plank of national sustainable development. This big area of research should go beyond technology to cover social and community factors.

19. Legal Aspects Relating to Sustainable Construction

The legal aspects of sustainable construction include legislation as well as civil and contract law. The statutes provide guidance; codes and standards provide help with good practice; and the norms of professional negligence keep practitioners mindful of their responsibilities. The various aspects of the law should be co-related and continually studied, with focus on ways of realising synergies among various elements in application.

20. Sustainable Facilities

The design and construction process might result in the creation of a sustainable constructed item. Systematic management of the item in its operation is of paramount importance. The concept of Strategic Sustainable Facilities Management, which is proactive, long-term and comprehensive, should be formulated and continually developed.

21. Education on Sustainable Construction

The inculcation of appropriate practice, attitude and behaviour among practitioners and companies in the construction industry to pursue sustainable development has been highlighted. It is important that this education is continuous, and the principles covered are appropriate. Students should be given a love for life-long learning, and an interest in, and commitment to, the pursuit of sustainability.

22. Linking Design and Construction to Operation and Maintenance

The importance of considering the construction and operation and maintenance stages during the design stage has been highlighted for several decades. Technology, such as BIM, will facilitate and enable the optimisation of the pre-consideration of

23. Disaster Management

The impact of human activity, including construction, on the environment is deemed to be a major cause of disasters. These range from the events of global warming such as floods and sea level rise; and droughts which affect food security. Munich Reinsurance (2016) reported that losses caused by natural catastrophes in the first half of 2016 were US$ 70bn, compared to the previous year’s US$ 59bn. The main loss drivers were powerful earthquakes in Japan and Ecuador, storms in Europe and the US, and forest fires in Canada. Disaster management and resilience in the built environment are major research areas.

Disaster prevention should also be considered in research. The impact of disasters on lives and livelihoods, beyond physical infrastructure and other assets is also worth investigating. Capacity building in resilience and disaster management, including industry preparedness and effective systems for marshalling resources are also relevant.

24. Other Possible Topics

24a. Time Management and Productivity

It is necessary to incorporate the sustainability dimension among the generic project performance parameters, so that it is not considered to be an optional extra. For example, it is necessary to balance it with many other aspects, and whereas the trade-off with cost is usually done, the possible impact on time and other parameters is also worth considering. Time should be built in to allow for comprehensive evaluation of the negative and positive environmental impacts of the proposed project.

Productivity should also relate to the workers in the completed facility. This puts into focus the impact of the indoor environmental conditions on worker performance.

24b. Safety and Health

These performance parameters should also be balanced with the sustainability dimension. The health implication of innovative materials is one key issue. The health and productivity of users is another.

24c. Logistics

It is often suggested that one of the elements of sustainability is to use local materials as much as possible. However, this is usually unrealistic as not all materials required on any project can be obtained from local sources. There is also the question of what is 'local'. For a large country, obtaining the material locally (from within the country) might involve a lot of travelling. Thus, in the era of globalisation, sustainable logistics should be a research area, especially in a field which uses such large volumes of heavy and bulky items.

24d. Technology and Sustainable Built Environment

It is suggested that the future of construction is technology. Thasarathar (2016) outlines technological trends in construction including: 3D printing, the Internet of Things (IoT), robotics, drones, cloud computing, infinite computing, reality capture, augmented reality, gaming engines, crowd-funding, crowd sourcing, generative design, big data and artificial intelligence. Beyond the building scale, there is the concept of smart cities and districts. It is necessary to explore the possible exploitation of the whole range of technologies, including the new and emerging ones, in the effort to attain a sustainable built environment. The possibilities of synergistic integration of technologies could also be studied.

5. CONCLUDING REMARKS

Entrepreneurship can enable built environment organisations and practitioners to produce more with less, with higher quality and “sustainability awareness”, and to constantly seek to innovate. Thus, entrepreneurship can act as a spur to the contributions of each participant in each project. Entrepreneurship could also replace legislation and clients’ cost-revenue considerations in the decision making on the planning, design, construction and management of the built environment. Entrepreneurship, risk taking and innovation are relevant to the need for balance among aspects of the development project in the built environment, and the need to explore new materials, methods, practices and procedures in order to attain sustainable built and managed items.

A personal characteristic of long-term entrepreneurship and constant innovation. Another notion is “sustainable entrepreneurship”, one which is long-term and enduring, and which grows and improves over time. That of “sustainable innovation” can also be perceived. It is pertinent to seek to develop such characteristics and aptitudes among built environment organisations, agencies and practitioners.

There have been debates on whether both entrepreneurship and the capacity to be creative and innovative can be developed. Whereas the discussion continues, it is pertinent to consider the role of education and training at least in creating awareness of knowledge on, and possibly, capability in, these two processes, in order to enable each nation to realise the potential of its citizens in these regards. It would be appropriate for tertiary educational institutions to build these into their curricula. The various professional institutions in the industry should also explore the possibility of setting up networking, coaching and mentoring schemes for the continuous development of entrepreneurship.

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PAPERS

3R.6R EXTENDED WATER HIERARCHY MODEL FOR SUSTAINABLE USE OF WATER DURING CONSTRUCTION

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ABSTRACT

There is a broad consensus in literature that effective utilisation of natural resources in any industry greatly influences sustainability of built environment. Hence, better management strategies of water began to emerge in all sectors; thus, different dimensions are in need to assess different industries. With this scenario, water sustainability on construction sites is one significant area, which demands the attention of construction stakeholders. Today many construction projects survive on potable water, and many strategies are available that can reduce the amount of water consumed by the construction industry. Water hierarchy is one strategy proposed for construction sites to reduce potable water consumption and encourage alternative water sources within the site. Literature and preliminary interviews further support identification of new 3R principles: Regulations, Responsibility, and Rewards that can influence on better water management on construction sites.

Therefore, purpose of this paper is to examine the applicability and implementation of 3R principles in conjunction with six stages (6R) of water hierarchy to improve efficient water use on construction projects in Sri Lanka. The study adopted triangulation convergence mixed method approach, and data collection involved case studies and a structured survey. Qualitative data is presented as narratives and quotations while quantitative data is presented as descriptive statistics. The results revealed that all factors were considered as 'applicable' and the possibility of implementing them on construction sites. Reuse and recycle were identified as the least applicable, and are rarely practised on sites, if it is not initially identified as a mandatory process. Experience and commitment of individual staff and costs are identified as important drivers on implication of each 9R principle. New 3R principles were recognised as supportive policies to implement all six existing stages of water hierarchy. Finally, the paper discusses the extended water hierarchy model developed for construction industry.

***Keywords**: Construction; Extended Water Hierarchy; Sustainability; Water Efficiency.*

1. INTRODUCTION

Previous studies have extensively addressed adverse environmental effects from construction activities such as energy consumption, waste generation, noise pollution, water discharge, misuse of water resources, water wastage, consumption of non-renewable natural resources, dust and gas emission, and land misuse (Chen *et al.*, 2000; Shen *et al.*, 2007). Kibert (1994) explained that all these issues are interconnected and embraced under the heading, 'sustainable construction'. Abidin and Powmya (2014) stressed that the approach to sustainable construction will enable construction practitioners to be more responsible towards the need of environmental protection. This emphasises the necessity of sustainability criteria for construction to achieve a more environmentally sound built environment. Simultaneously, rapid decreasing of freshwater resource availability directly threatens 1.1 billion people around the globe (UN, 2006). As stated by Ramachandran (2004), construction is a water intensive industry. Thus, water shortage severely affect construction sector. This implies the requirement of sustainable strategies for better management of water resource in construction industry. As Hart (1995) emphasised, how environmentally oriented resources and capabilities can yield sustainable resources of competitive advantage, is one challenge that demands attention in construction industry. This reveals the requirements

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and establishment of sustainable approaches to sustain water for a long-term benefit. However, Strategic Forum for Construction (SFfC) identifies that to date, relatively less work is performed on water sustainability in construction sites, and water use receives a relatively low priority in comparison to the focus made on reducing energy, waste, and improving the carbon footprint (Waylen *et al.*, 2011). Further, it revealed that many construction sites located in urban areas enjoy potable water at subsidised rates for construction work due to issues in alternative water source availability (Waidyasekara *et al.,* 2012). Moreover, it was observed that construction stakeholders in Sri Lanka pay less attention to water use in construction sites. Singh *et al*. (2010) mention the need of new approaches for long-term water planning and management that incorporate principles of sustainability and equity. Waidyasekara *et al*. (2012); Waidyasekara *et al*. (2014) stated a vacuum exists with the body of knowledge in water management in the construction industry, compared to other industries in Sri Lanka. Frequently, construction activities have a potential to have a negative effect on the surrounding environment. Meanwhile, Dharmaratna and Parasnis (2012) and Deveraja (2013) predicted that if water resource management is not sustainable, a water crisis is possible within the next ten years in Sri Lanka. Therefore, with the help of real case scenarios, this paper presents perception of construction professionals on the applicability and implementation of 9R principles and sustainable use of water during construction. The study refers to ‘sustainable use of water’, meaning the optimum use of water resources in construction sites with minimum wastage and misuse, while causing minimum damage to the ecosystem and preserving that scarce resource to meet the needs of the future generations.

The paper is organised as follows: First, a literature review, which include water in the context of sustainability, sustainable water usage in construction industry, and water hierarchy and R principles, is presented. This is followed by a justification of data collection methods used and the results of the study.

2. WATER IN THE CONTEXT OF SUSTAINABILITY

Water is precious and many scholars define water as a finite resource. According to Leonardo da Vinci, water is the driver of nature; even if one can live without energy, nobody can live without water (Luan, 2010). The common explanation for available freshwater is either 2.5% or 3.0% of the total water, from which only 1% is easily accessible; the balance is stored as ice caps or deep ground water. According to United Nations (UN) estimates, more than 1 billion people living on the earth face water scarcity, and this number could increase up to 1.8 billion by 2025 (Economist, 2008). According to OECD (2008), 47% of the world’s population will live in regions with severe water stress in 2030. Difference between the increasing demand for water and the limited water availability creates a gap that is transformed into water scarcity (Joyce, 2012).

Biswas and Seetharam (2008) recognise the importance of formulating policies and regulations. Accordingly, over pumping results in declining ground water levels, and alternatively, more energy is required to pump the same volume of water. Another problem faced by the water sector is that universally, the prices and tariff are almost below the full cost of supply (Rogers *et al*., 2002). Therefore, low-priced water encourages excessive consumption, and hence, services provided at a higher price would encourage water conservation and a better service. Currently, the demand for potable water is constantly increasing with population growth, industrial developments, and climate change (Johnston, 2003; Economist, 2008; Goodrum, 2008; Sala and Wolf, 2013) mentioned that at present, many services and industries depend on continuous availability of freshwater; however, freshwater is heavily subjected to spatial and temporal variability of its own quantity and quality. Many scholars identified limited freshwater is a major constraint on sustainable development (Khalfan, 2002; Horne, 2012). Smith *et al*. (2006) recognise that when actual amount of water extracted was below the sustainable level of extraction is not a problem, but over-extraction and subsequent overuse of river systems create undue pressure. Figure 1 depicts the investment on water infrastructure, wastewater treatment, desalination, and recycling expects to rise steadily over the next five years. It is apparent from Figure 1 that the demand for water grows further, which claim necessity for more sustainability applications.

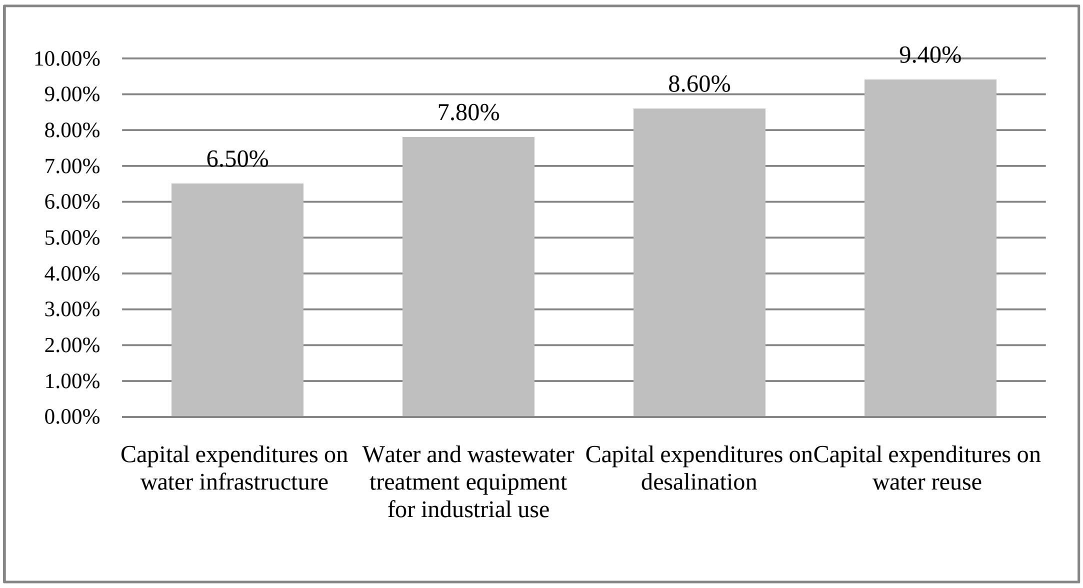

Figure 1: Growth in Global Water Industry Spending in Next Five Years
Source: Adapted from Rosegrant *et al.* (2012)

3. WATER USAGE IN CONSTRUCTION INDUSTRY

Construction industry is regarded as one of the largest users of water along with energy and material resources (Guggemos and Horvath, 2006). All construction work requires water from the inception to completion but the water quantity varies according to the site. In the past, the criteria for energy and water resources were not connected to one another, to materials selection, or to other issues of sustainable construction (Kibert, 1994). Water was merely considered as another input in construction projects (Kibert, 1994). At construction project level, water serves several purposes; it is not limited to mixing mortar and concrete, but also an essential component in curing work, dust controlling, soaking materials, vegetation establishments, geotechnical borings, pipe flushing, pressure testing, and washing and cleaning (The Workplace Health and Safety Queensland, 2007; Green roads TM manual, 2005; Utraja, 2010). According to Ramachandran (2004), use of contaminated water for mixing mortar and concrete, and curing will drastically reduce the structure life. However, many builders still do not realise the importance of such valuable processes and has not given the necessary priority during the practice. Alternatively, amount of water consumed by the construction is unknown and the extent of water consumption by the construction industry has not been adequately measured (Goodrum, 2008). While an enormous amount of water is utilised to operate buildings, a considerable amount is also used for extraction, production, manufacturing, delivery of materials to site, and for the actual on-site construction process (McComack *et al.*, 2007). As stated by Biswas (2008), water resource management attempts to optimise water usage and minimise the environmental impacts associated with its use.

Biswas and Seetharam (2008) recognise the importance of formulating policies and regulations for water construction activities; for instance, over pumping results in declining of ground water levels. Gleick (1998) mentions that sustainability criteria layout specific social goals that could, or should be attained, and it offers some guidance for future water management. As Ramachandran (2004) and Utraja (2011) stated, change of water quantity and quality in high or low degree greatly impacts on the product strength, but careless builders do not realise this in practice. This indicates the importance of adhering to design specifications and standard norms. According to Gonzales-Gomez *et al.* (2011), lack of intensive activities is one cause for poor water management practices. Responsibility, monitoring and supervision are other factors that influence sustainable use of water, as identified by many scholars. Based on the available literature, the Strategic Forum for Construction (SFfC) water sub-group, Waste and Resource Action Programme (WRAP), and Construction Industry Research and Information Association (CIRIA) are the main research bodies conducting research on water use on construction sites. SFfC mentioned that water use between construction sites and how water is consumed on a construction site varies over time. Aim of the above organisations is to work towards identifying and promoting water efficiency practices to reduce water consumption on construction sites in a sustainable manner. SFfC and WRAP emphasis the use of water technology, techniques and strategies actively influence a behavioural change, the work environment, and value for money (Waylen *et al.* 2011; McNab *et al*., 2011).

4. WATER HIERARCHY AND R PRINCIPLES

Water hierarchy is another area that supports efficient water use. The joint government and industry strategy for sustainable construction published in 2008 identified water usage on construction sites as a priority area and included many targets pertaining to the more efficient use of water (McNab *et al.*, 2011). Waste hierarchy (prevention, re-use, recycle, recovery, disposal) (DEFRA, 2007), 3R (Reduce, Re-use, Recycle), and avoid, reduce, reuse, recycle, and treat (Mirata and Emtairah, 2011) are some common and popular hierarchies available in literature to reduce wastage and enhance efficient use of resources. Similarly, Silva and Pimentel (2011) mention that water efficiency can be achieved through 5R principle, which incorporates Reduce consumption, Reduce loss and waste, Re-use water, Recycle water, and Resort to alternative sources. Meantime, Strategic Forum for Construction (SFfC) water sub-group introduced a water management hierarchy for construction industry as depicted in Figure 2.

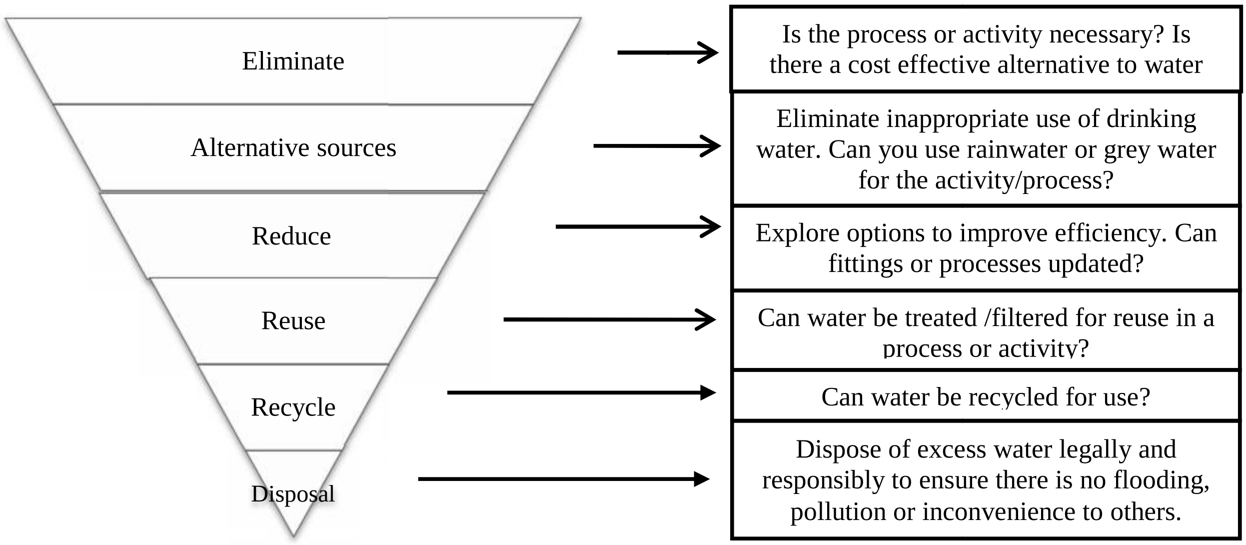

Figure 2: Water Hierarchy
Source: Adapted from Strategic Forum for Construction (SFfC): McNab *et al.* (2011)

Potable water standard is not always needed for all construction activities (McNab *et al*., 2011; Waylen *et al.*, 2011). It is apparent in Figure 2 that water hierarchy encourages alternative water sources for potable water. This is proved further with the findings of Waidyasekara *et al.* (2014) that potable water must be specified only where necessary and other options must be allowed in the contract. Tam and Lee (2007) suggested that it is necessary to encourage and educate the staff on monitoring water usage, water reusing and recycling systems, and the use of wastewater treatment during construction. As McNab *et al.* (2011) stated, creating a culture within the construction sector that changes staff attitudes and behaviour to accept ownership of water efficiency is fundamental to improve the use of water efficiently.

As discussed, literature bears evidence that 3R, 5R and 7R principles are introduced for water stages of existing water hierarchy for the construction industry by SFfC. Therefore, in relation to this study, the definitions adapted for each step of hierarchy are presented in Table 1 with the proposed R principle.

Table 1: Stages of Water Hierarchy with the Proposed 'R' Principles

No.	Existing Term	Proposed Term with the R	Definition Adapted for the Purpose of Study
01	Eliminate use	Review	Check whether the process or activity is essential for potable water
02	Alternative non-potable water source	Replace	Find cost effective alternatives to potable water
03	Reduce	Reduce	Explore options to improve water efficiency. Basically, applying water efficient technologies, techniques, and strategies
04	Reuse	Reuse	Water reuse elsewhere without treat (as it is)
05	Recycle	Recycle	Water be recycled for reuse elsewhere during construction
06	Disposal	Removal	Dispose of used or excess water legally and responsibly to ensure no flooding, pollution, or inconvenience to others

Holmes and Hudson (2000), Cole (2005), and Pahwa (2007) identified the necessity of conditions or regulations to protect natural resources and environmental impacts due to construction. As Byrne (2011) explains, in water consumption, 'fit for purpose' approach should be adopted using potable water for all purposes. As discussed in the background study and literature findings, many researchers identified it is necessary to formulate new policies and review the existing ones (Rosegrant *et al.*, 2012; McComack *et al.*,2007; Houser and Pruess, 2009). The study conducted by Houser and Pruess (2009) justifies utilising appropriate best management practices in construction projects yield a minimal impact on overall water quality of surrounding water bodies. Tam and Lee (2007) suggested that it is necessary to encourage and educate the staff on monitoring of water usage, water reusing and recycling systems, and the use of wastewater treatment during construction. This is the responsibility of top management staff, since inappropriate incentives and institutions often hinder the effective use of water during construction (Houser and Pruess, 2009; Sala *et al.*, 2013). This simply explains promoting rewards and incentives for water use efficiency practices and the importance of rewards discussed by the preliminary interviewee personnel. Similarly, Boberg (2005) identified incentives as a mechanism to promote water conservation and efficiency.

Therefore, in addition to the stages of 6R (refer Table 1) of the water hierarchy, literature and the preliminary interviews support to identify three (03) new R principles, which will impact on the sustainable use of water during the construction phase. These are Regulations, Responsibility and Reward. Table 2 presents the new 3Rs and definitions adapted in this study.

Table 2: New 3R Sustainability Principles for Water Efficiency

New 3R	Definition Adapted
Regulations	Adhere to project and environmental specific rules and norms during water consumption
Rewards	Remuneration towards positive attempts to reduce water consumption and innovative ideas
Responsibility	Actions towards environmental and social conservation and preservation of natural resources

As stated by Waylen *et al.* (2011), all such sustainability concepts depend on user behaviour and attitudes. Further, Sala *et al.* (2013) mentioned that human consumption and their behaviour greatly affect sustainable consumption styles and environmental consequences.

5. RESEARCH METHODOLOGY

This research is exploratory in nature. Creswell (2007) explained that exploratory research is more suitable when previous work on the subject area is limited. In Sri Lanka, water sustainability in construction industry is one of the less acknowledged areas by the industry practitioners. It is vital to understand the acceptance and effective implementation of 9R principles during the construction phase for efficient water management. The study adopted triangulation convergence mixed method approach, and case studies and structured survey were employed during data collection. A robust questionnaire was developed based on the factors identified in the literature review and using a purposive sample, 160 questionnaires were administered among project managers, civil engineers, quantity surveyors, and architects having over ten years working experience in the industry. The respondents were given a 5-point Likert scale (refer to Table 3) to indicate the level of applicability of 9R principles on construction sites based on their professional judgement. In addition, four (04) ongoing construction projects located in Colombo were selected to explore and examine the implementation of each R on construction sites. Multiple sources of evidence were employed during the case study data collection. Qualitative data is presented as narratives and quotations while quantitative data is presented as descriptive statistics, i.e. mean, standard deviation, frequencies, and percentages were used appropriately to analyse data originated from the survey.

One-way ANOVA is used to determine the presence of a significant difference between the mean values among different groups: project managers, civil engineers, quantity surveyors, and architects at the 95% confidence interval. As the next step, based on the central tendency, a benchmark-mean score of 3.40 helped to identify the 'applicable' factors, while a benchmark of 4.2 was used for 'highly applicable' factors (Kazaz and Ulubeyi, 2007).

Table 3: Likert Scale for Level of Applicability

Scale	**1**	**2**	**3**	**4**	**5**
Level of Applicability	Not applicable	Less applicable	Neutral	Applicable	Highly Applicable

6. FINDINGS AND DISCUSSION

One hundred and five (105) usable responses were received, which made the response rate a formidable 65.6%. Out of the 105 respondents, over 27% had over 25 years, 23% between 20-24 years, 23.8% between 15-19 years, and 25.7% between 10-14 years of experience respectively. The total sample consisted of 21% project managers, 30.5% engineers, 28.6% quantity surveyors, and 20% architects. Results of one-way ANOVA indicated no significant difference between mean values on each variable, since significance level for each factor was greater than 0.05. This laid a solid basis to analyse data, considering all participants as one sample.

As stated in Table 3, participants were requested to rate the applicability on a scale of 1 (Not applicable) to 5 (Highly applicable). Detailed distribution of responses in terms of 'applicability' is summarised in Table 4. According to Table 4, all factors were considered as 'applicable' for construction industry by the respondents since the mean value of each concept received more than 3.4. Among them, Reduce, Review, Responsibility, Replace, and Regulations scored as the top five factors. The results further indicated that less applicability of 'Re-use' and 'Recycle' for construction sites received the 8th and 9th ranks respectively. Alternatively, the combined results of 'Applicable' and Highly applicable' were reported more than 70% for Reduce, Review, Responsibility, Replace, and Regulations as applicable for enhancing water sustainability practices on construction sites. When compared with all other stages of water hierarchy 'reuse' and 'recycle' received less percentage, which was 50.4% for each case. This reveals builders are certainly not willing to pay for wasted water in addition to 'treated' water.

Table 4: Applicability of R Principles to Enhance Efficient Use of Water during Construction Phase

9R	#1 %	#2 %	#3 %	#4 %	#5 %	Mean Score	Std. Dev.	Effect Level	Rank
Reduce	0.0	1.9	19.0	40.0	39.0	4.162	0.798	Applicable	1
Review	0.0	5.7	10.5	47.6	36.2	4.143	0.825	Applicable	2
Responsibility	3.8	4.8	13.3	32.4	45.7	4.114	1.059	Applicable	3
Replace	1.0	3.8	18.1	41.0	36.2	4.076	0.885	Applicable	4
Regulations	1.0	4.8	22.9	41.0	30.5	3.952	0.903	Applicable	5
Removal	1.9	4.8	27.6	36.2	29.5	3.867	0.961	Applicable	6
Reuse	3.8	13.3	31.4	29.5	21.9	3.524	1.093	Applicable	8
Reward	3.8	7.6	23.8	40.0	24.8	3.743	1.038	Applicable	7
Recycle	7.6	12.4	28.6	29.5	21.9	3.457	1.185	Applicable	9

1.00 ≤ ‘Not Applicable≤ 1.80; 1.80 < ‘ Less Applicable ≤ 2.60 ; 2.60 < ‘Moderately Applicable≤ 3.40; 3.40 < ‘ Applicable (A/R) ≤ 4.20; 4.20<‘ Highly Applicable ≤ 5.00

Review: This is the first stage of the water hierarchy, which checks whether potable water is compulsory for construction activities or processes. It revealed that none of the site documents clearly mentioned the water source required according to the construction activity. However, it was noted that the contractor holds the responsibility of making arrangements to obtain water for construction.

Replace: The case study findings revealed that ‘Replace’ is practiced by the four construction sites. Project manager of Case 2 stated that, “*if potable water is used on construction sites, water hierarchy will provide more benefits. At present, we have looked for alternative water sources before using potable water*”. Similarly, initially Case studies 1, 3 and 4 implemented this stage (Replace). However, it revealed that ground water contamination was a main barrier faced by construction sites during the attempts to obtain water from tube wells as an alternative source of potable water. Limited space availability on sites was identified as the main barrier for implementing rainwater harvesting by Cases 3 and 4.

Reduce: Monitoring, supervision, assigning responsibility, worker awareness through meetings and posters were implemented in Cases 1, 2, 3 and 4 to minimise water wastage due to construction activities. In addition, pressure gun hoses were employed during vehicle washing and cleaning the site, to reduce water and minimise unnecessary water wastages. Project manager of Case 3 stated, “*If curing components are applied on concrete walls, columns, and slabs, it reduces water usage. This is more expensive than the usual pond system but if water is a scarcity this is a very good solution*”. As stated by project managers of Case 1 and Case 4, all these applications totally depends on the cost, which is the responsibility of the contractor and the client, and prioritised within that context. Curing agents were already in practise in Case 4.

Re-use: It was observed that the implementation of ‘Reuse concept’ was successful in Case 1, which had a proper system to collect rainwater and use for dust controlling, vehicle washing, and for fire emergency. As stated by the project manager, Environmental Management System (EMS) was the main reason to implement above strategies on the site (Case 1). Case 3 used dewatering water during the construction of pile foundation. The engineers stated that the project did not have a predetermined plan for water use efficiency during the construction stage; however, such practices were implemented through staff experience. Further, the project manager of Case 3 stated that during construction, “*it is possible to re-use water that is used for water proof testing. It can be used for mixing mortar for the tile bed in the same floor if it is planned in advance*”. However, interviewees believed that the re-use of water is rarely accomplished on construction sites unless it is identified as a mandatory requirement during project initiation.

Recycle: EMS of Case Study 1 was greatly conducive for the implementation of 'recycle' during the construction stage. As stated by the project manager, it saved usage of potable water significantly. This is the only site, which adopted 'Recycle' concept for water resource. The interviewees revealed that none of the sites practised 'Recycling' if the requirements were not identified initially. It was noted, to get more benefits from them in a cost effective way, the intention should be communicated during the tender stage.

Removal: Removal means disposing the excess water legally with the responsibility of ensuring no flooding, pollution, or inconvenience to others due to disposal of excess or wastewater. The findings revealed another step of water hierarchy, which is in practice by the four construction sites. All sites adhere to current regulations with wastewater disposal. It is noted that this is one of the successfully implemented regulation on construction sites, since relevant authorities conduct inspections on regular basis.

Regulation: 'Regulation' is one of the policies acknowledged in literature. Most interviewees agreed that firm establishment of certain regulations for water use in construction is required to enhance water use efficiency practices in construction sites. It was observed that regulations on wastewater disposal were well practiced on construction sites, mainly due to regular inspection and monitoring as claimed by the interviewees. Project manager of Case 4 stated that rainwater harvesting should be implemented on sites and it is important to find ways to enrich ground water than just disposing wastewater to the municipal waste drain. If these aspects (re-use, recycling) are strictly implemented as shown in regulations initially, the contractor will be more responsible. Another important point highlighted by the project manager of Case 1 was, city water usage per day is unlimited, and no rules and regulations established for extracting ground water. The engineer of Case 3 stated, "*Regular check on quality of water is rarely practiced on construction sites. On many construction sites, city water is used for all direct and indirect activities. Therefore, the use of potable water must be monitored constantly; excess use of potable water needs investigation and strict control to make consumers realise the need for conserving potable water. Thus, regulations are vital to use potable water intelligently."*

Reward: Interviewees of Case study 1 claimed, "*Rewarding is a good policy, which encourage both organizations (can be considered for contractor grading and awarding) and workers (incentives for innovative work) who strictly adhere to practice sustainability approaches*." Similarly, engineer of Case 3 mentioned, "*If the contractor is rewarded for practicing innovative and sustainability practices during the annual award ceremony and during contractor performance grading, there is a high tendency to popularise water use efficiency measures including maintaining water hierarchy among contractors. These aspects will be well established in the construction industry*." However, project manager of Case 2 stated, to implement water hierarchy, first it is important to educate management level, and these practices should begin at the director level or chairman level. Otherwise, planning and achieving his requirement becomes a massive task for the project manager. The project manager of Case 4 stated, "*Not only rewards but also penalties should be introduced with the system; then only people feel the value of taking steps on water saving measures*".

Responsibility: Responsibility of industry stakeholders and actions towards environmental and social conservation and preservation of natural resources on construction site are primarily important to achieve sustainable use of water. It could be observed that in all cases, Responsibility of tasks is already determined and well-practiced. The project manager of Case 2 stated, "*We have already assigned persons and given responsibility on different tasks on water management on the site (e.g. recording daily water meter readings, site inspection on water collection areas, and report on leakages)"*. Many interviewees reported it is important that top management do monitoring, although others have assigned responsibilities.

Case study results showed that it is possible to implement 're-use' and 'recycle' on construction sites; however, it should be communicated before starting the construction work.

Below is a previous experience on implementing water management strategies (stages of water hierarchy) on construction sites, shared during the empirical survey.

> *"This is an interesting exercise and a highly rewarding practice on the economics of the monthly cost overhead cycle of a contractor. I have personally practised this when working for ICC at the Pallekele Cricket Stadium site in 2003/2004. The labour accommodations had long tanks filled with potable water for bathing and washing. I did away with them and introduced showers and taps. The water bill reduced by over 70%. The ordinary toilet cistern used in female toilets and the male Water Closet flush down 6 litres each time. We introduced one litre plastic water bottle in the cistern and saved a litre of water on each flush. The runoff water from batching plant and the truck wash water was passed through sedimentation and a settling tank, and a filtering process. This water was subsequently used for curing work. It was so cost effective and interesting. Ultimately, it changed the attitudes and wrong practices of the workers as well".*

> "*According to my research, water curing is more effective than membrane curing. Water curing delays the initiation of corrosion more than membrane curing*".

In addition to the comments made on each R by interviewees, i.e. project managers and engineers, few made general comments on 3R as follows:

> *"None of the regulations work out properly without a proper monitoring system."; "Not only 'rewards' but also 'penalties' should come with the system. Then only people feel the value of taking steps on water saving measures"; "Even assigning responsibility among the parties, acknowledgement of attempts of each individual is crucial for better achievement".*

Furthermore, interviewees stated that, *"win-win sustainability situations are achievable and a close relationship exists among each other. For instance, monitoring is essential in 'responsibility' and 'rewarding' policies are in place. Consequently, if the job is performed in a more responsible manner, the rewards are offered automatically in return".*

7. EXTENDED WATER HIERARCHY MODEL

Information collated from findings of case study, questionnaire survey, and from literature findings, formed following conclusions in this study:

- The original six stages of sustainability strategies of water hierarchy (6R) of SFfC in the UK were statistically proved and accepted for the Sri Lankan construction industry.
- Case study results bear evidence that certain are followed in construction projects at present, but there is no proper way to establish such systems.
- New 3R principles (Responsibility, Regulations, and Rewards) were also accepted and identified as supportive to implement all six existing stages of water hierarchy; i.e. new 3R principles influence on receiving successful results from each strategy of existing water hierarchy.

Based on the above conclusions, the study presents 3R.6R extended water hierarchy model for efficient water use during construction phase, as illustrated in Figure 3, 3R principles represent the three vertical sides of the inverted pyramid that support each 6R principle This proposed extended water hierarchy model ensures excellent control of water resource and potential uses under the sustainability agenda and requirements may vary according to the unique characteristics in the construction projects and its goals. Thus, implementation of these concepts provides a positive indication of establishing water efficiency practices within construction sites.

Figure 3: 3R.6R Extended Water Hierarchy Model for Construction Industry

In addition, interviewees from case studies and questionnaire survey suggested that cost has a major impact on the implementation of water hierarchy other than challenges that may have to overcome initially, such as introducing at the design and tender stage, showing competitive advantages by implementing the system, and support from the authorised institutes. It revealed that the additional cost on attempting WEC measures and sustainable values in-use should incorporate into the contractual documents. Therefore, recognition of builders' capacity to deal with water use efficiency should integrate with pre-qualification and contractor selection criteria.

8. CONCLUSIONS AND RECOMMENDATIONS

The applicability of each R was explored with case studies and examined during the questionnaire survey. Thus, the study sought the views of construction professionals representing Project Managers, Civil Engineers, Quantity Surveyors, and Architects with over ten years of experience in building construction projects, on the acceptance of the applicability of 9R sustainability behaviour policies for water sustainability during the construction phase. In addition, four (04) ongoing construction projects were examined during the data collection process. Quantitative and qualitative approaches were employed during collection and analysis of data.

The study revealed that among the 9R principles, certain Rs in the hierarchy of SFfC, such as 'replace with alternative sources', 'reduce', 'reuse', 'recycle', and 'removal' are in practice in construction sites. Similarly, the Strategic Forum for Construction (SFfC) in United Kingdom identifies that 'reducing water use on construction sites' as an important aspect. However, idea of the majority of respondents was that "reuse" and "recycle" are rarely followed by construction sites, if not identified as a mandatory process. Conversely, the literature shows that 'Re-use' and 'Recycle' contribute positively to sustainability/ green concepts and to waste management processes. Interviewee personnel accepted the applicability of each R, and identified the importance of new 3R, i.e. Regulation, Responsibility, and Rewards. It denoted that all 9R are applicable, but actions taken by client/consultant during the design and tender stages and contractor (top management) during construction stage will inevitably propel the construction industry towards water sustainability. On the other hand, few respondents commented that application of certain 9R on construction sites totally depends on the experience and commitment of the individual staff. Cost was identified as an important driver on the implication of each R. New 3R attributes are identified as supportive principles to implement all six existing stages of water hierarchy. Based on empirical findings, the 3R.6R extended water hierarchy model was developed and that can be applied for sustainable use of water in construction industry**.**

Recommendations can improve the implementation of environmental policies on natural resources, and assigning responsibility and targets among the site staff. Concisely, sustainable use of water during construction phase is still in its infancy. Therefore, this research recommends that the relevant authorities in Sri Lanka, i.e. Construction Institute of Development Authority (CIDA), Central Environment Authority (CEA), Urban Development Authority (UDA), Road Development Authority (RDA), and National Water Supply and Drainage Board (NWS&DB) should formulate policy measures to promote and establish water sustainability policies during construction. The study will provide a platform for future builders, who shall be environmentally responsible and plan to implement water efficiency and conservation measures in practice. Finally, the study findings revealed that initiation of correct actions is necessary to bring sustainability or green concept in construction industry to the forefront of the development agenda of the country.

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A REVIEW OF CONSTRUCTION SAFETY, CHALLENGES AND OPPORTUNITIES - OMAN PERSPECTIVE

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ABSTRACT

Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries and in Oman it account 10% of the total GDP. Statistic indicates that a total of 723,000 residents were working in construction industry in 2014. Construction workers build, repair, maintain, renovate and demolish houses, office buildings, factories, hospitals, roads, bridges, tunnels, stadiums, docks, airports and more. During the course of their work they are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, among many others. In most developed countries, organizations have significantly reduced the risk of injuries and fatalities by understanding the impact of construction safety on their performance. This involves the development and implementation of construction safety rules and laws by the organizations itself and by authorities responsible for this purpose. Such safety rules and laws are based on the studies of organization safety cultural and post-accident investigations. Statistics indicates that worker deaths in America are down on average, from about 38 worker deaths a day in 1970 to 12 a day in 2014 and worker injuries and illnesses are down from 10.9 incidents per 100 workers in 1972 to 3.3 per 100 in 2013. This paper presents the challenges and opportunities available for Oman to improve the construction safety performance of the organization by developing and implementing standard safety rules and laws. The research methodology includes the comparison of existing construction safety in Oman with some of the developed countries. The paper further describe how Oman can improve construction safety by developing specific safety rules and regulation and their enforcement through inspection of construction site under an independent authority of health and safety.

Keywords: *Construction Industry; Risk; Worker; Safety Performance; Safety Rules and Laws.*

1. INTRODUCTION

Statistic published by International Labor Organization indicates that at least 108 thousand workers are killed on construction site every year, a figure which represents about 30 percent of all occupational fatal injuries. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Many more workers suffer and die from occupational diseases arising from past exposure to dangerous substances, such as asbestos. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries. It accounts for a large proportion of GDP for many countries for example, 10 percent in the U.K., 17 percent in Japan, and 10 percent in Oman. Statistics published in daily Times of Oman dated June 09, 2014, a total of 723,000 residents were working in construction industry. In most developing countries, construction is among the fastest growing areas of the labor market, continuing to provide a traditional entry point for laborers. It is, however, one of the most dangerous

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industries. Construction workers build, repair, maintain, renovate and demolish houses, office buildings, factories, hospitals, roads, bridges, tunnels, stadiums, docks, airports and more. During the course of their work they are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, among many others. The causes of accidents and ill-health in the sector are well known and almost all are preventable. A report published in Daily Times (2015) states that there is no official statistics of how many company workers get hurt in the course of their duties but according to the individual Health and Safety Environment's (HSE) records of top 10 contractors, more than 3,700 of them needed medical treatment in 2014. The injured workers who get hospitalized made up nearly 10 per cent of the total workers on this list. Sadly, about 18 percent of them died either at the sites or in hospitals last year. In comparison to the previous year, 246 more workers got injured in 2014 but for obvious reason, company directors do not want this part of the record to be made public. According to the results of the occupational safety and health (OSH) review study conducted by the ILO and the ILO Regional Office in Beirut at the end of 2007, Oman has not ratified any of the core OSH Conventions, notably Conventions No. 155 (Occupational Safety and Health Convention, 1981) and No. 161 (Occupational Health Services Convention, 1985), nor the latest Convention No. 187 (Promotional Framework for Occupational Safety and Health Convention, 2006). Traditional measures of safety are after-the-fact measures; namely, that safety is measured after injuries have already occurred. These measures are labelled reactive, trailing, downstream, or lagging indicators because they rely on retrospective data. Focusing on these measures e.g., accident rates and compensation costs often means that the “success of safety is measured by the levels of system failure” (Cohen, 2002).

In recent years, there has been a movement away from safety measures purely based on retrospective data or “lagging indicators,” such as accident rates, toward so-called “leading indicators” such as site investigation and measurements of safety climate (Flin *et al.*, 2000). In view of the importance of Occupational Health and Safety (OHS), countries such as the United Kingdom (UK), Singapore and Hong Kong (HK) have adopted a self-regulatory approach to safety, whereby proprietors (including contractors) are required to develop, implement and maintain safety management systems (Rowlinson, 1997; Wilson and Koehn, 2000). The practice of safety in construction in the USA is regulated by governmental agencies such as the Occupational Safety and Health Administration (OSHA), and in UK it is regulated by Health and Safety Executive (HSE) which provides strict rules and regulations to enforce safety and health standards on job sites. Some construction companies realize the importance of reducing their accident rates not only for humanitarian reasons, but also because of the many financial benefits which flow from the safe conduct of the work. Other companies do not have a strong belief in safety. This has serious repercussions when any unfortunate incidents occur. Good management should always insist that every engineer, supervisor and laborer must be familiar with all basic safety aspects and practices that guard those around the sites from accidents and injuries.

This paper present a thorough review of construction safety in Oman, focusing on the current status of safety, regulation of health and safety, enforcement and recommendation how the safety can be further improved by establishing a health and safety regulatory authority involving all stakeholder.

1.1. CONSTRUCTION PARTIES SAFETY RESPONSIBILITIES

The responsibility for safety on any construction project should be shared between all the parties involved in the project, namely, the owner, the designer or architect and the contractor. The owner, as part of his safety responsibilities, must ensure that the designer designs a safe project. He must also ensure that the contractor has a safety program. The owner should include the safety program as an element of the bidding technicalities. The architect or designer contributes towards ensuring the safety of the project by properly designing the temporary and permanent work from the safety point of view. The temporary works must be designed so that they provide a safe means of access to and about the construction work. The permanent work must be designed so that it is stable and safe for the users. Contractors should provide a safe environment for workers by meeting all safety requirements during construction processes, beginning with site preparation and ending with completion of the work. Regulatory and contractual requirements place the primary responsibility for construction site safety on the constructor (Behm, 2006). For instance, the federal OSHA regulations place the responsibility for worker safety on the constructor as the primary employer. Project owners who make safety a priority also place the responsibility for construction site safety directly on the constructor, by showing preference for pre-qualified contractors who have good safety records, lower insurance rates, and comprehensive safety programs.

Research into the root causes of construction accidents has also focused on the role of the constructor. Abdelhamid and Everett (2000) evaluated construction accidents in the United States and developed a model for tracing the root causes of accidents. Their research addressed activities and conditions at the construction site but did not consider potential root causes in the project concept and design phases. The authors attributed unsafe conditions to four main causes: management action/inaction, unsafe acts of workers and co-workers, events not directly human related (such as equipment failure and natural disasters), and unsafe conditions that are a natural part of the construction site (such as uneven terrain and concealed ditches). Abdelhamid and Everett's approach is consistent with conventional accident root-cause analysis, focusing solely on the actions and inactions of the constructor, rather than adopting a broader view of accident causality that looks at upstream influences, including the design process.

One recent study of causal factors in construction accidents looked at the designer's role. Haslam *et al*. (2003) studied the causes of 100 construction accidents in the United Kingdom, and found that permanent works designers (synonymous with "design professionals" in the United States) could have reduced the risk associated with the accidents in almost half of the cases. The authors also developed a construction accident causality model that described immediate causes, shaping factors, and originating influences in construction accidents. They concluded that the permanent works design influences the workers' activities, the site, and the materials and equipment specified for construction.

2. STATUS OF HEALTH AND SAFETY

Research conducted by Smallwood (2004b) in selective construction project measuring different projects parameter found that health and safety is the least important project parameter among five different other as shown in Table 1. It should be noted that the perceived importance of H&S is likely to influence the adopting of H&S as a value, as opposed to a priority. The adopting of H&S as a value is important as priorities change, and hence the importance of the status of H&S. However, the adopting of H&S as a value is a prerequisite for addressing and optimizing the other constituents of H&S culture. Giving less priority and importance to health and safety by construction organization shows the unawareness of cost of accidents and such action can lead the organizations to high number of accidents. The cost of accidents can be categorized as being either direct or indirect. Direct costs tend to be those associated with the treatment of the injury and any unique compensation offered to workers as a consequence of being injured and are covered by workmen's compensation insurance premiums. Indirect costs which are borne by contractors include reduced productivity for both the returned worker(s) and the crew or workforce; clean-up costs; replacement costs; costs resulting from delays; supervision costs; costs related to rescheduling; transportation, and wages paid while the injured is idle (Hinze 1994). Recent research conducted in the United Kingdom (UK) determined indirect costs to be 11 times the direct costs - 11:1 (Movement for Innovation, 2003). Research conducted in South Africa determined the indirect costs to be 14.2 times the direct costs (Smallwood, 2000). Research conducted in the United States of America indicates the total cost of accidents constitutes, inter alia, 6.5 % of the value of completed construction (The Business Roundtable, 1995) and in the UK approximately 8.5 % of tender price (Anderson, 1997).

Rowlinson (1997) maintains H&S performance cannot be measured in economic terms, but only in social terms. Consequently, the appropriate level of expenditure on H&S should be based upon economic, political and social considerations. However, various authors quantify the cost of prevention. The Business Roundtable (1995) cites research conducted in the USA, which determined that the cost of administering an H&S programme usually amounts to 2.5 % of direct labour costs. Based upon two projects undertaken by a South African general contractor and given that direct labour costs typically constitute 25 % of the total project, the cost of administering an H&S programme was estimated to amount to 0.65 % (25 % x 2.5 %) of the total project cost (Smallwood, 2000a).

Research conducted by Lai (Tang, Lee and Wong, 1997) in Hong Kong revealed that most contractors set aside an amount of less than 0.5 % and some even less than 0.25 % of the contract sum for investing in

H&S on their contracts. During recent research conducted among a group of 'best practice H&S' general contractors the question: 'On average, approximately what percentage does the cost of H&S constitute of total project cost?' was asked. Eight general contractors responded. Two GCs (25 %) recorded percentages, namely 3 % and 0.5 %, and six (75 %) identified ranges: three (37.5 %) '0 ≤ 1 %' and three (37.5 %) '> 1 ≤ 2 %' (Smallwood, 2004a). The health and safety statistics for 2014-15 mentioned the Health and Safety Executive (HSE, UK), indicate that a total of 27.3 million working days were lost due to work related ill health or injury. This further result to an estimated cost of £14.3 million. Although the contribution of construction industry towards the total GDP value for Oman and Great Britain are the same, however such analysis are not available in Oman since there is no such organization to deal with this.

The cost of prevention is of relevance to designers, particularly where they are the principal agent, because of the following. First, in terms of the Construction Regulations, clients may appoint designers or other consultants as their agents to fulfil their responsibilities. Given that clients are required to ensure that principal contractors have made adequate allowance for H&S, the cost of prevention is important. A further issue is that should the allowance for H&S be inadequate, based upon the negative effect of inadequate or the lack of H&S on the other performance parameters, overall project performance could be impaired.

Table 1: Degree of Importance of Various Parameters

	Response (%)							
	Un-Sure	**Not Important . . . . .Very Important**						
Parameter		1	2	3	4	5	**II**	**Rank**
Project Quality	0.0	1.0	0.0	3.1	26.8	69.1	3.63	1
Public Health and Safety	0.0	2.1	3.2	12.8	21.3	60.6	3.35	2
Schedule (Time)	0.0	1.0	0.0	15.5	38.1	45.4	3.27	3
Cost	0.0	2.1	3.1	10.3	35.1	49.5	3.27	4
Project Health and Safety	3.1	3.1	5.2	13.4	36.1	39.2	2.97	5

Source: Smallwood (2004b)

3. HEALTH AND SAFETY IN OMAN

Construction is a major industry of Oman contributing a major portion towards the total revenue and approximately 10% to GDP which is similar as of the United Kingdom construction industry. Currently a total of 100,000 are registered as contractor with a workforce size of 700,000 consisting of a major portion of expatriate workers. Construction industry is attractive for most of the international companies because of the high profit with low taxes and cheap workforce. The work carried out by these companies are normally of good quality because mostly it one of the consideration for their future awards, and a strict compliance from the clients. However, most of the companies do not maintain the required level of the worker safety due to several reasons including unawareness of benefits in terms of cost and productivity, lack of relevant rules, regulation and laws and enforcement of such laws by government or independent authority. Safety is further given less priority from client and designer as the primary responsibility of workers safety lies on employer i.e. contactors and normally these organizations (client and designer) save themselves by putting all safety responsibilities on contactors. A report compiled by Behm and Michael (2006) for the Centre to Protect Workers Rights wherein he analyzed 450 reports (post-accident) of construction workers' deaths and disabling injuries and found that in 151 cases (about one-third of those studied), the hazard that contributed to the incident could have been eliminated or reduced if design-for-safety measures had been implemented. Although the contribution of construction industry to economy is similar to the developed countries, however the health and safety measures are comparatively poor. The analysis of one Daily Newspaper (2015) shows that 9 construction workers were died and 25 were injured in Oman. The public Authority of Social Insurance (2014) which registered only Omani nationals' reports shows that 401 cases of work related injuries were disbursed which cost a total amount of 406,000 OMR (US$ 1,051,540). The number of active insures in the Social Insurance System was 197,510 in 2014; if a similar ratio is applied to the total workers working in construction industry of Oman will give the cost involves in construction accident of 1,428,571 OMR (US$ 3,700,000) per year.

3.1 HEALTH AND SAFETY LAW (RULES AND REGULATIONS) IN OMAN

Since the 1970s, Oman has been witnessing steady progress in the political and socio-economic fields. However, the country has had to rely on expatriates to implement its ambitious socio-economic programs of the five year consecutive development plans due to the limited number of qualified Omanis in these areas. The Ministry of Manpower is facilitating the issuance of permits for foreign workers, especially in the sectors that witness shortages in the number of qualified national workers. Expatriates work in different economic sectors; unskilled and semi-skilled expatriates are concentrated in the construction sector, which represents 32.5 per cent of the total expatriates in the private sector, according to the statistical bulletin of 2007. Articles 27, 40, 41, 87, 88, 89, 90, 98 and 99 of the Ministry of Manpower Labor Law stress both the workers and employer to abide the health and safety regulation mentioned in these articles. Oman has further four decrees; Sultanate Decree No. 40/1979: Occupational diseases and accidents compensation law, Ministerial Decree No. 10/1982: OSH regulations, Ministerial Decree No. 19/1988: OSH Act and Ministerial Decree No. 286/2008: Regulation of Occupational Safety and Health.

3.1.1. REGULATION OF OCCUPATIONAL SAFETY AND HEALTH (MINISTERIAL DECREE NO. 286/2008)

Based on the stipulation of the Labour Law, which entitles the Minister of Manpower to issue regulations, occupational safety and health has been regulated under the Ministerial Decision No. 286/2008, namely the Regulation of Occupational Safety and Health for Establishments Governed by the Labour Law. This Regulation is regarded as the framework legislation in OSH at the level of the Sultanate. It supersedes the Occupational Health and Industrial Safety Precautions issued by Ministerial Decision No.19/1982, which address general provisions regarding safety at work and the protection of the health of the workers in private-sector establishments. The Precautions consist of two chapters and fourteen Articles which cover:

- General provisions;
- Dangers of machinery;
- Working conditions (lighting, ventilation, drinking water, eating places, toilet facilities, sleeping quarters, fire);
- Health hazards;
- Safety supervisors for establishments employing 100 or more workers;
- Accidents;
- Construction work;
- Hoisting and hauling machines;
- Mines and quarries

Apart from presence of OHS laws which need to be updated as agreed in the memorandum of understanding between ILO and Oman (2010), there need to be specific rules, regulations relevant and applicable to construction industry and a regulatory authority to review and update and implement those rules and regulations in Oman.

3.2. OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

In recent years, governments, enterprises and international organisations have all been giving greater attention to the need to adopt systematic models for managing OSH. The so-called OSH management systems approach provides a promising strategy for augmenting traditional command and control approaches with performance improvement tools, more effective health and safety auditing concepts, and schemes for management systems.

The need for a global approach to OSH management was recognized as a logical and necessary response to increasing economic globalization, while the benefits of systematic models of managing OSH became apparent as a result of the impact of ISO standards for quality and the environment. Current management science theories suggest that performance is better in all areas of business, including OSH, if it is measured and continuous improvement sought in an organized fashion. Drawing from the principles defined in the ILO Guidelines on occupational safety and health management systems, 2001, Convention

No. 187 applies a similar approach to the management of national OSH systems to ensure they are improved through a continuous cycle of policy review, evaluation and action for improvement. The different steps in the OSH Management Cycle of continuous improvement are illustrated in Figure 1.

Small construction organisations normally don't have awareness of safety and health management systems and its benefits, therefore the possibilities of risk and accidents are more. Many researcher claims that small enterprises have special problems with work environment which lead the organisations towards high risk with a lower ability of controlling the risk (Hasle and Limborg, 2006). In Oman, 6,000 companies which employed a work force of 310,000 are registered as grade one and above are having company, staff ratio of 1:52. These construction organizations are carrying 95% of major construction projects in the country if assumed are having awareness of safety and health management systems and it is applied in their organizations, is not enough to reflect that the whole country workforce safety and health performance. The problem still exists with the 94,000 organisations that are registered as grade two and below and having a workforce size of 389,000, which gives a company, staff ratio of 1:4 only. This is the major challenge to ensure proper safety and health systems in such organisations. The government along with concerned stakeholder needs to develop strategies for implementation of safety and health systems in these small construction organizations to improve safety performance.

Figure 1: Guidance on Occupational Safety and Health Management Systems
Source: ILO-OSH (2001)

4. ENFORCEMENT

The ultimate purpose of the enforcing authorities is to ensure that duty holders manage and control risks effectively, thus preventing harm. The term 'enforcement' has a wide meaning and applies to all dealings between enforcing authorities and those on whom the law places duties (employers, the self-employed, employees and others). The purpose of enforcement is to:

- Ensure that duty holders take action to deal immediately with serious risks;
- Promote and achieve sustained compliance with the law;
- Ensure that duty holders who breach health and safety requirements, and directors or managers who fail in their responsibilities, may be held to account, which may include bringing alleged offenders before the courts in England and Wales, or recommending prosecution in Scotland, in the circumstances set out later in this policy.

The compliance with OHS standards will result in the elimination and reduction, of work-related illness and injury. The UK Health and Safety Commission envisages the purposes of enforcement as ensuring that duty holders deal immediately with serious risks; promoting and achieving ‘sustained compliance with the law’; and ensuring that duty holders who breach statutory provisions are ‘held to account’ through prosecution. Since its establishment in 1970, the U.S. Occupational Safety and Health Administration (OSHA) have been responsible for the enforcement of workplace safety and health standards in the United States. Between 2001 and 2010, OSHA conducted nearly a quarter million (247,997) federal inspections in construction. The proportion of construction establishments inspected by federal OSHA fluctuated, but generally showed a small upward trend. Even so, the proportion of construction companies inspected by OSHA is still low. OSHA has approximately 2,200 inspectors, including state-plan inspectors, for 8 million worksites and 130 million workers in all industries nationwide; this is equivalent to one OSHA inspector for every 3,600 worksites or 59,000 workers. Moreover, the number of construction worksites visited can be much lower than the number of inspections since multiple employers are usually working at one construction worksite. In addition, only 7% of the inspections in construction were health inspections, which is significantly lower than 20% of inspections for all industries. The number of OSHA inspections varied by construction subsector. In 2010, the majority (62%) of inspections occurred among Specialty Trade Contractors while 26% were conducted among General Contractors and 13% in Heavy Construction. Although the number of inspections was small in Heavy Construction, the proportion of establishments inspected in this sector was higher than the other two construction subsectors, considering that establishments in Heavy Construction only accounted for about 5% of the construction establishments with payroll. The health and safety statistic annual report for 2014-15 compiled by HSE (UK) indicates that there were 586 cases were prosecuted by HSE in England and Wales. 70 cases were prosecuted by Local authorities in England and Wales. 72 cases were prosecuted by the Procurator Fiscal in Scotland. 12,430 enforcement notices were issued by all enforcing authorities.

Oman labour law empower the ministry of manpower to ensure the health and safety standards through ministry inspectors and in event of the existence of any danger which threatens the safety and health of the Workers, the Ministry can take necessary measures to close down the place of work wholly or partially, or to stop the operation of one or more machinery until the elimination of the causes of such danger. The ministry can further improve the process of inspections and penalties by benchmarking it system with OSHA (USA) and HSE (UK).

5. RECOMMENDATION FOR IMPROVEMENT OF SAFETY IN CONSTRUCTION IN OMAN

Based on the literature review and fact related to construction industry of Oman, the following recommendations are made.

- Oman need to establish an independent Safety and Health regulatory authority to develop and enforce rules and regulations for improved safety and health for all industrial organizations including construction.
- More research is needed to be conducted to understand the current safety status.
- Construction organizations registration including renewal of registration is need to be linked with the safety and health performance of organization.
- Construction organizations specially small and medium organizations are need to be educated on safety and health benefits.
- Regulatory authorities are required to ensure appropriate safety and health system in all construction organizations.
- Construction workers are needed to be having adequate safety and health training before they are allowed to work in construction organizations.
- Construction organizations are needed to develop programs for assessment their safety and health performance.

- A proper procedure for inspection of safety and health is required to be defined for self-inspections and external inspections by regulatory organization.
- Old rules and regulations for safety and health are needed to be revised and further needed to be review periodically.
- Construction accidents are needed to be properly investigated both by construction organizations itself and externally be safety and health authority to know the root causes of the accidents and to develop strategies to minimize the accidents in future.

Based on the above recommendations, a safety model for construction in Oman is suggested as shown in Figure 2.

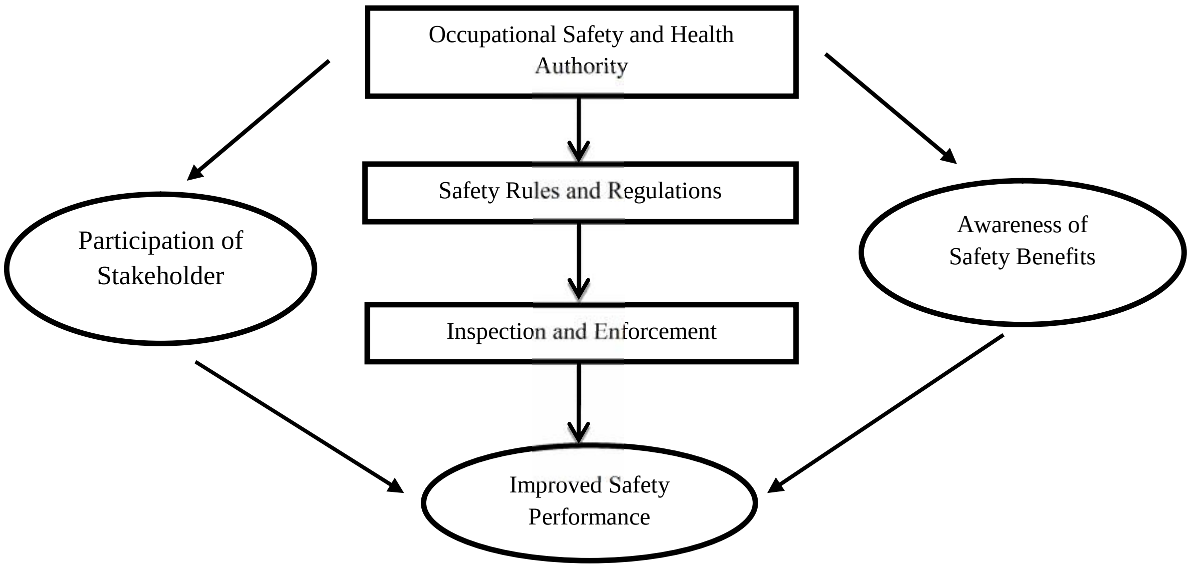

Figure 2: Safety Model for Construction

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A REVIEW OF SAFETY CLIMATE AND RISK-TAKING PROPENSITY IN OCCUPATIONAL HEALTH, SAFETY AND WELL-BEING IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Studies which take safety climate as a safety monitoring tool are rarely reported. This study reports a benchmarking program to identify prominent safety management issues in three ongoing railway projects using a combination of quantitative and qualitative methods. In the quantitative aspect, the research team conducted a safety climate survey with three random samples, one sample from each ongoing project. A robust 11-factor structure of the safety climate questionnaire emerged after factor analysis. Most of the mean scores of safety climate indicators for subcontractors were below 3 (out of 4) and specific indicators were identified as in need of urgent attention.ᴺ The main contractor's direct labour scored similarly with subcontractors. Two main contractor management teams had to do more to take on the leadership role. The major weaknesses were the following indicators: work procedure for safety, safety compliance, safety priority over work pressure, safety cooperation and involvement, and appreciation of risk. In the qualitative aspect, the research team sought respondents' comments on current safety management practice and suggestions as to further improvement in safety performance. Content analysis showed that conflicting safety rules and inadequate training were common in the three projects, and increased supervision was proposed as the way to improve safety performance.

Keywords: *Safety Climate; Risk-taking Propensity; Occupational Health, Safety and Well-being.*

1. SAFETY CLIMATE

Based on a diversity of cues in the workplace, employees develop consistent sets of perceptions and expectations about behaviour-outcome contingencies and act accordingly (Zohar, 1980). These sets of perceptions are organizational climate when they are shared by individual employees. Safety climate is a special case of organizational climate, i.e. the organizational climate for safety. In a safety climate, the workforce is expected to carry out their tasks in a safe manner (Shen *et al*., 2015a). Relevant literature from Zohar (1980); Seo *et al*. (2004); Shen *et al*., (2015b); Choudhry *et al*., (2009); Christian *et al*., (2009); Beus *et al*., (2010); Zhang *et al*., (2015); Cheyne *et al*., (1998) shows that safety climate reflects employees' perceived importance of safe conduct in their occupational behaviour, correlates with safety initiative effectiveness, and serves as a predictor of safety activity and a leading indicator of accidents in the workplace.

More importantly, as safety climate reflects safety management practice in an organization, measuring safety climate can diagnose the organization's temporal "state of safety" at a point in time (Cheyne *et al*., 1998; Huang *et al*., 2013). In this sense, safety climate serves as a safety monitoring tool, which informs management of areas to be improved. However, rarely reported are studies which take safety climate as a safety monitoring tool, with a notable exception of Mearns *et al*. (2001). Through benchmarking nine North Sea oil and gas installations in terms of safety climate at two different points in time, Mearns *et al*. (2001) raised awareness of safety climate issues across participating organizations and prompted poor performers to take efficient improvement measures.

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ᴺ*A score of 2 or less indicates disagreement with a safety climate indicator, such as safe behaviour for example. The eleven indicators and the items comprising them are listed in Appendix 1.*

2. THE PROBLEM

Benchmarking organisations' safety performance with safety climate as a monitoring tool has special implications for the construction sector. At the industry level, the construction sector is plagued with a much higher than all-industry average accident rate across the globe. In order to contain the situation, researchers and practitioners have been continuously proposing safety initiatives from management, organization and technology perspectives. An important way to measure the effectiveness of these safety initiatives is through safety climate survey, which can provide cues for improvement. At the organization level, through comparing different construction projects in terms of safety climate indicators can help the organization make informed decisions regarding development and implementation of safety initiatives. This has special implications for XXX Corporation (XXXC) which oversees multiple projects simultaneously.

A seemingly plateaued project safety performance prompted XXXC management to identify predominant safety management issues in ongoing projects, and hence develop effective and efficient safety improvement initiatives. For this purpose, XXXC worked with a research team led by the first author to carry out a study. Based on prior research experience and relevant literature, the research team decided to use a combination of quantitative and qualitative methods to gather information. The quantitative method was used to measure project participants' perceptions of current safety management practice. The qualitative method was used to seek project participants' comments on current safety management practice and suggestions as to further improvement.

3. METHODS

3.1. SURVEY INSTRUMENT DEVELOPMENT

Although the definition which defines safety climate as "shared perceptions with regard to safety policies, procedures, and practices" by Zohar (2003, p.125) is well accepted, operationalization of the construct is often subject to the context in which it is to be used. In consultation with the XXXC management, the research team decided to devise a safety climate questionnaire to accommodate unique characteristics of XXX projects.

A widely-used method to develop safety climate scales is that, a set of themes are obtained through reviews of the safety literature, and after that interviews and focus groups are conducted to customize the instruments to the sponsoring organization's requirements (Flin *et al.*, 2000). After a review of the construction safety literature of Pousette *et al.* (2008); Zhou *et al.* (2011); Cigularov *et al.* (2010); Choudhry *et al*. (2009); Glendon and Litherland (2001); Molenaar *et al*. (2009) and consultation with the XXXC management, the research team proposes a consistent profile of a perceived pro-safety workplace. In this perceived pro-safety workplace,

a) the project personnel are competent to deal with risks through training and education;
b) the project personnel are conscious of what is going on in a timely manner through a flow of information;
c) the project personnel's colleagues are safety-conscious and hence provide a supportive environment for inducing and sustaining the project personnel's safe conduct;
d) the project personnel's supervisors take safety seriously and never turn a blind eye to employees breaking safety procedures;
e) the project personnel are sensitive to work pressure and would prioritize safety over production pressure;
f) the project personnel are sensitive to and would act against those work procedures which contradict safety requirements;
g) the project personnel are compliant with safety rules;
h) the project personnel can sense the effectiveness of safety measures;

i) the project personnel are cooperative and involved in safety management;

j) the project personnel are able to appreciate risks in their work;

k) the project personnel are willing to behave in a safe manner, instead of taking risks.

Three to four questions to reflect each aspect of the perceived pro-safety workplace were adapted from similar studies, including Lingard *et al*. (2010a); Lingard *et al*. (2010b); Mearns *et al*. (2003). In total, 40 items were incorporated into the questionnaire. These items were short statements, soliciting respondents' agreement with them on a 4-point scale (1 = "strongly disagree", 2 = "disagree", 3 = "agree", and 4 = "strongly agree"). Some items were negatively worded, whereas the others positively worded. The psychological measurement literature suggests that in completing a questionnaire, respondents exhibit two tendencies (Barnette, 2000). One tendency is for respondents to generally agree with survey statements more than disagree. The other tendency is that respondents provide responses in a manner that is related more to their general feelings about the subject, instead of the specific content of the item. These negatively worded items were used to guard against these tendencies.

There were three sections in the questionnaire. The first section was to gather respondents' demographical information. The second part was a safety climate scale to measure respondents' safety climate perceptions. The last part using open-ended questions was to seek respondents' comments and suggestions. After pilot study, with the finalized questionnaire the research team conducted three random sample surveys on three separate ongoing projects.

3.2. SAMPLE

With assistance of the main contractors, the research team secured 336, 157 and 414 valid responses respectively from three projects. Among the respondents were both management and frontline staff.

3.3. DATA ANALYSIS

With the safety climate scale, the research team carried out exploratory factor analysis (EFA), and found a rather robust 11-factor structure. With the 11 indicators the research team made comparisons between projects and organizations involved in each project using ANOVA and *t*-test procedures. The questionnaire also elicited respondents' comments on current safety management approach and suggestions for further safety improvement. Conventional content analysis procedures of Hsieh and Shannon (2005) were used to analyse the comments and suggestions, and find out common issues across projects and peculiar issues specific to each project. The next section is to present the results in sequence.

4. RESULTS

4.1. THE EMERGENT 11 INDICATORS OF THE SAFETY CLIMATE SCALE

EFA was conducted with the aggregate sample, and 11 factors (indicators or dimensions) emerged, including competence, communication, safety supportive environment, pro-safety supervisory leadership, safety priority over work pressure, work procedure for safety, safety compliance, safety effectiveness, safety cooperation and involvement, appreciation of risk, and safe behaviour. They were in accordance with the 11 features of the perceived pro-safety workplace as mentioned earlier.

The indicator of competence refers to respondents' feeling that they are competent to deal with risks through training and education. The indicator of communication refers to the phenomenon that respondents are informed of what is going on in a timely manner through the free flow of information. The indicator of safety supportive environment refers to respondents' feeling that their colleagues are safety-conscious and hence provides a supportive environment for inducing and sustaining project personnel's safe conduct. The indicator of pro-safety supervisory leadership refers to respondents' feeling that their supervisors take safety seriously and never turn a blind eye to employees breaking safety procedures. The indicator of safety priority overwork pressure refers to the phenomenon that respondents are sensitive to work pressure and would prioritize safety over production pressure. The indicator of work procedure for safety refers to the phenomenon that respondents are sensitive to and would act against those work procedures which contradict safety requirements. The indicator of safety compliance refers to the phenomenon that respondents are can recognize and follow safety rules and procedures as proper. The indicator of safety effectiveness refers to respondents' realization that safety measures are effective in bringing down unsafe behaviours. The indicator of safety cooperation and involvement refers to the phenomenon that respondents are cooperative and involved in safety management practice. The indicator of appreciation of risk refers to respondents' acknowledgement that they have to do some jobs with taking risks. The indicator of safe behaviour refers to respondents' feeling that they would behave in a safe manner, instead of taking risks. The 11 indicators and related measurement items are shown in Appendix 1.

4.2. RATING OF ORGANISATIONS IN TERMS OF SAFETY CLIMATE INDICATORS

The research team compared the main contractor and subcontractors in terms of the 11 safety climate indicators. Table 1 shows the results and mismatches among project personnel's views on safety management practices on site. Specifically, the main contractor management scored significantly higher than the main contractor's direct labour in terms of five indicators (i.e. competence, communication, safety effectiveness, safety cooperation and involvement, and appreciation of risk). This suggests that across the three surveyed projects, the main contractors' frontline staff felt less competent to deal with safety issues, and were less likely to feel the effectiveness of safety initiatives. To the main contractors' frontline staff, there is insufficient communication about safety matters, their involvement in safety management is limited, and they are not confident that they can recognise and identify hazards as proper. The main contractor, including management and direct labour, scored significantly higher than subcontractors in terms of five indicators (i.e. competence, safety supportive environment, safety priority over work pressure, safety effectiveness, and appreciation of risk). This suggests that future interventions to upgrade subcontractors' safety performance should focus on strengthening their self-efficacy in dealing with safety issues, instituting a buddy system at the work crew level, reducing progress pressure, building up their capacity to identify risks. Through these measures they are more likely to feel the effectiveness of safety initiatives.

Table 1: Comparison between the Main Contractor and Subcontractors based on the Mean Values of Safety Climate Indicators

Indicators	Main contractor (management)	Main contractor (workers)	Main contractor (management + worker)	Subcontractors
Competence	3.3	3.1	3.2	3.1
Communication	3.1	2.9	3.0	2.9
Safety supportive environment	3.4	3.2	3.3	3.1
Pro-safety supervisory leadership	3.0	2.9	3.0	2.9
Safety priority over work pressure	3.0	2.9	2.9	2.8
Work procedure for safety	2.8	2.9	2.9	2.8
Safety compliance	2.9	2.8	2.9	2.8
Safety effectiveness	3.0	2.8	3.0	2.8
Safety cooperation and involvement	3.0	2.9	2.9	2.9
Appreciation of risk	2.8	2.6	2.7	2.6
Safe behaviour	3.1	3.0	3.1	3.0
Average	*3.0*	*2.9*	*3.0*	*2.9*
Sample size (n)	*171*	*117*	*288*	*631*

Note: Indicators were measured on a 4-point Likert scale (1 = "strongly disagree", 2 = "disagree", 3 = "agree", and 4 = "strongly agree").

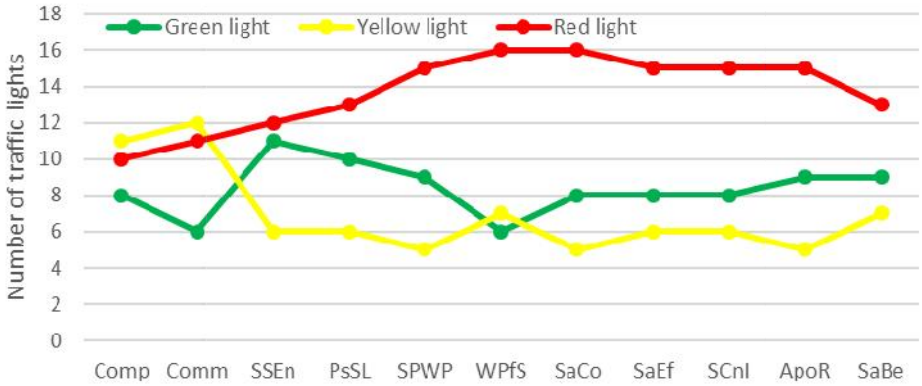
In order for XXXC to grasp the difference in perceptions of safety management practice between organisations, the research team rated organisations in terms of each of the 11 emergent safety climate indicators. Specifically, the top 30% organisations on each indicator were labelled as "can improve", and accordingly assigned green traffic lights. The next 20% organisations were classified as “need to improve”, and assigned yellow traffic lights. The remaining 50% organisations were labelled as “urgent improvement needed”, and assigned red traffic lights. Table 2 shows the ratings of organizations on Project YYYY against other organizations in other projects.

In general, most organisations were at a similar performance level in terms of two indicators (i.e. competence and communication), and their scores were around three. However, in terms of other two indicators (i.e. safety supportive environment and pro-safety supervisory leadership) there was a clear divisive line between good and poor performers. In other words, these two indicators are more capable of differentiating good and poor performers than other indicators. This also suggests that pro-safety supervisory leadership and safety supportive environment are key weaknesses of the poor performers, consonant with findings in other studies in Hong Kong and Australia where the role of the supervisor was found to be crucial in promoting safe behaviour (Lingard *et al*., 2009; Choudhry *et al*., 2008). In terms of the indicator of work procedure for safety, more organisations were labelled as “need to improve” than those labelled as “can improve”, which is contradictory to the expected outcome. This suggests that most organisations gave it a lower rating, i.e. most organisations would follow work procedures even though these work procedures contradict safety requirements. The trend can be seen in Figure 1, which features the number of traffic lights across safety climate indicators.

Table 2: Rating of Organisations on Project YYYY against Other Organisations

	Indicators	Sub5	Sub1	Sub8	Sub4	Sub9	Maincontr managemt	Sub2	Sub6	Maincontr labour	Sub3	Sub7
Safety values	Competence	🟢	🟡	🔴	🔴	🔴	🟡	🟡	🔴	🔴	🔴	🔴
	Communication	🔴	🔴	🔴	🔴	🟡	🟡	🟢	🔴	🔴	🔴	🔴
Safety priority	Safety supportive environment	🔴	🟢	🔴	🔴	🟡	🟢	🟡	🔴	🔴	🔴	🔴
	Pro-safety supervisory leadership	🟢	🟢	🟢	🔴	🟢	🟡	🔴	🔴	🟡	🔴	🔴
	Safety priority over work pressure	🟢	🟡	🟢	🟢	🔴	🟢	🔴	🔴	🟡	🔴	🔴
Procedures	Work procedure for safety	🟢	🟢	🟢	🟢	🟡	🔴	🔴	🔴	🟡	🔴	🔴
	Safety compliance	🟢	🟢	🟢	🟢	🔴	🔴	🔴	🟡	🔴	🔴	🔴
Engagement	Safety effectiveness	🟢	🟢	🟡	🟡	🔴	🟡	🔴	🔴	🔴	🔴	🔴
	Safety cooperation and involvement	🟢	🟡	🔴	🟢	🟢	🟡	🔴	🔴	🔴	🔴	🔴
Risk-taking	Appreciation of risk	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🔴	🟡	🔴	🔴
	Safe behaviour	🟡	🟡	🟢	🟡	🟢	🟢	🔴	🟢	🟡	🔴	🔴
	Sample size (n)	9	7	8	13	8	69	25	7	53	20	7

Note: 🔴 Urgent improvement needed; 🟡 Need to improve; 🟢 Can improve.



Comp: Competence; Comm: Communication;
SSEn: Safety supportive environment; PsSL: Pro-safety supervisory leadership;
SPWP: Safety priority over work pressure; WPfS: Work procedure for safety;
SaCo: Safety compliance; SaEf: Safety effectiveness;
SCnI: Safety cooperation & involvement; ApoR: Appreciation of risk;
SaBe: Safety behaviour

Figure 1: Number of Traffic Lights across Safety Climate Indicators

5. RESPONDENTS' COMMENTS ON CURRENT SAFETY MANAGEMENT APPROACH

Respondents were asked for comments on current safety management approaches on XXXC construction projects. 14 categories emerged across conventional content analysis of comments from the aggregate sample, and they were *rules, training, pace of work, engagement, blame culture, supervision, leadership, resources, tight programme, bureaucracy, safety priority, communication, incentive and penalty schemes,* and *practicability of safety interventions*. Table 3 shows the convergence and divergence in respondents' comments on safety management approach on their sites, based on the emergent categories.

Table 3: Respondents' Comments on the Current Safety Management Approach

Projects	**YYYY**	**VVVV**	**WWWW**
Convergence	Rules Training	Rules Training	Rules Training
Divergence	Pace of work Engagement Blame culture Supervision Leadership	Resources	Tight programme Engagement Bureaucracy Safety priority Communication Incentive and penalty scheme Practicability of safety interventions

Across the three projects, project personnel were complaining about inconsistent rule enforcement regarding safety policies. For example, respondents in YYYY reported that at least two safety standards are in operation, i.e. XXXC's safety standard and the main contractors' safety standards. The clash between these two standards and associated work practices often frustrated frontline staff. Besides, respondents were of the opinion that more safety trainings can improve safety performance.

Unlike respondents in other two projects, those respondents in Project VVVV expected allocating more resources to safety management, from PPE to monetary incentives. Respondents from Project YYYY and WWWW attributed poor safety performance to tight programme and limited engagement in safety management practice. Respondents in Project YYYY reported that there is a blame culture in accident investigations, and a lack of frontline supervisory leadership and supervision. Respondents from Project WWWW complained that safety management practice has been bureaucratized, safety is often sacrificed in case of tight programme, and there should be a communication channel between management and frontline workers. Impressively, they reminded management that only those interventions which meet the needs from the bottom can be effective.

6. Respondents' Suggestions for Safety Performance Improvement

Respondents' suggestions as to how safety performance could be improved were noted. 14 categories emerged from conventional content analysis of suggestions regarding safety performance improvement from respondents, and they were *supervision, rules, training, engagement, leadership, pace of work, resources, management commitment, communication, human resource management, incentive and penalty schemes, tight programme, safety priority,* and *near miss reporting*. Table 4 shows the convergence and divergence in respondents' suggestions with regard to improving safety performance.

Table 4: Respondents' Comments on the Current Safety Management Approach

Projects	**YYYY**	**VVVV**	**WWWW**
Convergence	Supervision	Supervision	Supervision
Divergence	Rules	Rules	Tight programme
	Training	Training	Resources
	Engagement	Engagement	Communication
	Leadership	Management commitment	Human resource management
	Pace of work	Communication	Incentive and penalty scheme
	Resources	Human resource management	Safety priority
		Incentive and penalty scheme	Near miss reporting

Respondents in all the three projects suggested that more supervision should be strengthened if safety performance is to improve.

Unlike respondents from other two projects, respondents in Project WWWW noted the importance of near miss reporting in safety performance improvement. Respondents in both Project YYYY and VVVV regarded consistent rule enforcement and increased worker engagement as the key to further improving safety performance. Unlike respondents in Project VVVV who were anticipating more commitment from the main contractor's top management, respondents in Project YYYY expected to strengthen supervisory safety leadership. Progress pressure and resources, PPE in particular, were mentioned by respondents from both Project YYYY and WWWW as primary hurdles to safety performance improvement. Respondents from both Project VVVV and WWWW suggested increased communication about safety matters, more incentives, and employment of experienced project personnel.

7. Conclusion

Safety climate refers to employees' shared perceptions of safety policies, procedures and practices. It reflects the value of safety in organizations' daily operations and organizations' temporal "state of safety". From this perspective, it serves as a safety monitoring tool. Through safety climate survey, an organization can detect areas to be improved. If the safety climate survey is carried out across comparable organizations, the results can help their superior organization formulate organization-specific effective and efficient safety initiatives. This has special practical implications for clients overseeing multiple projects simultaneously in the construction sector, which is notorious for poor safety performance.

This study reports a benchmarking program to identify prominent safety management issues in ongoing XXXC projects using a combination of quantitative and qualitative methods. In the quantitative aspect, the research team conducted a safety climate survey with three random samples, one sample from each ongoing project. A robust 11-factor structure of the safety climate questionnaire emerged after factor analysis. Most of the mean scores of safety climate indicators for subcontractors was below 3 (out of 4) and specific indicators were identified as in need of urgent attention. The main contractor's direct labour scored similarly with subcontractors. Two main contractor management teams had to do more to take on a leadership role. The major weaknesses were the following indicators: *work procedure for safety, safety compliance, safety priority over work pressure, safety cooperation and involvement,* and *appreciation of risk*. In the qualitative aspect, the research team sought respondents' comments on current safety management practice and suggestions as to further improvement in safety performance. Content analysis showed that conflicting safety rules and inadequate training were common in the three projects, and increased supervision was proposed as the way to improve safety performance.

The limitation is that, this study used a cross-sectional design. It was unable to reveal changes in safety climate indicators before and after a project implement safety initiative, although it could show weaknesses of one project against others. Furthermore, objective accident data at both the project and organization levels had not been collected, which makes it impossible to link subjective safety climate perceptions to objective accident rate.

Despite the limitations, this study makes contribution in using safety climate as a monitoring tool, which helps clients formulate project and organization specific safety improvement measures across ongoing multiple projects.

8. ACKNOWLEDGEMENT

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Appendix 1: Indicators of the Safety Climate Scale

	Indicators	Items
Safety values	Competence	I am clear about what my responsibilities are for health and safety.
		The induction training I have received at the Project covers all the health and safety risks associated with the work for which l am responsible.
		I fully understand the health and safety risks associated with the work for which I am responsible.
	Communication	I am satisfied with the way I am kept informed about what takes place on the Project.
		Workers at the Project site are consulted about safe work methods.
		Workers are told when changes are made to the working environment on a job site.
		Main contractor management provides safety training when employees change their work tasks.
Safety priority	Safety supportive environment	Safety comes from worker co-operation.
	Pro-safety supervisory leadership	As long as there is no accident, the supervisor doesn’t care how the work is done.
		The supervisor only keeps track of major safety problems and overlooks routine problems.
		As long as work remains on schedule, the supervisor doesn’t care how this has been achieved.
	Safety priority over work pressure	There is sometimes pressure to put production before safety at the Project by main contractor.
		Under pressure I need to ignore normal safety requirements at the Project for the sake of getting the work done.
Procedures	Work procedure for safety	Around here, there are lots of safety procedures that don’t really apply to the particular areas or circumstances in which they are supposed to be used.
		There are so many procedures that interfere with doing a job safely.
	Safety compliance	On this Project, people are often uncertain about what the safety procedures are for the work they do.
		Safety procedures tend to be too vague and general to apply in specific situations.
Engagement	Safety effectiveness	Our daily routines don't show that safety is an important value.
	Safety cooperation and involvement	I am not given enough time to get the job done safely on the Project.
		At the Project main contractor management officially encourages open communication, but in reality most people know not to speak up and 'rock the boat'.
		Some employees may hesitate to speak up about safety concerns for fear of retaliation.
Risk-taking	Appreciation of risk	Some jobs here are difficult to do safely.
	Safe behaviour	Sometimes it is necessary to take risks to get the job done.
		If I didn’t take risks, the job wouldn’t get done.

A STUDY OF DELAYS IN PROCUREMENT OF ENGINEERED EQUIPMENT FOR ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) PROJECTS IN INDIA: A MIXED METHOD RESEARCH APPROACH

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ABSTRACT

The supply chain of the EPC industry operates predominantly in an engineered to order manner. Most of the equipment procured are specially made for the project as per the technical specifications laid in the contract. Due to this the lead time of these equipment are generally higher than products that are 'out of the shelf'. Any delay in procurement of these equipment can have a cascading effect on the overall construction schedule. There is limited literature available on the procurement in the EPC industry. This paper thus presents a comprehensive review of the existing systems and practices for procurement of engineered equipment in EPC projects in India. The practices are analysed separating them into two segments, i.e. pre-order and post order procurement cycles. An exploratory sequential mixed method of research has been adopted for the purpose by taking inputs from Subject Matter Experts from different industries in the EPC sector. These inputs were in the form of semi structured interviews, which were analysed using the qualitative data analysis package NVIVO 10. A triangulation methodology has been attempted to validate the qualitative data collected. Finally a framework for improving the most significant of the delays in these projects has been presented.

Keywords: *Procurement; EPC; Engineered Equipment; Mixed Method; Delays.*

1. INTRODUCTION

EPC is an acronym for Engineering, Procurement and Construction. It is a form of contract agreement in the construction industry. The engineering and construction contractor is usually responsible for the detailed engineering design of the project, procurement of materials and equipment and construction of the facility for the end customer (EPC Engineer, 2016). The scope of work in an EPC project varies under different project settings. In some complex engineering projects, the scope of design is distributed between the client and the EPC contractor. Construction of certain critical components may also be in the scope of the client.

EPC projects are one of the most challenging construction models. This paper deals with the problems associated with the procurement of engineered equipment for large EPC projects in India. The main procurement and logistics activities in any construction industry include sourcing, purchasing, contracting and on site materials management. The supply chain of the EPC industry operates predominantly in an engineered to order manner (Cagno and Micheli, 2011). That is to say most of the equipment to be procured by the EPC contractor are not readily available with suppliers. They are specially made for the project abiding to technical requirements as laid in the contract. Due to this the lead time of these equipment are generally higher than products that are 'out of the shelf'. Procurement of these equipment is significantly different from bulk material procurement (Yeo and Ning, 2006). During the procurement cycle there is enormous flow of information between stakeholders. Also, most of the large engineering and construction firms have very elaborate processes laid for placing orders to suppliers. All this makes the process of procurement more complex than the traditional material procurement existing in the construction industry. Thus the objective of this study is to understand the existing systems and practices for procurement of engineered equipment in EPC projects in India and to analyse the various attributes causing delay in the process.

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2. BACKGROUND

Procurement is defined as the acquisition of goods, services, or construction, from a third party at the best possible price, in an appropriate quantity, at the right time and place. There is less clarity of procurement as a process in the construction industry (Ruparathna and Hewage, 2013). The scope of procurement is not only limited to the purchase of equipment/material but also to source any resource (like manpower) utilized in the project. An EPC project is a type of contract agreement made up of a large number of interconnected subsystems consuming considerable human effort (Yeo and Ning, 2002). There is limited literature available on the procurement in the EPC industry (Azambuja, 2014). Most of the available literature focuses on bulk material procurement, i.e. mandatory construction materials like cement, sand, concrete, etc., common to all construction projects (Yeo and Ning, 2006). EPC procurement is an extreme case of engineered to order environment operating under a high degree of complexity and value (Micheli *et al.*, 2009). Engineered to order materials have more complex requirements which influence their design and construction (Neuman, 2015). The same authors echo the concern that a majority of owners and their representatives accept the cheapest price as the most economical long term solution. Project material cost represents a high proportion of the total cost of EPC projects (Cagno and Micheli, 2011). This highlights the need for timely completion of procurement within cost.

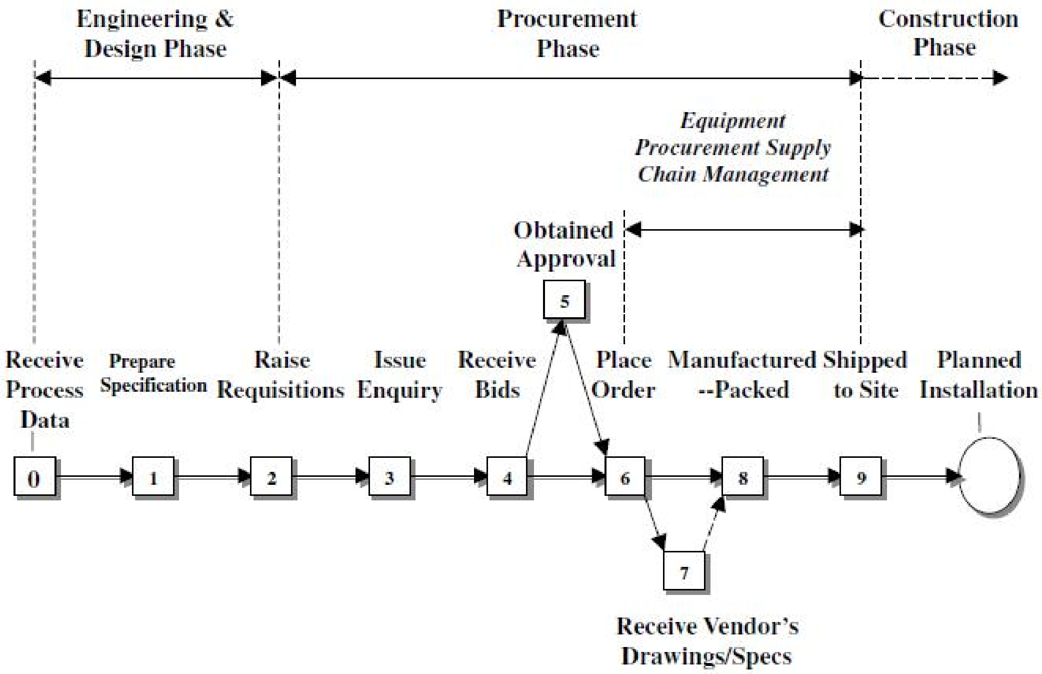

Figure 1: Procurement Process in an EPC Project
Source: Yeo and Ning (2006)

3. METHODOLOGY

Due to lack of available literature specific to EPC procurement in India, an exploratory sequential mixed methods approach has been adopted (Creswell, 2014). The purpose of qualitative study is to get a better understanding of the procurement process and to identify the bottlenecks in the execution. Quantitative analysis has been used to quantify findings from the qualitative study and to identify the most significant of the issues causing delay to the process.

To understand the procurement of engineered equipment for EPC projects in India a case study approach was adopted. Two large EPC projects from an engineering and construction major in India had been taken for the study. Procurement manuals and opinions of subject matter experts were sources of input for understanding the process.

To get a detailed understanding of the process and issues, subject matter experts were interviewed. These experts had vast experience in the field of EPC and procurement. A total of seventeen respondents comprising of directors, general managers, buyers, original equipment manufacturers were interviewed. The interviews lasted about half an hour to one hour depending on the extent to which the participants shared their experiences about the various questions put forward to them. The interviewees shared their opinion to a semi structured set of questions asked to them. The attributes causing delay were obtained after transcribing and analysing the interviews using the NVIVO 10 software. These attributes were attempted to be validated using a triangulation method. A purchase order[1] (PO) instrument was utilized for this purpose. A purchase order instrument is a questionnaire that is specific to a purchase order (of a company) and aims to track and validate the factors from the interviews with the purchase order data. These are filled by the respective buyers (procurement personnel) associated with the order. Finally a framework for improvements has been suggested.

4. CASE STUDY

Two large power projects (EPC) were studied to comprehend the process of procurement of engineered equipment. This helped understand the pre-order and the post-order procurement cycles involved in this process. The inputs for the case study were the procurement manuals and interviews with subject matter experts conducted in that organization.

4.1. PRE-ORDER PROCUREMENT CYCLE

Pre-order procurement cycle begins in a project with a ‘Shopping list’. These are the items that need to be procured under the scope of work of the project. Once the list is available, a procurement plan is prepared in synchronization with the project execution plan and the milestone completion dates. These procurement plans are prepared keeping in mind the criticality of the equipment and the lead time for manufacturing. Once this is done the ‘Request for Quote’s’ are prepared by the design team and floated by the buyers to the respective approved suppliers. The client or the contractor himself has a list of approved suppliers from whom these items are to be procured. These suppliers are shortlisted on the basis of their manufacturing capabilities and their past performance. The list of these suppliers may be provided by the client as a part of the contract or the EPC contractor has his own list of suppliers.

Once the RFQ’s are floated a two stage sealed bidding process (technical followed by commercial) is followed. All the approved suppliers are first evaluated on the basis of the technical offers submitted by them. Any queries or comments are clarified to all the bidders and a technical compliance sheet is prepared. This sheet will have the compliance status of all the bidders. Once this is completed the commercial offers of the qualified suppliers are only evaluated. Contractual terms, payment terms and delivery schedules are discussed with the qualified bidders. Commercial negotiations are done with the suppliers if need be. After this process the lowest price bidder (L-1) is finalized and approvals are taken. Finally a ‘Letter of Intent’ is issued to the L-1 bidder followed by a computerized purchase order. The flow of activities may vary slightly across firms, but the overall framework for operation more/less remains the same. The flow of activities is very similar to that shown in Figure 1 (steps 1-6). A schematic diagram of the pre-order procurement cycle as understood in this study is represented in Figure 2.

[1] *A purchase order is a document that is issued to the supplier for the scope of work to be completed by him under the order.*

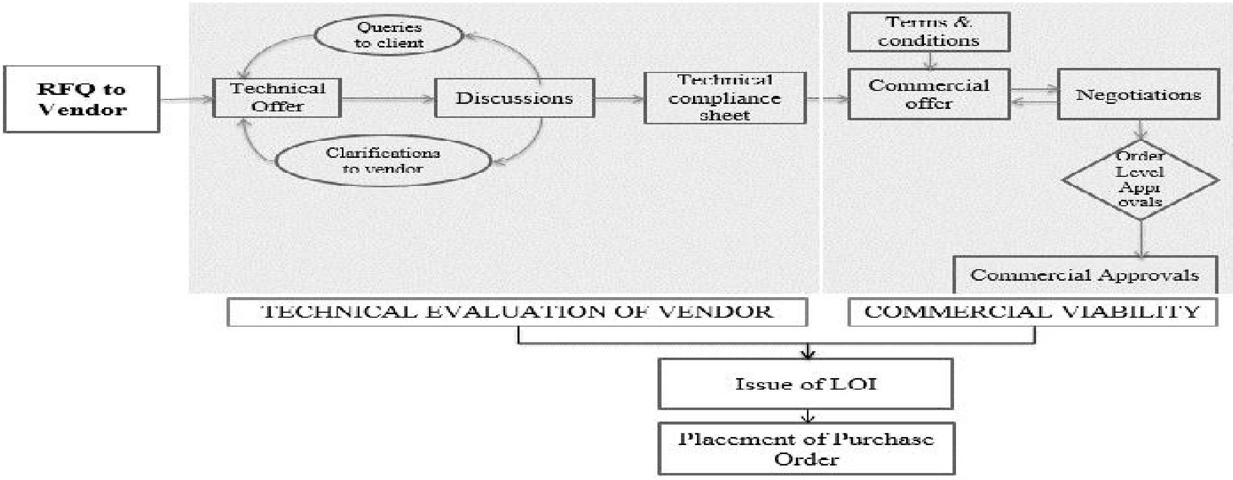

Figure 2: Pre Order Procurement Cycle

4.2. *Post Order Cycle*

Once the order is issued to the supplier a kick off meeting is held in the presence of the contractor and the client (refer to Figure 3). The major deliverables, schedule of work are discussed and documented in this meeting. A project specific expediting team consisting of engineers, procurement personnel and quality assurance engineers from the contractor/PMC side are made responsible for these item(s). This team is usually specific to a project. Detailed engineering and post order documentation as per the scope of work of the supplier is carried stage by stage. After the entire process is completed the manufacturer is given the clearance for manufacturing. Depending upon the quality assurance plan, stage inspections are carried out. Finally the supplier completes the manufacturing and the material is inspected before it is dispatched to project site. Logistics may or may not be in the scope of the supplier.

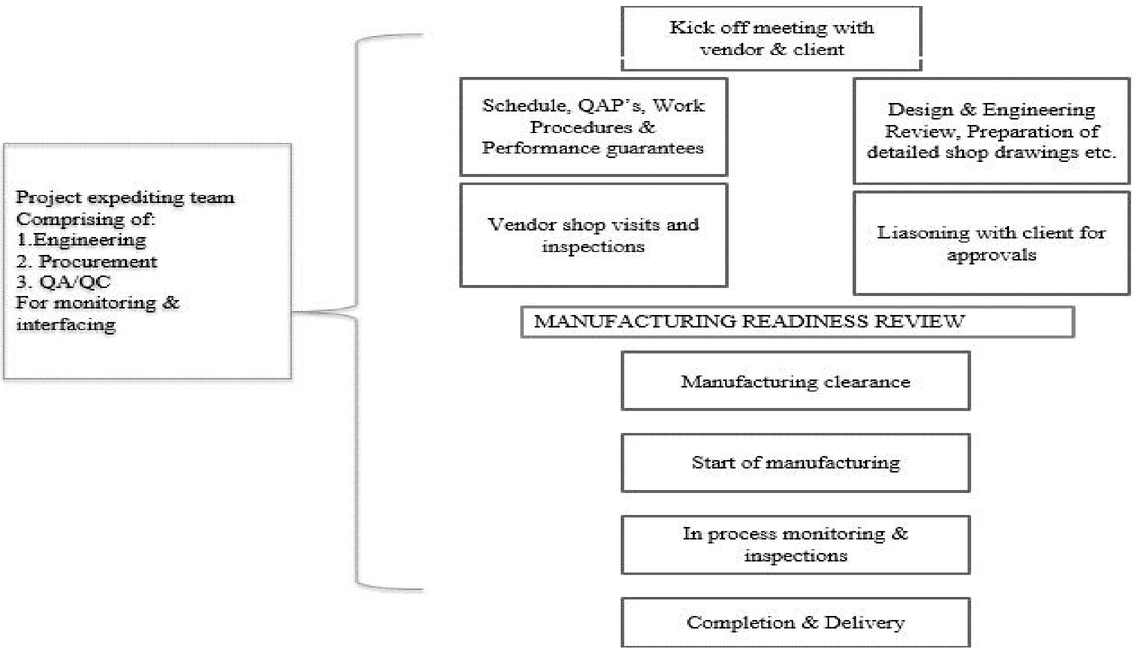

Figure 3: Post Order Procurement Cycle

This case study helped understand the elaborate process of procurement and the various stakeholders involved in the process. It also helped apprehend the issues put forward by the respondents in their interviews.

4.3. DELAY DEFINITION

Currently, there is no standard definition of delay in the pre order procurement cycle. For the post order period this study has considered as any excess time taken from the specified purchase order duration as delay in this stage.

5. QUALITATIVE DATA ANALYSIS

A total of seventeen interviews were conducted to understand the issues relating to the procurement of engineering equipment for EPC projects. The respondents were primarily from petrochemical, oil and gas, nuclear and electrical EPC projects. The interviews were analysed using the qualitative data analysis package NVivo 10 (QSR International, 2016). This software package was used to transcribe the interviews and to find patterns from the transcribed data. Standard reports available on the software were used for reporting the data. The data obtained after coding the transcripts is shown in Table 1. 'Count' represents the number of times an issue pertaining to that category has been highlighted. 'Number of issues' are the total issues highlighted under that category. A word frequency search in the transcribed interviews is shown in Figure 4. The word 'vendors' was used the most number of times by all the respondents. The issues in Table 1 were categorized on the basis of their nature and on the experience of the authors of this paper.

Table 1: Nature of Issues

Nature of Issue	Count	Number of Issues	Significance
Procurement Planning	21	13	24.1%
Information Management	19	9	21.8%
Procedural Hindrances	11	5	12.6%
Supplier Related Issues	8	5	9.2%
Contractor-Organizational Issues	7	3	8.0%
Technical Issues	6	1	6.9%
Working Capital / Payment Issues	5	2	5.7%
Client Related Issues	4	3	4.6%
Contractual / Order Issues	3	3	3.4%
Others	3	3	3.4%

Figure 4: 'Key Word' Search from Nvivo 10

5.1. FINDINGS FROM STUDY

The key issues causing delay from the qualitative data collected are discussed below:

Procurement planning - This was seen as the most significant type of issue. Issues such as unrealistic project completion dates, lack of a defined procurement lifecycle time, lack of engagement of suppliers in the initial stages of procurement, lack of accurate in-house cost estimates, lack of a project procurement plan and improper supplier pre-qualifications were highlighted here. Ideally planning forms the backbone of any process and it is evident that this supply chain faces problems in it.

Information management - Due to the involvement of a large number of stakeholders, the quantum of information shared and processed in the supply chain is very large. In this scenario the respondents agreed that there were delays in receiving, sharing information and document approvals.

Procedural hindrances - Most of the respondents were from very large EPC firms and had a very well laid work flow for the activities. As highlighted by a few respondents this proved to be a hindrance as well. Some of the government contractors for example felt stringent purchase procedures time consuming leading to delay. Allocation of some minimum orders to MSME (Micro, Small and Medium Enterprises) suppliers was also seen a hindrance. Another significant delay was observed in getting new suppliers qualified.

Supplier related issues - Delay in initiation of the contract post the award of the order, non-compliance at crucial stages and lack of control over the sub-vendors were some of the issues leading to delays in the procurement process.

Contractor/Organisational issues - Indecisiveness and incompetency can lead to delays in the procurement process. Delay in taking decisions, lack of applied oriented qualified engineers and lack of role clarity were the main issues highlighted by the respondents

Technical issues - Unclear and ambiguous specifications was the only issue that was repeatedly highlighted by most respondents. Lack of clarity in the specifications, often leads to delays both during the pre-order as well as the post-order stage of the purchase order

Working Capital/Payment issues - Delay in payments to the suppliers and delay in payments by the clients leads to significant delay in the supply chain. Once the supplier is not paid, he will not have the necessary funds to pay his sub-vendors and the effect cascades throughout.

Client related issues - Lack of cooperation of the client to inspection calls and inadequate staff to provide approvals in time were some of the main issues highlighted.

Others - Lack of proper raw materials, lack of certain testing companies are some of the issues grouped under this category.

6. DATA VALIDATION

A triangulation approach has been attempted to validate the findings from the qualitative data collected. A purchase order instrument has been used for this purpose.

6.1. PURCHASE ORDER INSTRUMENT

This is a questionnaire specific to a purchase order completed by the respective buyers (procurement specialists) associated with the order. This instrument aimed at checking the impact and significance of the issues from the qualitative survey against purchase order. A total of six purchase orders were taken and the respective buyers were asked to complete the purchase order instrument. The purchase orders were of mechanical, electrical and instrumentation equipment taken from a large EPC firm. The buyers were initially asked to indicate whether the issues (from qualitative analysis) led to delays in a particular purchase order and if so the impact of those issues on the order. These impact scores were added to identify the most significant issues.

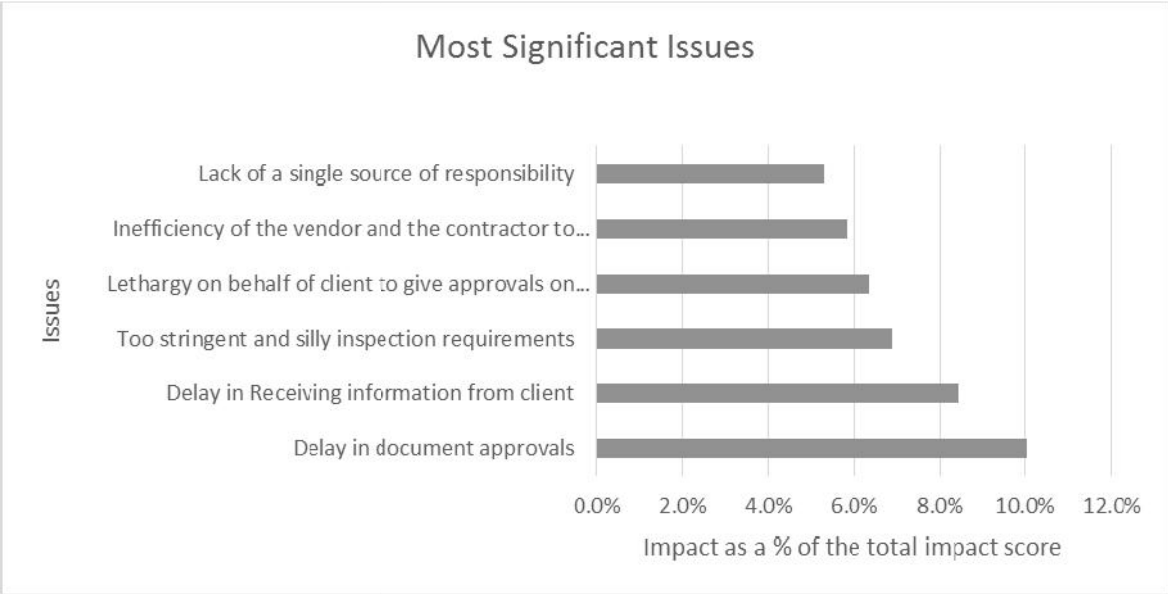

Figure 5: Significant Issues from Purchase Order Instrument

Delay in getting documents approved and delay in receiving information from the client were indicated to be the top two significant issues that buyers faced in purchase orders (refer to Figure 5). Almost all the buyers had given an impact rating of 5 (maximum) to 'Delay in getting documents approved' which highlights the importance the process of document approval plays in a purchase order.

6.2. Challenges Faced

The lack of actual documented delay data had proved to be a hindrance in validating the findings from the qualitative data obtained in this study. In most EPC firms, the buyer is responsible for the equipment from start to the end. Due to this the opinion of the buyer was taken into consideration. But because the opinion of the buyer was only taken the element of bias in the output could not be eliminated. Due to this the results from the PO instrument were not sufficient to validate the findings from the qualitative study. But this has opened up the need for new and innovative means of validating qualitative data where the actual documented delay data is not present.

7. Mitigation Measures

Four areas for improvements have been suggested to improve the most significant of the issues:

7.1. Procurement Planning and Monitoring

Partnerships

Tie-ups and partnerships with equipment and material suppliers can help address the starting hiccups and reduce the procurement the lifecycle time. These suppliers are to enter into an agreement with EPC contractors for the supply of specialized equipment for their projects. This will help save time for detailed engineering as the supplier will be conversant and may not have to tweak the design completely. Due to the nature of this collaboration, the supplier should be in a position to address any fluctuations in demand. Activities like background checks and commercial negotiations can be avoided which significantly reduce the process time. This model will be successful provided the EPC contractor has enough projects in the pipeline.

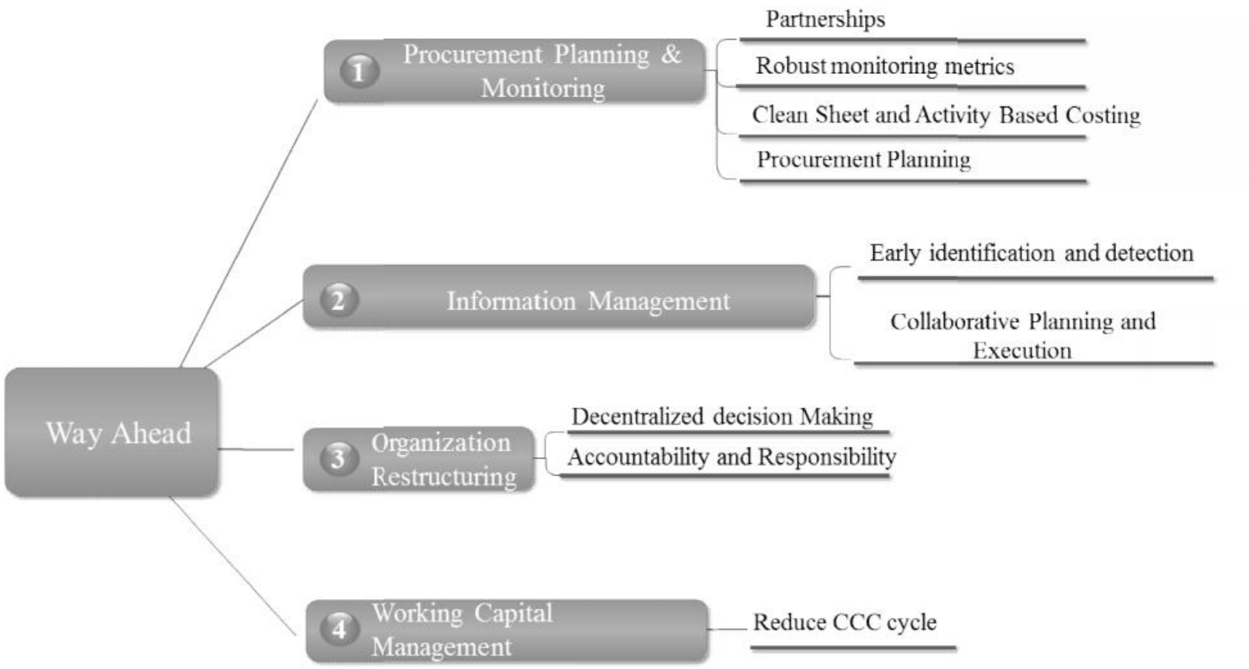

Figure 6: Mitigation Measures

Robust Monitoring Metrics

One of the initial findings of the study were the absence of any robust procurement monitoring metrics in the EPC industry in India. The practice was to follow the purchase order dates as a guideline for measuring delays in the lifecycle. New project specific metrics such as the productivity of the design team (time taken to given technical compliance), productivity of the procurement team (time taken to place an order) etc., depending on the complexity need to be framed.

Activity based Costing

A method of capturing the total cost of a product by including the overhead costs (on the basis of the amount of resource consumed) is used in manufacturing (Accounting Coach, 2016). Such a decision support is required in the procurement process to capture the overhead costs associated with every equipment procured. It will help bifurcate the products which require more time to the ones that can be easily procured, thereby reducing the cycle time significantly.

Procurement Planning

A project specific procurement strategy taking both the upstream suppliers and the downstream clients is required in order to ensure the materials are received at site in time.

7.2. INFORMATION MANAGEMENT

Early Identification and Detection

Most of the delays in document approvals occur due to incomplete or incorrect information submitted by the supplier/contractor. This is partially due to the abundance of documents that are transmitted to and from between the stakeholders. The success here is to ensure that these issues are detected in the early stage of the order and corrected either by having a robust document management tracker or by clearing the documents along with the supplier’s team in the first place itself.

Collaborative Planning and Execution

A major cause for delays in the procurement process is the lack of synergy between the stakeholders. It is essential that the client and the prospective suppliers are together involved in the process of procurement planning to ensure that all the information is equally disseminated. The same applies for the interdepartmental information exchange within the EPC contractor’s organization.

7.3. Organizational Restructuring

Decentralized Decision Making

In order to get a cost advantage most EPC firms have a centralized procurement and overseeing team. Though this process helps achieve that purpose, the orders are inadvertently delayed due to the long chain of approvals. To add to this the buyers, the client and the material suppliers are usually not stationed in the same vicinity. Due to this the amount of communication is extremely large. An ideal situation would be to transfer a few decision making and purchasing operations to the project site. This will help bring the buyers and the client on one platform and ensure a faster approval process.

Accountability and Responsibility

One of the causes of delays in procurement as observed in this study is the lack of a single point of responsibility. Due to the wide-spread nature of the activities having one person responsible (say a buyer) for all the activities may not be feasible as he may be involved simultaneously in multiple projects. It is thus essential to have project specific expediters who will be earmarked for a particular project and will be responsible for the end to end execution.

7.4. Working Capital Management

Reducing the Cash Conversion Cycle (CCC)

CCC is the liquidity of the working capital of a firm (Investopedia, 2016). The lesser the CCC, the more liquid cash available to be spent. In the context of this study, CCC cycle can be kept low by ensuring appropriate payment terms by the client and to the supplier at the starting of the contract. Studying the cash conversion cycle helps understand the working capital requirements in advance so that appropriate action can be taken in time.

8. Summary

EPC projects are one of the most challenging construction models. Procurement in EPC operates predominantly in a ‘made to order’ fashion with material costs representing a major proportion of the total project cost. In such a scenario any delay in the procurement process has a cascading effect on the construction process and in turn on the overall project schedule. There is limited study done on procurement in EPC industry specific to an Indian setting. This study thus aims to understand the procurement process specific to engineered equipment and identify issues that lead to a delay in the process.

An exploratory sequential mixed method approach has been adopted in this study. A case study was done to understand the procurement process. A qualitative analysis was carried out to understand the process of procurement and the issues during execution. Subject matter experts were interviewed to understand the same. Quantitative analysis of the data was carried out to quantify and rank the findings from the qualitative study. An attempt to validate the findings using a triangulation method was carried out.

The case study helped understand the stages of pre-order and the post-order procurement cycles in a typical EPC procurement life-cycle. An analysis of the issues form the qualitative data collected was presented in this study. The data from the interviews were broadly classified into ten categories of which procurement planning and information management were the top two most significant issue areas. A framework for improvement of these issues focussing on procurement planning, information management, organization restructuring and working capital management has been presented.

While this study followed a structured approach from start, the absence of documented delay data proved the biggest challenge in validating the findings from the study. The results from the purchase order instrument were not sufficient to validate the findings and this calls for an extension to the current work and identifying new and innovative means of validating qualitative data where the actual documented delay data is not present.

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ADOPTABILITY OF GREEN LEASE IN DEVELOPING COUNTRIES: THE CASE OF SRI LANKA

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ABSTRACT

The concept of Green Buildings is now being promoted as there is an increasing requirement for energy efficient buildings. With the boom of Green Buildings, Green Lease concept has become significant. However in Sri Lanka, presently Green Lease is not practiced very much. Nevertheless, attempts at adopting Green Lease cannot be ignored as there are clauses relevant to green buildings even in the existing lease agreements. Therefore, this research was carried out to investigate the adoptability of the Green Lease concept in Sri Lanka. Firstly, a literature synthesis was carried out to understand the Green Lease concept and its significance. Semi structured interviews and a documentary review were done thereafter to further identify the importance, and enablers and barriers of Green Lease. Subsequently, the findings were validated through expert interviews. The analysis revealed the significance of the Green Lease concept which provides a healthier work environment, lower utility charges and a good reputation for both the tenant and the landlord. However, there can be enablers and barriers of Green Lease. The contribution from the Green Building Council of Sri Lanka (GBCSL), the Government's attempts to promote sustainable activities and conducting of business in Green Buildings are few of the enablers. Factors such as lack of policies and government rules, and poor awareness of the community about Green Lease are the significant barriers. The Government's positive influence and the promotion of the Green Lease within the community will be beneficial towards adopting Green Lease. Several suggestions to minimize the identified barriers also have been made through the developmentof a framework.

***Keywords**: Green Building; Green Lease; Sri Lanka; Adoptability.*

1. INTRODUCTION

The concept of Green emerged at the time the industrial revolution took place with the history of the concept going back many years (Stone, 2011). A Green Building enhances both the environment and its occupants' well-being (Mendis, 2013). According to WGBC (2013), there are two major parties that have interest in Green Buildings, i.e. tenants and the landlords. Sharp (2009) has reported that each party has his/her own interests in Green Buildings. According to Welsh School of Architecture, United Kingdom (WSAUK, 2009), clauses on rental property can be included in a lease agreement with the mutual consent of the tenant and the landlord. Early action on the part of the commercial leasing market is essential to address global warming (Brooks, 2008). The incorporation of environmentally favorable practices in a commercial lease may enhance building performance (WSAUK, 2009).

A Green Lease is a lease agreement between a landlord and a tenant that ensures sustainable operation and management of Green Buildings (Hughes and Melia, 2010). Commercial leasing of Green Buildings enhances building performance and improves the relationship between the landlord and the tenant (Dingwell, 2010). Green Lease also enhances the efficiency of resources, increases the asset value, reduces the operating cost and heightens the occupant's comfortability and health (Kaplow, 2009). Kremer and Nicholas (2012) have pointed out that both the landlord and the tenant may benefit through a Green Lease. Department of Climate Change and Energy Efficiency (2012a) has stated that a Green Lease may help to reduce Green House Gas Emissions (GHG) as well as enhance the energy efficiency of a building. However despite its benefits, it is not easy to introduce a fresh concept to landlords and tenants (Sharp, 2009).

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The clients of recent building projectsin Sri Lanka have made considerable effort to pursue the Green Building concept towards optimizing building performance. The world's first green factory is in Sri Lanka (Sri Lanka Export Development Board, 2012) and the first Leadership in Energy and Environmental Design (LEED) certified building in the world and the first LEED certified building outside the United States of America (USA) - the "Heritance Kandalama" is also in Sri Lanka (Sri Lanka Business and Bio diversity Platform, 2014). Still, Green Lease is a new concept to Sri Lanka. Therefore, it is important to identify the adoptability of Green Lease in Sri Lanka in which most of the researchers in the past have not been interested.

Eventhough, there have been studies to ascertain the requirement, risks and the applicability of Green Lease in developed countries, no attention has been paid to the adoptability of this novel concept in developing countries. There is therefore a need to investigate on "How to adopt Green Lease concept in Sri Lanka?" Hence this research aims to investigate the adoptability of Green Lease concept in Sri Lanka. The study set the following objectives to achieve the aforementioned aim.

1. Review the Green Lease concept
2. Identify the importance of the Green Lease concept
3. Investigate the enablers and barriers of the adoption of the Green Lease concept in Sri Lanka
4. Make suitable suggestions to minimize the identified barriers

2. LITERATURE SYNTHESIS

2.1. GREEN BUILDINGS AND EXISTING LEASE PRACTICES RELATED TO GREEN BUILDINGS

Buildings were identified by Kibert (2004) as having a direct, complex, and long lasting influence on the environment. According to USDE (2009), buildings are in the highest energy consumption sector. Green Buildings have been recognized worldwide as a solution to mitigate the inefficient energy usage while contributing to the reduction of global GHG (Howe, 2010; Brown and Southworth, 2006; Berardi *et al.*, 2013). Basically, Green Buildings minimize resource usage (Vancouver Economic Commission, 2009).

Green Building is not just the assembling of environmentally friendly elements or just retrofitting existing buildings (Karolides, 2002). According to Green Building Council of Australia (GBCA, 2015), the concept should include designing, constructing, operating, maintaining and demolishing a building. Environmental Protection Agency (EPA), one of the reputed agencies in USA, defines Green Building as the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle starting from its siting to its design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the usual building design concerns on economy, utility, durability and comfort. A Green Building is also considered as a sustainable or 'high performance' building (EPA, 2014).

Atputharajah and Bombugala (2010) state that even though Green Buildings cost 20 - 25% more than a conventional building, their benefits can be ten times more than those of conventional buildings. Baier (1999 cited Heerwagen, 2000) has reported that Green Buildings will lead to a higher demand for space when renting or selling that space. The study therefore considers only rentable green built space. Existing leasing practices basically fulfill the goals of the landlord and the tenant independently (WSAUK, 2009). None of the common objectives can be met through existing lease agreements. This is a major disadvantage. Furthermore, Brevard (2012) reports that the existing leasing practice is not contributing to the active participation of both the tenant and the landlord.

Dingwell (2010) considers a well-established Green Lease as a step towards achieving energy efficiency as well as obtaining the commitment of stakeholders for ensuring sustainability. Thus, a Green Lease goes beyond an existing lease and provides for optimum resource utilization with a higher environmental responsibility while eliminating barriers of the existing lease practices (Kaplow, 2009).

2.2. GREEN LEASE CONCEPT

Green Lease is an agreement between a tenant and a landlord (Green Building Alliance, 2013). Up to now, there has been no accepted definition for Green Lease. A Green Lease can be defined as a collaborative agreement between a landlord and a tenant to ensure sustainability and to achieve both shared and individual objectives.

The involvement of the government in Green Lease is an important enabler of Green Lease (WSAUK, 2009). However, implementing Green Lease is not an easy task since it gets obstructed by its barriers. As stated by the Department of Climate Change and Energy Efficiency (2012b), the following costs incurred by the tenant are the major barriers for implementing Green Lease.

- Costs associated with administration, e.g., record keeping, participation at meetings etc.
- Costs related to changing the behaviour and the attitudes of tenants - tenants have to adjust their behaviour in order to achieve the targeted energy efficiencies.

Other than these barriers, a few other categories also were identified, viz., process related barriers, organizational related barriers, and economical and other cost related barriers and social related barriers. Accordingly, USDE (2009) has reported that the low commitment of tenants and their lack of awareness on the costs and benefits of Green Lease practices are barriers for implementing Green Lease. EMW (2015) has identified the following challenges for Green Lease:

- Longer time duration
- Higher initial cost
- Lack of awareness on the importance of energy efficiency and Green Lease
- Disagreements among landlords and tenants

Barriers of Green Lease have to be avoided to enable its development as there are merits in adopting Green Lease such as lower operating and maintenance costs, achievement of environmental objectives of landlords, tenants and good reputation for them (James, 2010). It is essential to identify the possibility of introducing the Green Lease concept in Sri Lanka. Therefore, Green Building practices in Sri Lanka as well as Green Lease need to be discussed. According to Mendis (2013), in Sri Lanka there is an increasing tendency to convert existing buildings into green buildings. Therefore, the requirement for adopting the Green Lease concept in Sri Lanka is quite clear.

3. RESEARCH METHODOLOGY

In this study, the qualitative research approach was selected as Green Lease is not practiced very much in Sri Lanka as at present. Since numerical data cannot be taken to analyze the adoptability of Green Lease in Sri Lanka, three case studies were selected to verify the strength of the data. Since when there are many cases, similarities and differences need to be understood, it is better to go for multi-case studies (Yin, 2003). The researcher selected semi-structured interviews and a documentary review as data collection techniques for the selected case studies. In addition, viewpoints of industry experts were considered in arriving at conclusions. Data was collected through three case studies, interviews and a documentary review. From the data collected, the importance of the Green Lease concept was identified fulfilling the second objective of the study. The third and fourth objectives were fulfilled by identifying the enablers and the barriers of Green Lease and from suggestions made based on the case study findings. Ultimately, the findings were consolidated with an expert interview. Figure 1 shows how the case study contributed to data validation.

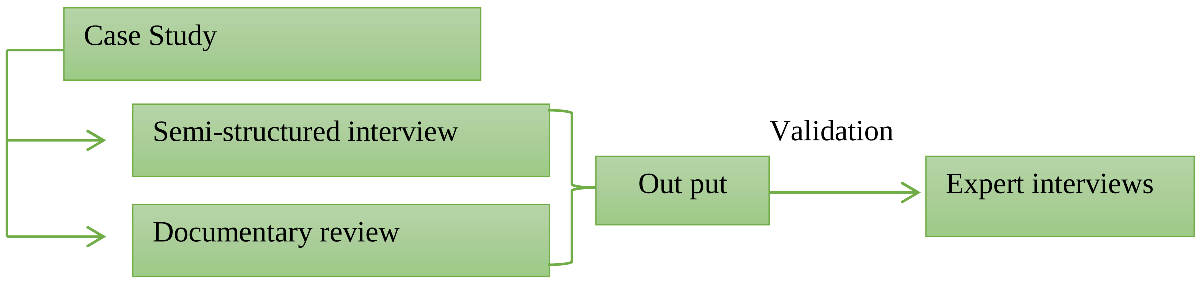

Figure1: Research Methodology

Two respondents (see Table 1) were interviewed for each case.

Table 1: Respondents

Case	Respondents
Case A	Senior Manager (Facilities Management)
	Legal Manager
Case B	Chief Engineer
	Legal Manager
Case C	Administrative Executive
	Manager (Facilities Division)

Table 2 gives details pertaining to the expert interviews conducted to consolidate case study findings.

Table 2: Expert Interview Details

Agency	Designation of the Expert	Sector	Number of Years of Experience in the Field
E1	Professor	Government Sector (Academic)	22
E2	Chief Executive Officer (CEO)	Private Sector	11
E3	Legal Consultant	Private Sector	24
E4	Manager (Administration)	Private Sector	12
E5	Chief Executive Officer (CEO)	Private Sector	30

4. RESEARCH FINDINGS

The research considered Green Buildings that have been identified as being energy efficient and rentable since the research was to focus on the adoptability of Green Lease.

4.1 IDENTIFYING THE IMPORTANCE OF THE GREEN LEASE CONCEPT

It was important to study existing lease agreements before analyzing the requirement for Green Lease in Sri Lanka. The pros and cons of existing lease agreements were presented at the interviews and most of the respondents agreed on the need to have a Green Lease concept in Sri Lanka, considering the deficiencies of the current leasing practices. The following were studied to gather the required data:

- Rent and other utility charges stated in the existing lease agreements
- Split incentive barriers stated in the existing lease agreements
- Clauses relevant to Green Lease in the existing lease agreements
- Benefits of adopting Green Lease

There are no special provisions in Sri Lanka regarding the payment of rent and other utility charges of Green Buildings. In general, the operating cost is borne by the tenant. Therefore in most of the cases, a split incentive barrier was provided in the existing lease agreements. The developer does not have to invest on energy efficiency systems, as he will not reap the benefit of energy reduction. This is one of the major deficiencies of the existing lease agreements.

Although Green Lease is not currently practiced, there are clauses relevant to it in existing lease agreements as indicated below which the tenants are bound to adhere to:

- Abstaining from covering or obstructing window sky-lights and ventilation shafts
- Keeping all trash and garbage in suitable receptacles and arranging their proper removal from the premises
- Ensuring a pre-defined water efficiency level and obtaining permission from the facility management before installing new fixtures
- Abstaining from installing new air conditioning equipment as it will affect the pre-defined energy efficiency level
- Abstaining from using CFC based refrigerants

The benefits of the Green Lease concept indicated below underline the significance of the concept.

- Lower operating cost
- Attraction to foreign customers
- Independence from energy
- Independence from water
- High impact the use of recycled material has on the cost of both the tenant and the landlord.
- Good reputation available for both the tenant and the landlord. Easy marketing of the leased space and the lower carbon emission that positively affects the building
- Good interior and exterior appearance and pleasant environment

After studying the existing lease agreements, the respondents agreed on the adoption of the Green Lease as a concept. In Sri Lanka there are both enablers and barriers to the adoption of Green Lease.

4.2. ENABLERS, BARRIERS AND SUGGESTIONS TO ADOPT GREEN LEASE CONCEPT

The findings convinced that in Sri Lanka there are national as well as organizational enablers of Green Lease. Categories identified from the literature were further developed by the respondents as indicated below. Accordingly, enablers, barriers and suggestions that will minimize the identified barriers were grouped into six categories as indicated below.

- Process related barriers connected with the Green Lease process
- Organization related barriers connected with organizations
- Economical and other costs related barriers connected with the economy
- Government and other legal related barriers connected with the Government and the legal system
- Socially related barriers connected with individuals and the community
- Others

4.3. ENABLERS OF THE GREEN LEASE CONCEPT

Most of the respondents agreed that there are enablers of the Green Lease Concept in Sri Lanka that promote the implementation of the concept in the country. Table 3 presents these enablers**.**

Table 3: Enablers of the Green Lease Concept

Category	Identified Enablers
Process Related	▪ Not many restrictions to incorporate new clauses ▪ Tendency to go green
Organizational Related	▪ Carrying out business in a Green Building ▪ Ease with which it can be adopted by rich tenants
Economy Related	▪ Low cost of natural resources ▪ Attraction of foreign tenants
Government and Legal Related	▪ Absence of restrictions on Green Lease ▪ Support of the Government to enhance sustainable activities
Social Related	▪ Peace prevailing in the country in the absence of the civil war ▪ Young and knowledgeable crew ▪ Contribution from the GBCSL
Others	▪ Availability of natural resources ▪ Presence of a non-profit oriented organization to encourage Green Lease

According to Table 3, there are six types of enablers identified from semi-structured interviews. These enablers were further verified through experts in Green Building and construction law. The Green Lease process being not stringent, it is not difficult to incorporate new clauses in the existing lease agreements. Even though according to case studies, conducting a business within a Green Building is an enabler, the experts did not totally agree with this as the trend of constructing Green Buildings is not satisfactory. However, because of the significance of the Green Lease concept, the experts considered the conversion of a proposed building to Green as an enabler.

The Government indirectly influences sustainable activities. Training programmes conducted by the Green Building Council of Sri Lanka, a non-profit oriented organization motivated by the Green Building concept, is also another important enabler.

4.4. BARRIERS OF THE GREEN LEASE CONCEPT

Barriers impede the adoption of the Green Lease concept and based on case study findings, they were categorized as indicated in Table 4.

Table 4: Barriers of the Green Lease Concept

Category	Identified Barriers
Process Related	▪ Difficulty in adopting the concept immediately as it comes from overseas ▪ Difficulty to adopt new clauses at once ▪ Long time taken by the process
Organizational Related	▪ Need to conduct meetings ▪ Need to conduct internal auditing ▪ Need to conduct awareness and training programmes ▪ Need to maintain proper documentation ▪ Need to bear the cost of meetings, training programmes etc. ▪ Lack of financial support from the organizations concerned ▪ Other administrative costs
Economy and Other Cost Related	▪ The fact that Sri Lanka is a developing country ▪ Difficulty in competing in the foreign market
Government and Legal Related	▪ Absence of government policies, rules and regulations on Green Lease ▪ Absence of encouragement from the government to adopt Green Lease
Social Related	▪ Lack of understanding of the value of Green Lease ▪ Lack of concern on the environment and the sustainability ▪ Lack of awareness on Green Lease
Others	▪ Lack of commitment by the management ▪ Use of less manpower ▪ Considering the concept as an additional financial burden

The identified barriers were further verified through experts. E1 was of the view that it is not easy to incorporate sustainable clauses in a lease agreement, since the tenant may not like them. Even though administrative barriers were identified through the literature and case studies, experts did not consider them as barriers.

The fact that Sri Lanka is a developing country has also been identified as a barrier. However, the experts were of the view that although there are certain areas that need to be developed, *a considerable progress has already been made by Sri Lanka. They were of the view that the status of the country's economy cannot be a barrier and that there is a need to adopt the concept*. The absence of government policies, rules and regulations was also identified as a barrier by experts. However, the lack of awareness of the Green Lease concept and the lethargy in implementing sustainable concepts were considered as other important barriers.

4.5. SUGGESTIONS TO MINIMIZE THE IDENTIFIED BARRIERS

Since all the enablers and the barriers were verified through expert interviews, suggestions were developed through case study interviews and through expert ideas and opinions. Suggestions that will minimize the identified barriers were grouped into six categories which respondents tabulated as given in Table 5.

Table 5: Suggestions to Minimize the Identified Barriers

Category	Barriers	Suggestions Proposed
Process related	▪ Difficulty in adopting the concept immediately being a concept that comes from overseas ▪ Difficulty to adopt new clauses at once ▪ Long time taken by the process	▪ Should explore advantages and disadvantages of adopting Green Lease ▪ Should incorporate standard clauses relating to sustainability, energy efficiency, waste management and emission reduction ▪ Should make both parties aware of sustainable clauses when incorporating them
Organizational related	▪ Need to conduct meetings ▪ Need to conduct internal auditing ▪ Need to conduct awareness and training programmes ▪ Need to maintain proper documentation ▪ Need to bear the cost of meetings, training programmes, etc. ▪ Lack of financial support from the organizations concerned ▪ Other administrative costs	▪ Should promote awareness among main stake holders. ▪ Should conduct awareness and training programmes for employees. ▪ Should encourage Green Lease within organizations ▪ Should transfer the benefits of energy efficiency system implementation to tenants.
Economical and other cost related	▪ Difficulty in competing in the foreign market. ▪ Centralized electricity supply ▪ Increased cost of products	▪ Should decentralize the electricity supply ▪ Should introduce alternative energy solutions ▪ Should offer tax benefits to green followers ▪ Should offer subsidiaries to the companies ▪ Should increase private sector involvement ▪ Should lower interest rates for the building sector to motivate it to adopt the Green Lease concept
Government and legal related	▪ Absence of government policies, rules and regulations to adopt Green Lease ▪ Lack of encouragement from the government to adopt Green Lease	▪ Should develop a policy framework ▪ Should introduce rules and regulations that empower Green Lease ▪ Should amend the law to ensure sustainability of Green Lease ▪ Should incorporate clauses relating to Green Lease in construction law, condominium law etc. ▪ Should conduct awareness programmes to make the public aware of the value of sustainable living
Social related	▪ Lack of understanding of the value of Green Lease ▪ Lack of concern about the environment and the sustainability ▪ Lack of awareness on the Green Lease	▪ Should develop correct attitudes in the public ▪ Should conduct awareness and training programmes ▪ Should develop positive mindsets on Green Lease ▪ Should make tenants aware of the benefits of Green Lease

5. CONCLUSIONS AND RECOMMENDATIONS

Green Buildings provide the most comfortable environment to their occupants and increased profits to their developers. Green Lease is therefore required to enhance the efficiency of Green Buildings. The Green Lease is a significant concept that should be adopted early by the construction industry in Sri Lanka as the rapid development of the building industry can damage the environment. Both the enablers and barriers of Green Lease as applicable to Sri Lanka were recognized organizational wise as well as national wise. Enablers have to be further developed while barriers have to be eliminated.

Suggestions were made to minimize the identified barriers, e.g., introduction of a policy framework, rules and regulations, conducting awareness programmes, provision of tax benefits and subsidies to Green followers, and the promotion of the private sector. It is recommended that the Government and the Green Building Council of Sri Lanka take action to conduct suitable awareness programmes to promote the Green Lease concept in Sri Lanka. Through workshops and seminars, construction industry stakeholders should also be made aware of this concept.

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ADOPTING NET ZERO ENERGY BUILDING CONCEPT TO REDUCE ENERGY COST OF COMMERCIAL BUILDINGS IN SRI LANKA

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ABSTRACT

Fulfilling energy demand has become a major challenge faced by most of high rise buildings today as it creates high utility cost to the organization. Hence, most of the organisations, especially in commercial building sector seek better options to fulfil their energy demand as a major energy consumer among the other building facilities. Hence, several energy management practices have been introduced to enhance energy efficiency. In the governing concern on less energy and less environmental impact, Net Zero Energy Building concept has received attention. Net Zero Energy Buildings have a greatly reduced energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources. However, the adaptation of this concept has become a major challenge due to various barriers. Therefore, the purpose of this research is to identify the barriers to adopt Net Zero Energy Building concept to commercial buildings in Sri Lanka for proposing probable solutions. As this research required a detailed investigation, case study approach was selected under qualitative phenomenon. Three cases were conducted in three selected commercial buildings to collect the data. Cross-case analysis technique was applied as the appropriate data analysis technique. Nvivo and Decision-Explore software's are used to analyse and present the data. As the focal point of the research, barriers to adopt Net Zero Energy Building concept was determined relating to five major categories, such as, financial, legal, policy, social, and technical barriers. According to case study findings, this concept is more suitable for new building constructions than the existing buildings, as it is more effective to adopt it at the early stage of the building. Further, major barriers include limitations of organisational internal policies, preference of organisations for short term profits, unawareness and government rules and regulations. Accordingly, a framework is developed to propose probable solutions. The developed framework gives a value to the research, as it could use as a firm base in both organisational and national levels to adopt Net Zero Energy Building concept to reduce energy cost of commercial buildings in Sri Lanka.

Keywords: *Net Zero Energy Building; Commercial Buildings; Energy Conservation; Barriers; Solutions.*

1. INTRODUCTION

With the rapid development of the world, more and more buildings are constructed by creating an ever increasing energy demand. This has raised serious environmental problems such as global warming, air pollution and acid rain (Iwaro and Mwasha, 2010). Therefore, various building energy regulations, energy standards, codes, taxes, and subsidies have being introduced by most of the countries to reduce energy consumption of buildings (Iwaro and Mwasha, 2010; Balaras *et al*., 2007). According to Laustsen (2008), both building codes and energy standards provide a guideline to maintain minimum energy requirements for energy efficiency in buildings. However, energy standards are subjected only to minimize energy cost of buildings which is not optimally reducing the effect on environment. From several years, Net Zero Energy Building (NZEB) concept has been received attention. The core idea of NZEB is that NZEB buildings can meet all their energy requirements from low-cost, locally available, non-polluting, renewable sources (Torcellini *et al*., 2006).

According to Kneifel (2010), NZEB has several benefits compared to other types of buildings. NZEB needs least cost for maintenance and operation. NZEB generates not only financial benefits from energy efficiency improvements, but also it reduces carbon footprint. This reduction is average 16% carbon

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footprint which greater than countries energy generate using coal and oil. Similarly in Sri Lankan energy context, commercial sector consumes about 23% electricity. Pathmasiri (2010) mentioned that 77.54% the energy is used for air conditioning, 15.97% is used for lighting, where 2.17% and 4.32% of energy are used for lift and office equipment respectively. After several attempts, the national policy and strategies are adopted by Sri Lankan Parliament to face the energy challenge in Sri Lanka (Munasighe, 2010). However, the NZEB concept is still new to Sri Lankan energy sector. Hence, the adaptation of this concept has become a major challenge, as most of the buildings are fulfilling their energy demand from national energy grid. Therefore, the purpose of this research is to identify the barriers to adopt NZEB concept to commercial high rise buildings in Sri Lanka. To fulfilling the above purpose, the rest of the paper is structured to present the secondary data gathered through literature, key research findings and solutions proposed with the framework developed.

2. LITERATURE REVIEW

2.1. NET ZERO ENERGY BUILDING (NZEB) CONCEPT AND ITS IMPORTANCE

As the definition given by National Science and Technology Council (2008, P.48), "net zero energy (commercial) building is a high performance commercial building, that is designed, constructed, and operated to require a greatly reduced quantity of energy to operate; meets the balance of energy need from sources of energy that will result in no net greenhouse gas emissions; and is economically viable". The US Department of Energy (2015, p4) defines the NZEB is "an energy-efficient building where the actual annual energy consumption from sources is balanced by on-site renewable energy." At net zero source energy, building is produced as much energy as it was consumed. When total source energy is calculated, both imported and exported energy are considered. As Crawley *et al*. (2009) by using renewable energy with the building footprint, within the site, energy sources available off site and energy generation within the site and purchase off-site renewable can be achieve for the net zero source energy building. Building owners are interested in net zero energy cost buildings because this method tend to use energy efficiency strategies and renewable energy as part of their business plan. In this method financial credits were received for exported energy (Torcellini *et al*., 2006). As Crawley *et al*. (2009) mentioned, by using renewable energy with the building footprint, within the site and energy sources available off site and energy generation within the site can achieve net zero cost building. Among those definitions "Net Zero Site Energy" definition given by Torcellini *et al*. (2006, P.7) is used in this research: "Net Zero Site Energy: A site zero energy building produces at least as much energy as it uses in a year, when accounted for at the site."

As Li *et al*. (2013) stated, NZEB helps to reduce use of conventional energy resources and the deterioration of the environment. Further, NZEB plays important role in sustainable development. According to Sesana and Salvalai (2013), more than 80% of the operation cost of the slandered building can reduce by this NZEB concept. Further, researcher pointed out that, more than 75% of life cycle cost is determined by the operation and maintenance cost. Accordingly, NZEB can be used to reduce the 60% of life cycle cost of buildings. NZEBs have a greatly reduced energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources such as, wind, biomass, solar, hydro-electric, geothermal, and ocean energy (Boyle, 2004; Doty and Turner, 2013; International Energy Agency, 2014). To become a net zero energy building, two main strategies are available. One is to minimizing the energy need for buildings from more energy-efficient measures whilst adopting renewable energy to meet the minimum energy needs is the second option available (Li *et al*., 2013). According to a study by Torcellini *et al*. (2006), on site and off site supply options are available to use renewable energy sources to become a net zero energy building. As Torcellini *et al*. (2006) further mention, use of renewable energy sources available within the building's footprint and at the site are onsite supply options where off site options include purchasing and using renewable energy sources which are available off site to generate energy on site. However, mostly in NZEB, enough renewable energy is generated on site to equal or exceed its annual energy use. NZEB needs two main strategies to minimize the energy need for buildings from more energy-efficient measures, and by adopting renewable energy to meet the minimum energy needs (Li *et al.*, 2013).

2.2. *ISSUES IN CURRENT PRACTICE*

The adoption of NZEB has become a major challenge faced by buildings due to various issues. According to previous literature reviewed, various categories of issues were identified to adopt NZEB concept. A study by Lindkvista *et al*. (2014) has founded out key issues as technical, financial, social, organization and legal related issues. As per the study by Brostrom and Howell (2008), technical, financial, policy and training are the key issues to adopt NZEB concept. Accordingly, five major categories of issues are identified (refer Figure 1).

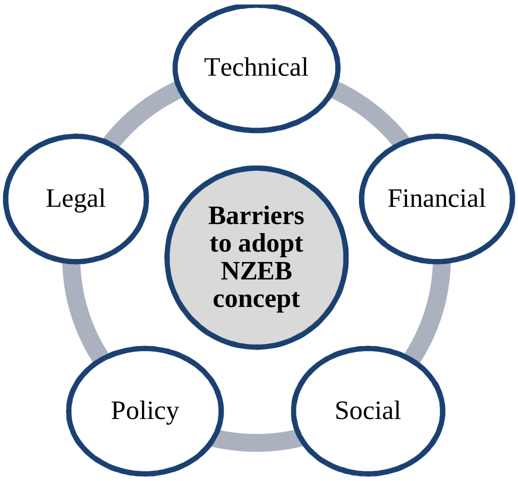

Figure 1: Barriers to Adopt NZEB Concept
Source: Lindkvista *et al*. (2014); Brostrom and Howell (2008)

2.3. *ENERGY MANAGEMENT PRACTICE IN SRI LANKA*

Currently, Sri Lanka also moves towards the energy efficient building concepts. According to Sustainable Energy Authority (2009), Clause 36 (g) of the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007, it empowers the Sri Lanka Sustainable Energy Authority (SLSEA) to specify and enforce a code of practice for buildings on efficient energy utilization. This code was applied to all commercial buildings, industrial facilities and large scale housing developments. As per the preliminary investigation, NZEB is a newest concept to Sri Lanka.

As the major renewable energy sources used, high proportion has been obtained by the hydroelectricity, wind energy, solar power and bio mass. However, in Sri Lankan renewable energy sector, it has mainly focused on grid and off grid power generation. Hydroelectricity is the most popular method used in grid power generation. Solar power, wind power and bio-mass are also used for the grid electricity generation, however not optimally. Hence, there is a less concern on adopting newest energy efficient building concepts. Further, few buildings have been concerned to adopt NZEB as a newest concept however; it has limited to use solar power due to several issues.

Therefore, as the focal point of this research, barriers to adopt NZEB concept were determined with special prominence to commercial high rise buildings in Sri Lanka. Accordingly, a theoretical framework is developed based on literature findings as illustrated in Figure 2. This was considered as the basic framework to evaluate the adoptability of NZEB concept in commercial buildings in Sri Lanka. As per the framework developed, current energy management practice in high rise commercial buildings was examined in order to identify existing practices and barriers to adopt NZEB concept to reduce energy cost of the building. The key categories of issues identified in literature, such as; financial, legal, policy, technical and social issues are acclimatized to evaluate the current practice.

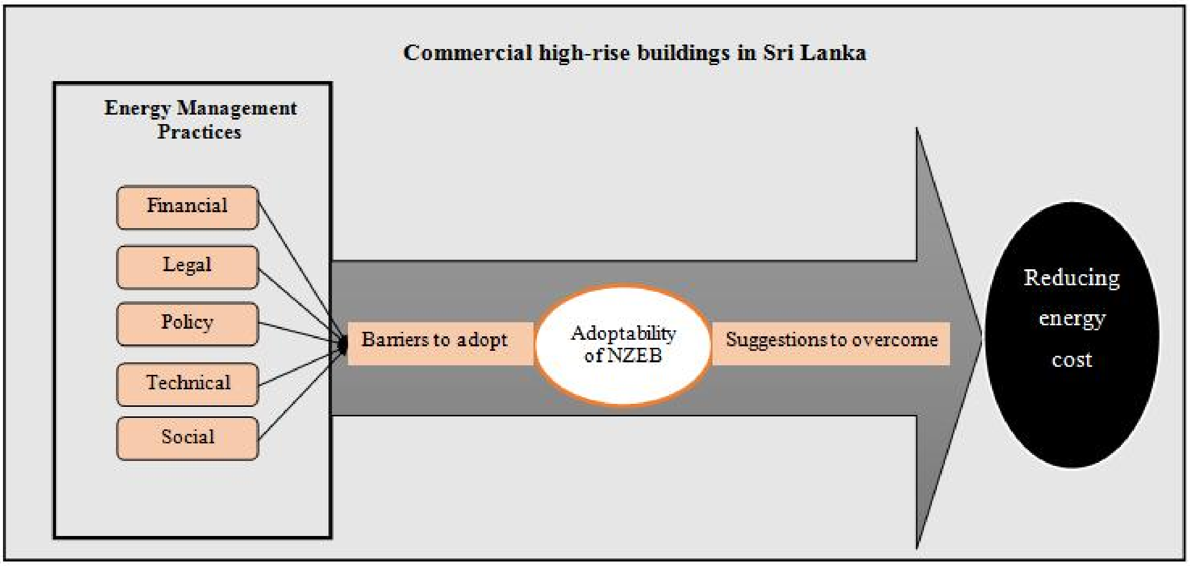

Figure 2: Theoretical Framework

The Section 3 describes the methodology adopted in this study.

3. Research Methodology

The research was designed as two stages. Literature review was conducted as the first stage by reviewing key research papers in the area of energy management with special emphasis to net zero energy buildings. As this research required conducting a detailed investigation into the energy management practices in commercial buildings and, its qualitative outcome, the research was conducted by case study method under qualitative phenomenon. According to Yin (2009), case study approach is more appropriate to bringing an understanding of a complex issue or object. In the case study design, three cases were selected under multiple case study approach. Hence, three high-rise commercial buildings were selected, those who have high energy consumption and have a concern on modern energy management practices.

Both direct observations and semi-structured interviews were selected as suitable data collection techniques. Eight semi-structured interviews were conducted among industry professionals who have involved in the field of energy management and net zero energy management practice in commercial buildings in Sri Lanka to collect the data. The interview profile is illustrated in Table 1.

Table 1: Interview Profile

Case	**Designation**	
Case A	A1	Senior manager Operation and maintenance
	A2	Manager Mechanical and MVAC
	A3	Project Manager
Case B	B1	Maintenance Engineer
	B2	Mechanical Engineer
	B3	Assistance Maintenance Engineer
Case C	C1	Consultant Engineer
	C2	Assistance Consultant engineer

Code-based content analysis was used to analyse the case study data. QSR. NVivo and Decision Explorer software’s are used to analyse and present the data. Cross-case analysis was conducted under two major headings as, barriers to adopt and solutions proposed. Figure 3 illustrates the coding structure developed to analyse the data.

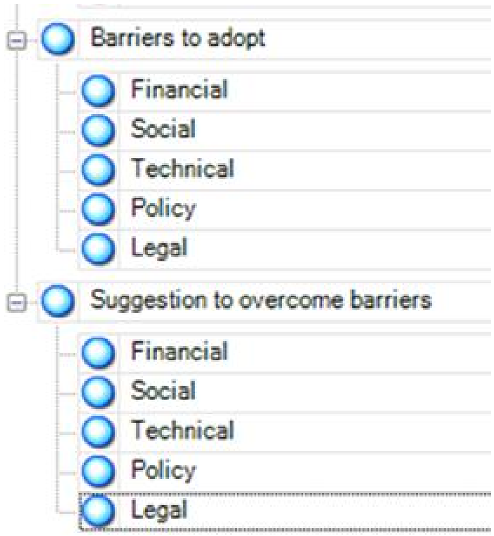

Figure 3: Coding Structure

Section 4 presents the case study data analysis and key research findings.

4. RESULTS AND DISCUSSION

4.1. CURRENT ENERGY MANAGEMENT PRACTICES IN COMMERCIAL BUILDINGS

According to the case study data, most of commercial buildings are fulfilling their energy requirement thorough Ceylon Electricity Board (CEB) grid power generation. However, most of buildings have been implemented the various active and passive mechanisms to save energy and to reduce energy cost such as, passive design of the building, building orientation, building automation, Building Management System (BMS), installation of Variable Speed Drives (VSD), etc. At the present, use of renewable energy is still a newest concept for most of commercial buildings. As most of the interviewees responded, there is a management commitment to introduce renewable energy options to cater their energy requirement. Therefore, introducing NZEB to high rise buildings would be more effective to utilize their own renewable energy sources for reducing energy cost.

4.2. BARRIERS TO ADOPT NZEB CONCEPT

As the case respondents interviewed, high initial cost is a major barrier to adopt NZEB concept. As it proved by the Assistance Consultant Engineer in case C "*Initial cost is high in these renewable equipment such as solar panels, invertors*" Maintenance Engineer in case B also verified that "*The problem is the initial cost. Cost of renewable energy generation equipment is relatively high*." One of the other barriers identified was these projects are not aligned with the internal policy. It was clarified by Senior Manager Operation and Maintenance in case A as *"As our internal policy project which has payback period more than 2-3 year it was not viable project."* However, as argued the Consultant Engineer in case C *"We will have to find fund to installation solar system. Marginally it is nearly about 220 million so we have to get the approval but the recovery payback period is nearly 6 to 7 years."* So this project is not a viable project as per the internal policy. Among these eight participants, only two members were knowledgeable about the concept. Senior Manager Operation and Maintenance in case A has an idea about the concept however it is not total understanding. It was clarified by his statement as *"We have heard about it, but no clear idea. Can you brief on it?"* Most of them were not aware about this concept. For an example Mechanical Engineer in case B mentioned that *"Especially I haven't any experience in this concept."* Manager Mechanical and MVAC in case A also pointed out that unawareness of the concept is a key barrier to adopt this concept. Furthermore, less government and organizational policies, lack of space and lack of technology are also identified as barriers to adopt NZEB concept. As the key research findings acquired through cross-case analysis, key barriers are determined as shown in Table 2.

Table 2: Barriers to Adopt NZEB Concept

Key categories	Barriers identified		
	Case A	**Case B**	**Case C**
Financial	▪ High initial cost ▪ Longer payback period ▪ Resent of the investors ▪ Converting of old building is not economical ▪ High maintenance cost of the renewable power plant ▪ High transportation cost of biomass	▪ High initial cost ▪ Longer payback period ▪ High transportation cost of biomass ▪ High maintenance cost of the renewable power plant	▪ High initial cost ▪ Longer payback period ▪ Converting of old building is not economical
Legal	▪ No clear rules and regulation for off-site energy generation ▪ Less national level regulatory framework ▪ Getting approval is difficult	▪ No clear rules and regulation for off-site energy generation ▪ Getting approval is difficult	▪ Less national level regulatory framework
Policy	▪ Restriction from organizational policy ▪ Management concern about core business ▪ Less government policies	▪ Management concern about core business ▪ Less government policies	▪ Restriction from organizational policy ▪ Less government policies
Technical	▪ Lack of space ▪ Lack of expert knowledge ▪ Lack of suitable renewable resources ▪ Lack of technology ▪ Architectural designs ▪ Inadequate land raw material and other facilities	▪ Lack of space ▪ Lack of suitable renewable resources	▪ Lack of space ▪ Lack of expert knowledge ▪ Lack of suitable renewable resources ▪ Lack of technology
Social	▪ Unawareness	▪ Unawareness	▪ Unawareness ▪ Less management commitment and support

In order to adopt this newest concept to commercial buildings, these barriers are required to be eliminated. Hence, according to the different views and opinions of experts in energy management field, probable solutions are proposed to overcome the above barriers.

4.3. SUGGESTIONS TO OVERCOME IDENTIFIED BARRIERS

To overcome financial barriers, experts have given some practical suggestions. One of the suggestions is to reduce the equipment cost by reducing government tax levels. It was pointed out by Manager Mechanical and MVAC in case A as *"Solar panel price can reduce by reducing tax level on this solar panel and other equipment."* Not only that Maintenance Engineer in case B also suggested introducing a new loan system. As he indicated in his statement *"There should be loan system with the low interest rate for organizations to for this kind of projects, as most of organizations are suffering from the lack of financial initiatives and resources."* According to case analysis, less management commitment and support was identified as a major social barrier to adopt NZEB concept. To overcome this barrier, respondents suggested making the working environment more flexible where it gives a way to explain the situation to the management and to get their support. It is further proved by the Consultant Engineer in case C as *"So basically we have to explain as the technical manager to the finance manager and top managers about the short term and long term benefits of these energy management projects and should ask them to consider the present situation because, this the latest and energy saving solution. Further, maintaining energy saving building is important otherwise there is no profit from this building. In my idea technical team should get together and convince to them to implement energy saving methods in this* *building."* Not only the Consultant Engineer, but also Project Manager in case A further reinforced it as *"If we can go ahead with the solar energy and thought the management, the gain is this much through this much of period. By convincing them we can go for next step. This is very practical if we can implement it then of course it will beneficial for the organization end to country."* According to the case analysis, converting existing building to adopt this concept was not identified as an economical option. To overcome this barrier, respondents proposed to adopt this concept since the design stage of buildings. This has clearly indicated by the Assistance Maintenance Engineer in case B as *"For commercial high rise buildings, it should be come from the design stage. It should be advised to the design team including architects at the design stage. Then the building can use maximally for the use of solar lighting, at least one side of building which has maximum sunlight can set for the solar panels, such things should be considered at the design stage."*

Accordingly, a framework is developed for implementing NZEB concept for reducing energy cost of commercial high-rise buildings in Sri Lanka by combining the key barriers identified and solutions proposed (refer Figure 4).

5. SUMMARY

Fulfilling total energy requirement is a major challenge today, especially in high rise buildings. Commercial buildings are a major energy consumer who has faced this vital challenge due to high energy demand. Accordingly, most of the organizations seek better options to fulfil their energy demand and to reduce their energy cost without generating serious threat to environment. Net-zero energy building concept has gaining momentum in this regard, as it contributes greatly to reduce energy demand by an equivalent generation of energy from low-cost, locally available, non-polluting, renewable sources. However, the adoption of NZEB concept is a greater challenge, as most of the organizations have faced several issues to adopt this new concept. As the purpose of this study, the barriers to adopt the NZEB concept was determined through comprehensive literature survey and case studies conducted in three selected commercial high-rise buildings in Sri Lanka. Key barriers are identified as technical, financial, social, policy and legal related barriers to adopt the concept. High initial cost is a major barrier where less government and organizational policies, lack of space and lack of technology, etc. are also identified as key barriers to adopt NZEB concept. Accordingly, a framework is developed by proposing probable solutions to overcome the identified barriers. Reducing equipment cost, facilitating flexible working environment, introducing the concept at building design, national regulations for renewable energy generation, conducting awareness programs are some of the solutions proposed. Hence, the developed framework could be used as a firm base in both organisational and national levels to adopt Net Zero Energy Building concept to reduce energy cost of commercial buildings in Sri Lanka.

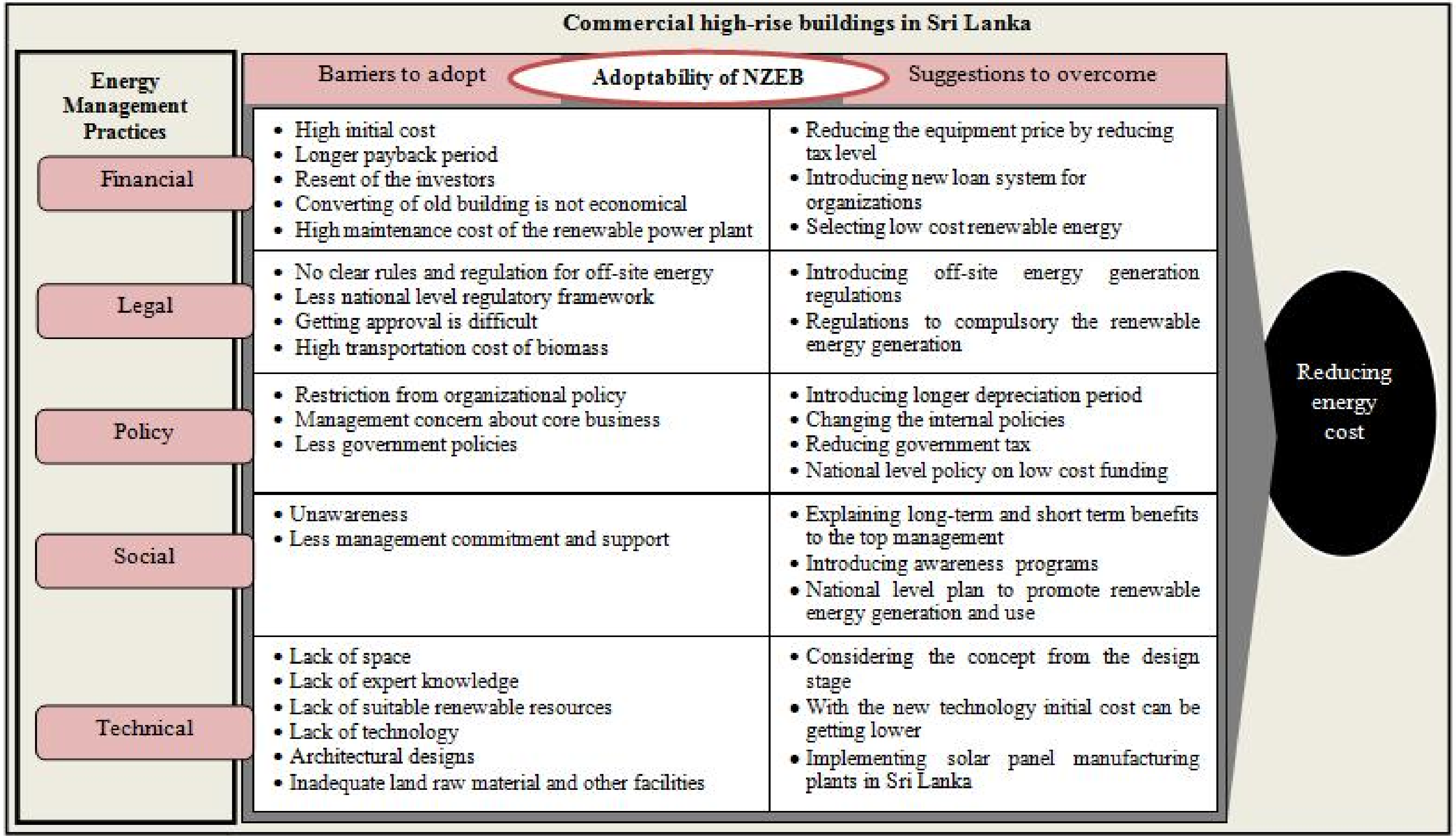

Figure 4: Framework to Adopt NZEB Concept

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APPLICABILITY OF GREEN HUMAN RESOURCE MANAGEMENT CONCEPT TO ACHIEVE SUSTAINABLE GOALS OF GREEN BUILDINGS IN SRI LANKA

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ABSTRACT

Nowadays in world, construction of green building becomes a new trend. Many studies noticed that there are considerable amount of investments to the green buildings than conventional buildings. Since in last decade, the world has concerned about green building concept as one of the solutions to reduce environmental impacts. In achieving such foremost benefits of green buildings, human resource plays a vital role, especially to achieve sustainable goals of green buildings. Green Human Resource Management came into practice as a newest concept to create green responsive employees who make a significant contribution to environmental sustainability. However, Human Resource is not utilized in effective and efficient manner in most of the organizations. Therefore, the intention of this research is to investigate the applicability of Green Human Resource Management concept to achieve sustainable goals of green buildings in Sri Lanka.

As this research required an in-depth investigation, the research problem was approached through three case studies which are conducted in three selected green buildings in Sri Lanka. Content and cross case analysis techniques are used to analyse the data. QSR. Nvivo software is used to simplify the data analysis. As key research findings derived through case analysis, in Sri Lanka, existing green buildings have not been implemented the proper Green Human Resource Management process. Hence, the gaps in existing Human Resource Management process in green buildings are identified in relation to the job analysis, recruitment, selection, induction, training and development, performance evaluation and discipline management. Improper job designing, not including green competencies, use of traditional Human Resource Management process, unawareness, no proper performance evaluation criteria are identified as major gaps in Human Resource Management process in green buildings. Accordingly, a framework is developed to propose various strategies to fill the gaps in existing process to effectively utilize the Human Resource for achieving sustainable goals of green buildings in Sri Lanka as the main implication of this research.

Keywords: *Green Human Resource Management; Green Buildings; Human Resource Management Process; Gaps; Sri Lanka.*

1. INTRODUCTION

During the last 30 - 40 years, the world has to face some major environmental problems, such as, global warming, ozone diminution, resource diminution, energy scarcity, environmental toxicity, human toxicity, and acid rains. These indicated to change the way they operate on the earth. In response to the severe and irreversible climatic changes, the world concerns more towards sustainable development to reduce the impacts on people and the environment (Khalil and Husin, 2009). In such governing concern, green building movement is rapidly becoming a necessity. It aims to fundamentally change the built environment by creating energy efficient, health and productive buildings (USEPA, 2014; United States Green Building Council, 2009 cited Gou *et al.*, 2013).

Green building is refers to the practice of creating structures and which are using processes that are environmentally responsible and resource-efficient practise throughout a building's life-cycle from inception and design to construction, operation, maintenance, renovation and deconstruction. This

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practice expands and complements the classical building design concerns of economy, utility, durability, and comfort (USEPA, 2014). Nowadays in the world, there are considerable amount of investments to the green buildings than conventional buildings. It is more important to adapt the green concept in construction of buildings to achieve the benefits of sustainability (Mallikage, 2012).

According to the Rinkesh (2015), more benefits can be achieved through the green building concept. Those benefits can be categorised as environmental benefits, economic benefits and social benefits. Human Resource (HR) is the most significant factor in an organization to attain those benefits. Human Resource play a vital role in organizational success and it constitutes a significant source of competitive advantage by using their collective skills, abilities and experience, coupled with their abilities. To achieve organisational goals and objectives effectively and efficiently, Human Resource practices, procedures and systems should be developed and implemented based on organisational needs (Ogedegbe, 2014). Specially, the whole context of Human Resource Management is currently being considered in achieving sustainable goals of green buildings.

Green Human Resource Management (GHRM) is referred to all the activities involved in development, implementation and on-going maintenance of a system that aims at creation of green employees. GHRM is concerned with transforming normal employee to green employees to achieve environmental goals of the organization and finally to make a significant contribution to the environmental sustainability (Opatha and Arulrajah, 2014). As Opatha and Arulrajah (2014) further mentioned, employees may play four roles for becoming a green employee such as, preservationist, conservationist, non-polluter, and maker. Therefore, to achieve sustainable goals of green organisation, GHRM system is important to implement. Further, all the employees must be encouraged, empowered and trained (Sudin, 2011). Hence, the intention of this research is devoted to investigate the applicability of Green Human Resource Management concept to achieve sustainable goals of green buildings in Sri Lanka.

2. LITERATURE REVIEW

2.1. GREEN HUMAN RESOURCE MANAGEMENT (GHRM) AND IT'S IMPORTANCE

According to Lewis (2015), when organisations move towards green, it mainly affects to its profit. Further, 73 percent of consumers consider that companies have good environmental records. Customers seek a company which has low environmental footprint. Therefore, companies try to make their employees green. As Mandip (2012) stated, there should be a proper sense of balance between organisational growth for wealth design and protection of natural environment. Past decades people concern only about the profit and wealth of the shareholders of the company. Thus, each and every industry is currently paying more attention toward minimization of environmental footprints plus improving awareness to social and environment phase.

In this regard, GHRM refers to using every employee to support sustainable application and increase employee responsiveness and commitments on the problems of sustainability. At the same time, GHRM is frequently refers to the concern of managing people by leading them towards a broader corporate environmental schedule (Mishra and Rani, 2009). GHRM implements environmental friendly HR initiatives while enhancing efficiencies, lower costs and better employee engagement. It will benefits to decrease the employee carbon footprints by electronic filings, car sharing, job sharing, teleconferencing and virtual interviews, recycling, telecommuting, online training, energy efficient office space (Scribd, 2015). GHRM initiates the organisation to find alternative ways to bring down cost without losing their talent and it also gives assistance to create a culture of having anxiety for environmental defence (Prasad, 2013). Organisations provide much attention towards sustainability and corporate social responsibility. Sustainability provides the basis of long lasting solution for the business and it helps to improve the socio economic background of the organisation that connects with society. Therefore, sustainability plays a vital role in HRM (Mishra and Rani, 2009). Most of the organisations use human resource and environment management integrated approach to achieve sustainable goals (Mandip, 2012). Further, when implementing the sustainable goals for green building, it should be measurable and should be considered about energy efficiency, water conservation, on-site treatment of rain water and storm water, material and resource management. Nevertheless, it should be based on best practices where it further requires appropriate resources to achieve those goals within the given time frame, there should be time bound and should be based on best practises (USEPA, 2015).

2.2. GREEN HUMAN RESOURCE MANAGEMENT PROCESS

Green Human Resource is most often used to refer to the contribution of HRM policies and practices toward the broader corporate environmental agenda (Scribd, 2015). The GHRM process generally includes, green job analysis, green HR recruitment, selection, induction, training and development, performance management and discipline management (Renwick *et al.,* 2013; Opatha and Arulrajah, 2014).

Green Job Analysis

A number of environmental protection related task, duties and responsibilities can be used to specify job descriptions of employee (Wehrmeyer, 1996; Renwick *et al.,* 2013). Job description could include at least one duty related to environmental protection and also specifically includes environmental responsibilities. Job descriptions and person specifications may include environmental, social, personal, and technical requirements of the organizations as far as possible. For example, environmental protection duties should be included, along with the allocation of environmental reporting roles and health and safety tasks (Wehrmeyer, 1996).

Green HR Recruitment

Retention/recruitment and satisfaction is one the most vital benefit scopes of HR and sustainability. So gaining reputation as a green employer is an effective way to attract novel talent. Green recruitment can be defined as the process of hiring individuals with skills, knowledge, approaches, and behaviours that identify with environmental management systems within an organization. Green recruiting is a system where the focus is given on the importance of the environment (Wehrmeyer, 1996). As stated by Opatha and Arulrajah (2014), there are four categories of green HR recruitment, such as, green competencies, green attitude, green behaviour and green result.

Selection

Environmental concern and interest is the major focused context of selecting candidates for the organization. When interviewing candidates or assessing them for selection, environmental-related questions are asked by the selection panel is becoming a frequent factor. Certainly, these are some of the worthy green selection practices any organisation can adopt to select environmental friendly people (Opatha and Arulrajah, 2014).

Induction

For fresh employees induction give the first impression about what needed to understand and approach to their corporate environmental culture in a thoughtful way (Wehrmeyer, 1996). After selecting the candidates for the posts, these companies provide necessary basic information about the corporate environmental management policy, system and practices. Subsequently, organizations should ensure that new recruits understand their environmental responsibilities, become familiar with health and safety arrangements, appreciate the corporate environmental culture, adopt the company's environmental policy and practices, and know given relevant contact persons within the organisation (Wehrmeyer, 1996; Renwick *et al.,* 2013).

Training and Development

Providing environmental training to the organizational members (non-managerial employees and managers) to develop required skills and knowledge is an important function of green HRM. This will helpful to implement corporate environmental management programs of the company. In the green training program, employee should be able to develop and acquire the knowledge regarding the environmental management, green skills and attitudes (Prasad, 2013).

Performance Management

Green performance management consists of issues related to environmental concerns and policies of the company. It also concentrates on use of environmental responsibilities. When HR managers integrate environmental performance into performance management systems they safeguard environment management against any damage. Further, environmental incidents, usage of environmental responsibilities, reducing carbon emission and the communication of environmental concerns and policy can be covered by Performance Appraisal (Prasad, 2013).

Discipline Management

In green discipline management, it is required to enforce rules to carry out greening policies and practises and to establish a system to maintain a progressive disiplinary system within the organisation (Opatha and Arulrajah, 2014).

Accordingly, the applicability of GHRM is investigated in relation to HRM process which is practiced in green buildings in Sri Lanka. Therefore, the gaps in existing practice are identified relating to green job analysis, green HR recruitment, selection, induction, training and development, performance management, reward management and discipline management in order to propose probable strategies.

Section 3 describes the methodology adopted in this study to achieve the above aim.

3. RESEARCH METHODOLOGY

In order to achieve the research aim, qualitative research approach was identified as the most suitable method for gathering and analysing data. As this research required conducting a detailed investigation in HRM process in green buildings, case study method was applied. Three case studies were conducted in green certified office buildings in Sri Lanka. Eight semi-structured interviews were conducted with HR professionals and other employees in selected case buildings to collect the data. The interview profile is illustrated in Table 1.

Table 1: Interview Profile

Case		**Designation**
Case A	A1	Director (Geology)
	A2	Assistant Administrative Officer
	A3	Maintenance Supervisor
Case B	B1	HR Manager
	B2	Assistant HR Manager
	B3	Maintenance Manager
Case C	C1	Branch Manager
	C2	Assistant Manager

Code-based content analysis and cross case analysis techniques, together with QSR. NVivo software are used to analyse the data. In the data analysis, a coding structure is developed as illustrated in Figure 1.

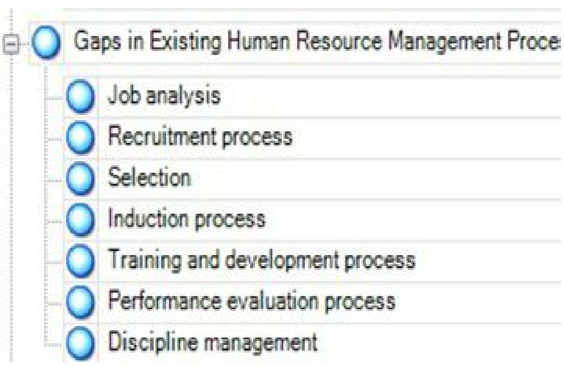

Figure 1: Coding Structure

Section 4 presents the case study data analysis and key research findings relating to applicability of GHRM in green buildings in Sri Lanka.

4. RESULTS AND DISCUSSION

The existing human resource management practice in green buildings was investigated and gaps are identified.

Job Analysis

According to case analysis, designing job without intention of sustainable goals of organisation and, not including green competencies into job specification are identified as major gaps in job analysis. as it further revealed, Director (Geology) in Case A stated that "*In the existing Human Resource Management process there is no clear work areas proposed for the job and this created confusion in work line. And the most important thing is job is not design to achieve sustainable goals in green building*". Further, in Case Assistant Administrative Officer mentioned that "*It is a government error, for not having a proper way to attach sustainability goals in government job analyzing procedure*". In case B both Assistant HR Manager and HR Manager said that *"In current situation we do not apply tasks to achieve sustainability goals."*

Recruitment

In recruitment process according to the maintenance supervisor in case A, *"government did not apply any statement in order to achieve sustainable goals in Green HRM concept.* Both Assistant Administrative officer and Director (Geology) in case A also mentioned that *"the government sector is still following the traditional method in recruiting people and it needs a change which will focus on green recruitment".* Also maintenance supervisor of case A stated *"government have to focus on the abilities of protecting the environment".* In case B, Assistant HR Manager, HR Manager and Maintenance Manager said that "*we didn't apply Green HRM concept in recruitment process. And yet we don't have any idea of applying Green HRM concept with recruitment process".* In case C, both Branch Manager and Assistant Manager said that *"we did not concern about linking green HRM and sustainable goals with the process of recruitment.* Accordingly, less concern on green and use of traditional recruitment process especially in government sector are identified as gaps in existing recruitment process in green buildings.

Selection

In the existing selection process, there are no evaluation criteria for green competencies. Assistant Administrative officer of case A mentioned that, *"there is no step which links the procedure with Green Movement."* In case B Maintenance Manager also said that *"we don't evaluate their knowledge in Green Competencies."* Assistant HR manger and HR manager confirm that statement as *"we don't judge their awareness on Green HRM concept in selection process."* Further, Assistant HR Manager said that *"we don't evaluate their knowledge regarding Green HRM concept as because they should adopt to protect environment and achieve the sustainable goals while they engage with their work in the company."* Furthermore, there is no rewarding system for achievement of sustainable goals by green employees.

Induction

No any case organisation has linked green concept to induction program of employees. In case A both Director (geology) and Assistant Administrative Officer said *that "it is still unaware that this step can link with Green HRM in order to achieve Sustainability Goals."* In case C, both Branch Manager and Assistant Manager said that *"we did not link induction process with Green HRM concept"* Further, the development of green abilities of employees is also not considered in the induction program.

Training and Development (T&D)

According to Maintenance Supervisor in case A, they are not following any kind of training programs to improve knowledge of employees on green concept. As Director (Geology) said *"we have training programs for employees but they don't improve their knowledge regarding Green HRM and sustainable goals."* Further, Assistant HR Manager and HR Manager in case B said that "*we don't practice green competencies of employee in training and development programs."*

Performance Management

According to Maintenance Supervisor in case A, *"It is vital to include some criteria to evaluate environmental protecting performance of the employees."* In case B according to Assistant HR Manager he said that *"every department in the company has a particular zone to grow trees and the functioning of the process is evaluated by them"*. Both HR manager and Maintenance Manager confirm the statement of Assistant HR Manager. In case C both Branch Manager and Assistant Manager said that "*we don't have any evaluation procedure to analyse the knowledge on green HRM concept of their workers."*

Discipline Management

In case B there is no rules in discipline management process. Assistant HR Manager said that "*we are strictly observed how they maintain their zone which the company allocate to grow trees*" According to Branch Manager and Assistant Manager in case C said that "*we don't have green concept on discipline management* ." Assistant Administrative Officer (AAO) in case A expressed that "*implementing rules and make it to work in the institutions should be a must, and that will be very important fact in functioning the green human resource management in the institute.*" Hence, no rules and function to control the employee behaviour regarding Green performance and no proper procedure regarding the green behaviour of the employees are identified as gaps in existing discipline management process. The identified gaps in existing HRM process are summarised in Table 2.

Table 2: Gaps in Existing Process

HR practice	Gaps
Job Analysis	Job is not design to achieve sustainable goals Green competencies has not been included in to job specification
Recruitment	Use of traditional method for the recruitment process Less concern on green concept
Selection	No evaluation criteria for green competencies of employees No rewarding system for achieving sustainable goals
Induction	Fewer knowledge to adopt green concept into induction Less concern on developing green abilities of employees
Training and Development	Not facilitating training programs to develop green competencies
Performance Management	No criteria to evaluate environmental protecting performance of employees No any procedure to evaluate achievement of sustainable goals
Discipline Management	No rules and function to control the employee behaviour regarding green performance No proper procedure regarding the green behaviour of the employees

As per the different views and opinions of the HR professionals and key literature findings, probable strategies are proposed to apply GHRM concept in green buildings to fill the gaps in existing process. Accordingly, a framework is developed as the final outcome of the research and illustrated in Figure 2.

Gaps in existing process		Suggestions to overcome
▪ Job is not design to achieve sustainable goals ▪ Green competencies has not been included in to job specification	**Job analysis**	▪ Adding green competencies into job specification ▪ Introducing environmental defence connected task, duties and responsibilities
▪ Use of traditional method for the recruitment process ▪ Less concern on green concept	**Recruitment**	▪ Introducing new recruitment criteria concerning the green concept ▪ Recruiting people who aware about green concept
▪ No evaluation criteria for green competencies of employees ▪ No rewarding system for achieving sustainable goals	**Selection**	▪ Introducing criteria to evaluate green competencies of employees ▪ Environmental concern and interest should be checked ▪ Knowledge and ability of green should be checked
▪ Less knowledge to adopt green concept into induction ▪ Less concern on developing green abilities of employees	**Induction**	▪ Green awareness program for new employees
▪ Not facilitating training programs to develop green competencies	**T&D**	▪ Training program for employees to aware about sustainable goals of organization ▪ Special training programmes by expertise in green sector
▪ No criteria to evaluate environmental protecting performance of employees ▪ No any procedure to evaluate achievement of sustainable goals	**Performance management**	▪ Criteria to evaluate the achievement of green goals ▪ Level of achieving green competencies should be evaluated ▪ Introducing environment protecting performance
▪ No rules and function to control the employee behaviour regarding green performance ▪ No proper procedure regarding the green behaviour of the employees	**Discipline management**	▪ Introducing rules and policies for environmental protection ▪ Organizing awareness programmes on green behaviour

Green Human Resource Management

Achieving sustainable goals of green buildings

Figure 2: The Framework Developed

5. SUMMARY

In improving organisation's environmental performance, people factor is one of the key factors. To create, practice and maintain environmental related innovative behaviours of employees coupled with right attitude of greening, green HRM practices are critical. Without proper green HRM practices, it is difficult to create and maintain sustainable environmental performance. Hence, as this research aimed, the applicability of GHRM was investigated in green buildings in Sri Lanka. Through the case analysis, gaps in existing HRM process are identified. As investigated, there is no proper HRM procedure in green buildings to convert employees to green employees in order to apply them effectively to achieve its sustainable goals. Further, no any step in HRM process has been considered about the green building concept. Therefore, several strategies can be applied to incorporate green concept into HRM process in green buildings. Hence, as the main implication of this research, the gaps in job analysis, recruitment, selection, induction, training and development, performance management and discipline management are identified. Accordingly, a framework is developed by proposing probable solutions to fill the gaps identified. Further, it can be used as a basis to effectively utilize human resource for achieving sustainable goals of green buildings in Sri Lanka as the main implication of this research.

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APPROACHES TO FOSTER GREEN BUILDING CONSTRUCTIONS IN SRI LANKA

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ABSTRACT

With world's trend, though the Sri Lankan government has taken a substantial effort for local green building movement, still it has not become as a major and pressing concept in Sri Lanka due to several barriers. Those barriers could be identified under five key areas as financial barriers, regulatory barriers, social barriers, knowledge/skills barriers and industrial barriers. Thus, the purpose of this study is to recommend the probable approaches to foster green building constructions in Sri Lanka by overcoming the existing barriers.

A qualitative research approach was adopted for attaining the research aim while conducting semi structured interviews with 15 local professionals who are in local regulatory bodies for green buildings and sustainable constructions, who are involving with green building constructions as well as who have not still involved with green constructions but expect it in future. The findings were analyzed with content analysis technique. It was recommended to follow simple and primary green strategies, take the correct consultation, implement mandatory regulations, make collaboration between existing authorities, increase public awareness, correct common misconceptions, provide knowledge and education, promote research and development, government takes the leadership and take the support from organizational managements as few major approaches to overcome the identified barriers for Sri Lankan green building constructions. The recommended approaches can be followed by industry players in order to foster green building constructions in national level, local level or organizational level and it will provide a basis to achieve the sustainability goal of Sri Lanka.

Keywords: *Barriers; Foster Green Building Constructions; Green Building Concept; Probable Approaches.*

1. INTRODUCTION

The Green Building has become as a salient concept in global construction industry in regard to protect the environment through sustainable development (Chan *et al*., 2009). According to the World Green Building Council in California (World Green Building Council, 2013), there are more than 140,000 green buildings registered globally. The Leadership in Energy and Environmental Design (LEED) green building rating system has been applied to more than 72,500 projects in the world (USGBC, 2015). In Asian context, Singapore is at the top among 62 surveyed countries worldwide (McGraw-Hill Construction, 2013) and India is the third best country in the world on LEED (Astarini, 2015).

Equally, Sri Lankan government also has taken a significant effort for local green building movement. However, Waidyasekara and Sandamali (2012) revealed that still there is no significant result on local green building practices and there are many challenges to achieve the sustainability goal of Sri Lanka. There are only 16 LEED certified buildings (Sri Lanka Business and Biodiversity Platform, 2014) and 15 certified buildings under GREEN^{SL} Rating (GBCSL, 2015). McGraw-Hill Construction (2013) identified the higher initial cost, lack of public awareness, lack of policy and governance, lack of coordination, lack of market demand and lack of trained green building professionals as barriers for green building movement in Asian countries.

Further, the improper understanding and misinterpretations within the society are the reasons for less embrace of sustainability concept (GBCSL, 2010 cited Waidyasekara and Sandamali, 2012). Therefore,

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this study aims to recommend the probable approaches to foster green building constructions in Sri Lanka by overcoming the existing barriers. Next section of the paper presents compressive review on Sri Lankan context of green building constructions.

2. Sri Lankan Context of Green Building Construction

With rapid growth of construction activities, adoption of green concept has become as a quick need in Sri Lankan construction industry (Waidyasekara and Fernando, 2013). Already there are several government rules and regulations in Sri Lanka that support the local green growth. The National Environmental Act established in 1980 and the Central Environmental Authority, Environmental Council as well as the District Environmental Agencies that were established under above act govern the environmental impact of local industries including construction industry with several rules and regulations (National Environmental Act, 1980). Additionally, the Sri Lankan government has introduced several national policies which indirectly drive the local green building movement as National Environment Policy (2003), National Energy Policy (2003), National Climate Change Policy (2011), National Air Quality Management Policy (2000), Cleaner Production Policy (2004), National Forestry Policy (1995), National Solid Waste Management Policy (2008) and National Bio safety Policy (2005) (Ministry of Environment Sri Lanka, 2012). The Green Building Council of Sri Lanka (GBCSL) works as the principal association by giving the foremost commitment in developing sustainable buildings in Sri Lanka (GBCSL, 2015). Thus, Ratnasiri (2012) identified several drivers for Sri Lankan green building constructions under three main categories (Refer Figure 1).

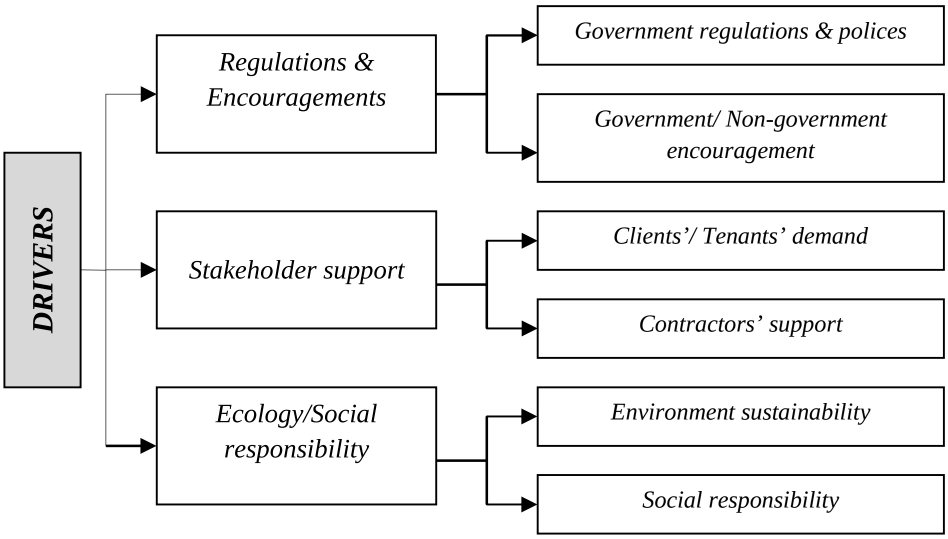

Figure 1: Drivers for Sri Lankan Green Building Construction

With above drivers, Sri Lanka already has LEED certified buildings as well as the buildings which are expecting to have the LEED certification in future (GBCSL, 2015). Sri Lanka has carried off the First LEED certified Green Hotel in the World; the Heritance Kandalama (Seneviratne, 2014). The other modern and innovative green construction in Sri Lanka is MAS Thurulie factory at Thulhiriya (MAS Holdings, 2015). Brandix Causual Wear Ltd. in Seeduwa is another highly recognized manufacturing company in Sri Lanka for its great environmental and social standards (OECD, 2012). Further, Jayalath (2010) mentioned the Hatton National Bank in Nittambuwa, CKT Apparel (Pvt) Ltd. in Agalawatte, Ulagalla Walawwe in Anuradhapura, Vocational training Centres in Ahangama and Ampara as other most identified green buildings in Sri Lanka.

Above mentioned green building practices are the evidences for the statement by Seneviratne (2014) that the Sri Lankan green buildings have a higher completion rate than other countries. But as per Waidyasekara and Sandamali (2012), this concept has been limited only for few buildings in Sri Lanka. Thus, it is important to identify the barriers for Sri Lankan green building constructions and search how to mitigate such barriers in order to foster green building constructions in Sri Lanka.

2.1. BARRIERS FOR SRI LANKAN GREEN BUILDING CONSTRUCTION

Many studies have identified various barriers and implementation difficulties of green building construction in many countries (Arif *et al*., 2009; Pedini and Ashuri, 2010; Bond and Perrett, 2012; Djokoto *et al*., 2014; Ametepey *et al*., 2015). Geelani *et al*. (2012) identified the higher initial cost as a major challenge associated with green buildings. Jayalath (2010) revealed that, there is 20 - 25% increment in construction costs of green buildings in Sri Lanka. It is substantiated by the fact that, the initial construction cost of Thurulie green factory building in Sri Lanka is 30% higher than a conventional factory building (Holcim Foundation for Sustainable Construction, 2009 cited Waidyasekara and Fernando, 2013). This financial barrier for green buildings is lifted up by the fact that, most of the benefits from green buildings can be achieved in long run with a high payback period (Kats 2003). Thus, Ametepey *et al*. (2015) identified the long Pay-back period as another barrier towards green building movement. On the other hand, Abidin *et al*. (2012) argued that, the government actions and guidance may be resulted for a pressure on the construction activities towards a better environmental safe guard. Though there is an adequate number of regulations and policies concerning the environmental protection, there is no any specific regulation or policy that directly focuses on the green building practices in Sri Lanka. As well as, lack of enforcement in existing government regulations and policies is another barrier (Hewage and Mallika, 2011).

There are common misconceptions of general public as green buildings are much more costly than traditional buildings and it is somewhat a difficult task to reach by middle or low class people (Azizi *et al*., 2015). Therefore, Djokoto *et al*., (2014) identified the lack of awareness as a serious barrier for green building constructions. Additionally, there is a resistance of people to change as they think that the change is always a challenge (CEC, 2008). Lack of professional knowledge is identified as another barrier for green constructions (Abidin *et al.*, 2012; Ametepey *et al.*, 2015). It is emphasized by the fact that the scarcity of professional knowledge may lengthen the green building development time frame (Choi, 2009). On the other hand, the inexperienced or untrained workforce may threaten the green building industry by increasing the risk (CEC, 2008). Further CEC (2008) revealed that averaged funding for green building related researches in United States of America (USA) is representing only 0.02% from the estimated annual value of USA building constructions. Thus, there is a lack of research investments on green building practices. Additionally, Financial Risks, Market Risks, Industry Risks, Performance Risks and Legislative Risks are identified by Pedini and Ashuri (2010) when going for a green building construction. Ametepey *et al.* (2015) identified several other technical barriers for sustainable constructions as lack of special materials that are environmentally sustainable, lack of demonstrations and lack of technology. Other than that, Ametepey et al. (2015) stated that the implementation of green building concept may be very difficult with the lack of support from management and leadership of the organizations.

By considering above exposed facts, the barriers for Sri Lankan green building constructions can be categorized as financial barriers, regulatory barriers, social barriers, knowledge/skills barriers and industrial barriers (refer Figure 2).

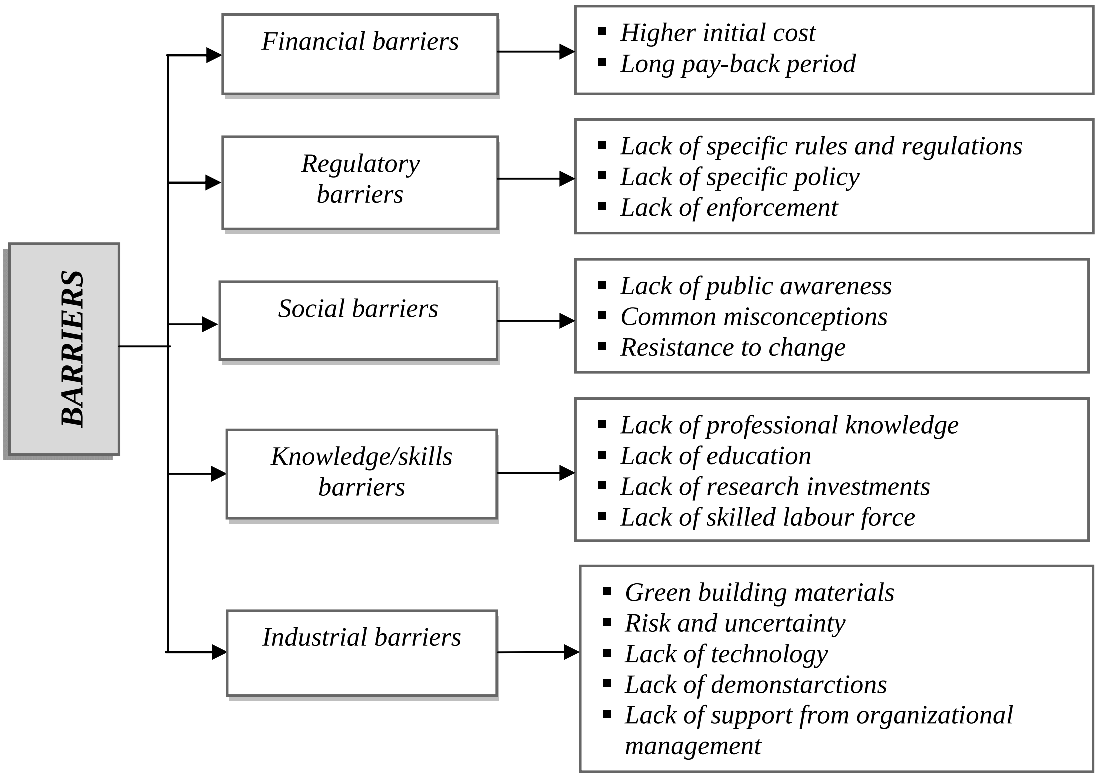

Figure 2: Barriers for Sri Lankan Green Building Construction

With identification of the reasons behind, it creates a further need of finding out the approaches to mitigate the identified barriers and next presents the methodology adopted.

3. RESEARCH METHODOLOGY

To verify the identified barriers and to recommend the probable approaches to mitigate those barriers, a qualitative research approach was adopted by carrying out the expert interviews. Semi structured interviews were selected as the mode of data collection with fifteen local professionals covering who are in local regulatory bodies for green buildings and sustainable constructions, who are involving with green building constructions as well as who have not still involved with green constructions but expect it in future (refer Table 1).

Table 1: Profile of Expert Interviews

Category of Experts	No. of Interviews
Local regulatory bodies	02
Experts involve with green building constructions	10
Experts not involve with green building constructions	03

Code-based content analysis technique with NVivo software was adopted to analyze the findings from interviews in order to recommend the probable approaches for existing barriers under five key areas as financial barriers, regulatory barriers, social barriers, knowledge/skills barriers and industrial barriers.

4. RESEARCH FINDINGS

As findings from expert interviews, it could be identified the severity of each identified barrier within the practical Sri Lankan context and various probable approaches to mitigate the each could be recommended under key five areas (refer Table 2).

Table 2: Recommended Approaches to Overcome the Identified Barriers

Key Area	Identified Barrier	Approaches to Overcome the Barrier
Financial Barriers	Higher initial cost	▪ Follow simple and primary green strategies. ▪ Select a suitable and honest green building consultant. ▪ Buy green products from a reputed company for a reasonable price and warranty. ▪ Achieve a majority of green features during design stage.
	Long pay-back period	▪ Follow the best design strategy as to achieve a shorter payback period. ▪ In determining the payback period, weigh on intangible benefits also. ▪ Consider the buildings' life span when applying green components. ▪ Reduce the cost of green buildings with low cost green strategies.
Regulatory Barriers	No specific rules and regulations	▪ Amending a provision in existing acts. ▪ Implement mandatory regulations for green buildings.
	No specific policy	▪ Apply more green building concepts into existing policies. ▪ Make collaboration between existing policies.
	Lack of enforcement	▪ Take acts and regulations into the action with hard rules. ▪ Take political support to implement and enforce the rules. ▪ Carry out a proper inspection for implemented rules.
	Unavailability of a responsible authority	▪ Appointing an authorized body for green buildings. ▪ Make collaboration between existing authorities.
Social Barriers	Lack of public awareness	▪ Conduct exhibitions, seminars and workshops. ▪ Conduct award ceremonies for green buildings and green professionals. ▪ Organize competitions within schools and offices. ▪ Give the publicity and awareness by media. ▪ Practice green concept within government buildings and other public places. ▪ Form social clubs for green buildings.
	Common misconceptions	▪ Give the correct awareness for clients by professionals. ▪ Give the correct publicity by media.
	Resistance of people	▪ Make more green building demonstrations and publish them. ▪ Explain to the people about the danger of ignoring this concept. ▪ Make people's minds with religious concepts to think about others and nature.
Knowledge/Skills Barriers	Lack of professional knowledge	▪ Conduct training programs for individual professionals. ▪ Conducts training programs for professionals as company wise. ▪ Consider the green certification for a professional as an important qualification. ▪ Conduct CPD programs for professionals. ▪ Include green concept related modules into university courses.
	Lack of education	▪ Include green concept related subjects into school

		syllabus. ▪ Give the knowledge in all 3 main languages of the country. ▪ Convert the schools, universities and other educational institutes into green.
	Lack of research investments	▪ Universities can play a significant role. ▪ Focus on green concept related R&D by private companies.
	Lack of skilled labour force	▪ Organize district or provincial training campaigns for construction labours. ▪ Integrate the green concept with industrial training courses in technical colleges. ▪ Allocate some amount from the contractors' fees of renewing their grades, to train labours.
Industrial Barriers	Lack of green building materials	▪ Introduce green production methods as self-occupations for village people. ▪ Encourage manufacturers who follow green production methods.
	Lack of demonstrations	▪ Government takes the leadership in converting buildings into green.
	Lack of support from organizational managements	▪ Give rewards for the management of green organizations. ▪ Introduce a green services certification system.

4.1. FINANCIAL BARRIERS

Financial barriers can't be identified as a major challenge to go for green buildings. The initial costs of green buildings are not always high. It may depend on several factors as building design and the technology used. That initial cost can be basically reduced by following simple and primary green strategies instead of using more advanced green technologies. As examples, to conserve energy, the buildings can be designed as to acquire the natural light and ventilation as much as possible with principles such as correct orientation, more openings and cross ventilation. As water conservation methods, it can be used advanced fittings for appliances which use low water amount with high pressure, used pipelines with small diameters and used rain water harvesting methods. As materials, it can be used green labeled materials which used a low energy consumption production process, used salvage materials after recycling and minimized the distance of material transportation. Further, the green concept promotes using of brown field lands instead of using vegie lands and also minimizing the material wastages. Thus, such primary green strategies actually reduce the unnecessary costs of constructions. Using advanced technologies such as solar panels is the next step for going green and they are not compulsory for buildings to be green.

Sometimes the costs of green buildings are unnecessarily increased by some parties by purposely. Therefore, the client should always be careful to select a suitable and honest green building consultant as major responsibility of reducing the cost is having for the consultant. A major part of the green concept can be achieved in the design stage of building without any additional cost. Thus, if the building design has been done well with a majority of green features, it can be achieved a lower initial cost as well as a shorter payback period.

4.2. REGULATORY BARRIERS

When it comes to the Sri Lankan context, the regulatory barriers identified from literature can be modified as no specific rules and regulations, no specific policy, lack of enforcement and unavailability of a responsible authority. Further, they are one of the major challenges in Sri Lanka to go for green buildings. It is better to amend a provision for green buildings in any existing act as National Environmental Act, Construction Industry Development Act or Urban Development Authority Act. Implementing mandatory regulations for green buildings is an essential approach in Sri Lankan context. As examples, it can be implemented the mandatory regulations to have the rain water harvesting in all buildings, to have the green roofs with solar panels for buildings in which the roof area is more than a certain limit, to convert the building walls into green, in which the vertical area is more than a certain limit or it can be imposed high tax for buildings in which have higher monthly electricity and water bill than a certain limit. On the other hand, it should be applied more green building concepts into the existing policies as National Environment Policy, Energy Policy, Climate Change Policy, Air Quality Management Policy, Cleaner Production Policy, Solid Waste Management Policy and Bio safety Policy.

Most of the acts in Sri Lanka are limited only for their names. Lack of political support also is one of the main reasons in Sri Lanka for the low enforcement of rules and regulations. Therefore, the existing acts and regulations should be taken into the action with hard and fast rules with the support of all political parties. Mainly the National Environmental Authority, Construction Industry Development Authority, Green Building Council of Sri Lanka and Urban Development Authority have to collaborate with each other to implement and enforce the regulations related to green building concept.

4.3. SOCIAL BARRIERS

Social barrier is another major challenge to implement the green concept in Sri Lanka. Through exhibitions, seminars, workshops, competitions and award ceremonies, the green building concept can be carried into the close with general public. The public media can play a responsible role to attract the end users to adopt the green building practices. The consultants and other professionals should give the correct awareness for clients in order to correct the common misconceptions of general public. It can be made more green building demonstrations and publish them with their benefits in order to reduce the resistance of people to go for green buildings. It should be given an urgent explanation for people about the danger in front of them if they ignore this green building concept. Additionally, it can be formed some social clubs for green buildings in order to promote this concept among youths.

As per the experts' opinions, it should be made a mental revolution in our people at first. Most people are going to the green concept by looking for their personal benefits as awards, certificates, reputation or profits. Thus, people's minds and attitudes should be changed as to go for green concept voluntarily with an intention of saving our Mother Nature and future generations.

4.4. KNOWLEDGE / SKILLS BARRIERS

Overcoming knowledge/skills barriers is very important for fostering green constructions in Sri Lanka. Producing knowledgeable professionals by conducting training and CPD programs is essential because they are the people who can carry this green concept into general public. It can be done in individually or in company wise. If the certification as a green professional is considered as an important qualification, then the professionals always try to get the knowledge and to be certified as a green building professional. To give an education on this concept, green related subjects can be included into the university courses, technical college courses and school syllabus. It is very important that, the knowledge should be given in all 3 main languages of the country as in Sinhala, Tamil and English. Then only the knowledge is spread to all levels of the society. Promoting green research and developments is a further important approach. In there, local universities and privet sector companies can play a significant role.

There is a responsibility on local contractors and on Construction Industry Development Authority (CIDA) to train the construction labors on green practices. It can be organized some training campaigns for those labors in district or province wise.

4.5. INDUSTRIAL BARRIERS

There are no industrial barriers as risk and uncertainty and lack of technology in Sri Lankan green building constructions and they are only our mental barriers.

Introducing green production methods as self-occupations for village people is a practical solution to increase the green construction materials in local market. Further, it can be encouraged the green product manufacturers by giving incentives, interest free loans, tax reductions and other benefits. The local government is the major party who should understand the importance and take the leadership in converting buildings into green. Therefore, it should be started from government buildings as schools, universities, hospitals, public libraries, government offices and other public places as train stations, bus stands, cities and parks. To motivate the organizational managements, it should be introduced some reward systems with high recognitions for those who go for green within their organization. The services sector of the country can be promoted to practice this green concept by introducing a green service certification system.

As highlighted by experts, fostering green building constructions in Sri Lanka can't be done by one party. Thus, every one such as the government, political parties, public media, general public, professionals, schools, universities, industry players, organizational managements and all other parties have to play a significant role in the green building movement of Sri Lanka.

5. CONCLUSIONS

Since many nations have identified the importance of going for green buildings, there is an emerging trend in global green building practices. In Sri Lankan context also there are several drivers for green building movement as regulations and encouragements, stakeholder support and ecological goals and social responsibilities. With those drivers, Sri Lanka already has the green certified buildings with higher completion rates but, it has been limited only for few buildings. Many studies show that still the green building has not become as a major and pressing concept in Sri Lanka.

Literature findings revealed that there are several barriers for Sri Lankan green building constructions under five key areas as financial barriers, regulatory barriers, social barriers, knowledge/skills barriers and industrial barriers. Hence, this paper recommends the probable approaches to mitigate the identified barriers in order to foster green building constructions in Sri Lanka.

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BEHAVIOUR CHANGE IN THE SUSTAINABLE BUILT ENVIRONMENT

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ABSTRACT

Humans are always driven by their sensation for adequate comfort. Occupants' behaviour is important in the built environment as it affects the building performance and the indoor comfort requirements. The built environment industry is moving towards high-performance buildings. However, high-performance buildings often fail to achieve 'as designed performance'. It is due to occupant behaviour. The purpose of the paper was to investigate the theoretical background of behavioural economics and its relevance in developing sustainable human behaviour in a building's lifecycle. Behaviour Economics uses the combined knowledge of psychology and economics to analyse and understand human behaviour. It has been successfully used to influence human behaviour in consumer markets, healthcare and insurance policies. This study explains six behavioural anomalies along with their applications in different industries. Behavioural anomalies such as Status Quo Bias, Incentives and Social Norms have been applied in consumer industry to create a positive impact on human behaviour. It concludes by highlighting the potential of applying behaviour economics in built environment and influencing occupant behaviour towards eco-friendly behaviour. This research study is a part of a research endeavour to develop strategies for office buildings' operation to change human behaviour towards more eco-friendly behaviour. It will be useful for built environment professionals to use these literature findings in design and operation strategies of an office building. It also provides a good initial research note for researchers working in the field of sustainable human behaviour.

Keywords: *Behavioural Economics; Energy Consumption; Occupant Behaviour; User Energy Behaviour.*

1. INTRODUCTION

Energy crisis in the built environment can be traced back from the 1970s. The research focused on the energy crisis in the 1970s highlights the relevance of consumer behaviour, lifestyle and attitude in the analysis of energy issues (Katzev and Johnson, 1983). The human dimensions of energy conservation focusing climate change and sustainability were further established in the 1990s (Sweeney *et al*., 1997; Stern and Dietz, 2002). Human behaviour and its consequences on the environment have attracted researchers from sociology, psychology and economics towards energy research (Osbaldiston and Schott, 2011; Abrahamse *et al*., 2005). The occupant behaviour can influence the building energy usage across the globe hence impacting the 40% of the world's annual energy consumption (Omer, 2008). Workplace occupant behaviour can lead to considerable amount of money. 1E (2009) suggest that US office workers waste 2.8 billion dollars annually by bad practice of not shutting down computers when they leave the office. It also suggests that single company with 10,000 computers spends $260,000 along with 1.871 tons of CO_2 in the environment due to computers left switched on during the night and the weekend (1E, 2009; Yun *et al*., 2013). The paper aims to explore behavioural economics literature to identify behavioural economics anomalies that can be used to influence occupant behaviour in the built

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enviornment. The paper has used latest references in a multi reference sentence in order to adhere to conference format and guidelines.

2. OCCUPANT AND BEHAVIOUR CHANGE

Human behaviour and behaviour change literature is very vast and extensive (Maio *et al.*, 2007). The paper limits its focus on behaviour change relevant to the built environment. Occupant behaviour can play a substantial role in reducing greenhouse gas (CHG) emissions and energy use (Frederiks *et al.*, 2015). There has been a rise in research interest focusing the occupant behaviour in the built environment and sustainability (Wolfe *et al*., 2014). Behaviour change is crucial for high-performance buildings as these buildings often fail to achieve their “as designed performance” due to occupant behaviour. The highest energy use buildings are driven by the energy loads of occupant activities as contrary to basic building system (Turner *et* al., 2008; Wolfe *et al*., 2014). The building performance is highly influenced by occupant behaviour and can vary a lot. A study of 121 LEED-rated buildings (Leadership in Energy and Environmental Design) reflects that 30% of the buildings perform better than expected, and 25% perform worse than anticipated and few have serious energy consumption issues (Turner and Frankel, 2008; Hauge *et al*., 2011).

Energy-related behaviour has numerous models. These models on energy behaviour suggest that overall there are two types of behaviour; the first one is the high-frequency behaviour involving activities that influence daily energy usage. It includes activities like operating appliances, lights and setting thermostats on a daily basis. The second is the low-frequency behaviour that involves activities that influence energy consumption in the long timeline. It includes activities like buying energy using appliances (Van Raaij and Verhallen, 1983; Stern and Dietz, 2002; Laitner *et al*., 2009, Karatasou *et al.,* 2014).

The literature focused on energy usage theory identifies three theories that relate to individual decision making involved in energy consumption (Wilson and Dowlatabadi, 2007; Moezzi and Lutzenhiser, 2010; Karatasou *et al*., 2014).

- Conventional and behavioural economics
- Social and environmental psychology
- Sociology

This paper seeks to understand behavioural economics to understand human behavioural traits and anomalies around decision-making process.

3. BEHAVIOURAL ECONOMICS

Behavioural economics uses the combined knowledge of psychology and economics to analyse and understand human behaviour at individual and group level (Thorgeirsson and Kawachi, 2013). It agrees with the standard economics models that markets and incentives play a significant role influencing human behaviour. However, it departs from the standard economics model in three behavioural traits; bounded rationality, bounded willpower, and bounded selfishness (Mullainathan and Thaler, 2000). It seeks to provide accurate explanations regarding the emotional responses and cognitive abilities of humans in an efficient decision-making process. It analyses both organisational rules and norms of social interaction, also considering unique circumstances (Schwartz, 2007; Gradinaru, 2014).

Behavioural economics questions the traditional economics theory base, its human behaviour modelling and principles of utility and rational choice (Darnton, 2008). Economics is a social science with its core point derived from its understandings of humans and their behaviour (Paula-Elena, 2013). The standard economics uses a rational choice model that assumes that humans make behavioural decisions based on a rational calculation of the expected cost and benefit. It follows neoclassical models of assuming human to be homo economicus or economic man or Econ. The Econs are forward-looking and perfectly informed and take fully rational decisions without any influence of external or contextual factors (Wilkinson and Klaes, 2012). The rational choice model has been challenged and criticised by social scientists and economists (Sen, 2009; Stiglitz, 2002). Behavioural economics combines the knowledge and research of psychology and economics to identify irrational behavioural patterns and anomalies in human behaviour.

Herbert Simon was one of the early scientists to work on behavioural economics. He postulated that economics and psychology should be reunited to develop a better understanding of human behaviour and decision-making process. He proposed the concept of 'bounded rationality' of human nature and challenged the main assumptions of rational choice theory and traditional economics (Simon, 1955). 'Bounded rationality' concept advocates the limited capability of rationality in humans and their behaviour. It states that humans adopt thumb rules or mental shortcuts, also called 'heuristics' to solve a problem or take a decision (Schwartz, 2007). These 'heuristics' are useful but can lead to errors and wrong decision in some situations depending on the context and complexity of the problem (Thorgeirsson and Kawachi, 2013). Many behavioural anomalies are considered as an outcome of bounded rationality. Some of these are anchoring, status quo bias and loss aversion.

Tversky and Kahneman jointly researched on effects of heuristics on human judgement, human choice behaviour under risk and framing effects and their implications for rational-agent models (Tversky and Kahneman, 1973; Kahneman and Tversky, 1979; Tversky and Kahneman, 1992; Kahneman, 2003). The primary research focus of Tversky and Kahneman was psychology. Economist Richard H Thaler worked towards theorising and applying behavioural economics concept in economic hypothesis and research (Thaler and Sunstein, 2008; Thaler, 1980). The principles and concept of behaviour economics have been implemented in consumer markets, policy development of sustainability strategy and governance.

Thaler and Sunstein proposed choice architecture as a primary tool of applied behaviour economics (Thaler and Sunstein, 2008). The choice architecture uses framing effects to nudge humans to make a better choice. Choice architecture follows a movement known as 'Libertarian paternalism'. It applies knowledge about how humans make their decisions and frame the choice situation in such a way that most people will make right choices (Leonard, 2008). A good choice architecture uses six principles to nudge human behaviour towards better choices. These are incentives, understanding mappings, defaults (status quo Bias), giving feedback, and expect error and Structure complex choices (Leonard, 2008, Thaler *et al.*, 2014). The next section explores different behavioural anomalies and how they can be used to influence occupant behaviour.

4. BEHAVIOUR ANOMALIES

Humans exhibit very poor rational behaviour and demonstrate a broad range of cognitive biases and behaviour anomalies in their daily behaviour and less general behaviour. This part reviews different behaviour anomalies that are related to principles of behaviour economics and behaviour change. It also explores various strategies to implement these anomalies to change office occupant behaviour towards more sustainable behaviour.

4.1 STATUS QUO BIAS / DEFAULT SETTING

Most decision-making processes have default option in a spectrum of other choices. This option comes into force when there is no active choice. This behaviour is due to individual's inertia that makes them defer a decision making an effort and go with the pre-set options. It increases when the amount or complexity of information increases (Kahneman *et al*., 1991). A structured default option can help to maximise the benefits of individuals as it can influence behaviour without regulating individual choices (Dolan *et al*., 2012). The default option strategy has been used in the various industries and settings by policy makers. The policy makers usually provide a default option with a 'prompted' or 'required' choice to avoid a scenario when individuals are not choosing any option. Evidence suggest that reception of energy related programmes and initiatives adoption can be raised using the automatic enrolment for all the customers and disinterested customers can opt out from the suggested default option. This strategy has been used to boost the usage of green electricity by offering it as a default option rather than 'grey' electricity (coal or atomic) as the default option (Pichert and Katsikopoulos, 2008). The literature also indicates that interventions can influence consumer's daily behaviour. The interventions can directly target daily energy-related practices like dishwasher's default option as cold water and washing machine's default programto 'short cycle' (Frederiks *et al.*, 2015). Similar interventions can be used to influence consumer behaviour at workplaces by setting least energy using option as the default option for various electrical appliances. Sensor operated lights can be used as default option for office occupants. It provides occupants with default option that is convenient, non-intrusive and helps to save energy.

4.2 THE FRAMING EFFECT

The rational man in the traditional economics has consistency in this choice behaviour, and it is not affected by the framing of the choices. This view was challenged and invalidated by the formulation of "prospect theory". The theory states that individual assesses options and changes on their reference point (Kahneman and Tversky, 1979). The framing effect means that frame of reference may be influenced by how a choice is presented and thus affecting the payoff decision (Miller, 2006; Gowdy, 2008).

The informed feedback affects the individual's behaviour. Energy behaviour of a person may be influenced by feedback (Tetlow *et al*., 2012). However, the way feedback information is framed can have an enormous influence on the decision-making process of the individuals. The framing effect can be used in the feedback of energy behaviour and paper usage of office employees. Office management can monitor the energy and paper consumption of each department and use the information to provide monthly feedback using departmental ranking. By framing the 'ranking' in the feedback would motivate the employees to use less energy and paper.

4.3 INCENTIVES

Incentives have been central to economics and human behaviour. They have been used in different policies and strategies to influence human behaviour. Behavioural economics has highlighted various aspects that affect how individual respond to incentives at decision-making situation. This paper highlights few aspects that are relevant to energy behaviour.

RISK AVERSION

Behaviour research suggests that humans prefer to avoid risk even with given prospect of positive gains. Humans are more risk averse when faced with the high probability of gains or uncertain losses whereas they become more risk-seeking when confronted with certain losses or uncertain gains(Tversky and Kahneman, 1992). The long-term, low-frequency energy behaviour on investment in energy-saving products has been influenced by highly unreliable electricity supply, market prices and long-term financial payoffs (Kuliasha and Zucker, 1992; Hirst and Brown, 1990). The household energy market provides offers like discounts, rebates and money-back guarantees for financial risks in the market. Time risks are reduced by quick delivery and installation whereas effort risks are reduced by providing simplified product design and helpful customer service. Other perceived risks are tackled using free samples, trials, extended warranties and different safety certifications (if required) (Lantos, 2015).

LOSS AVERSION AND REFERENCE FRAME

Human behaviour research suggests that individuals dislike losses than they like gains of the same amount (Kahneman and Tversky, 1979). Literature suggests that individual's brain and emotional system mediates decision biases based on fear of loss (De Martino *et al.*, 2006). The fear of loss has a higher effect on decision-making process than the probability of gain (Kahneman *et al*., 1991). Behaviour economics studies also highlight the importance of reference point. The value of something depends on the reference point of view. The change is large or small based on the reference point of an individual's perspective (Kahneman and Tversky, 2000; Dolan *et al*., 2012).

Studies suggest that feedback to the consumer on energy saving messages can have higher memorable and motivating effect if they are framed to highlight individual's loss in environmental and cost parameters. The messages have more impact if they indicate a future loss to individual than highlighting benefits or payoffs (Cheng *et al*., 2011). The communication messages have a higher impact on consumers if they reflect the energy or monetary loss in the messages rather than potential gains by changing their energy behaviour (Gonzales *et al*., 1988). Office management can use print and electronic medium to highlight the loss of energy due to occupant's actions and communicate the energy loss in terms of 'bonus money'. The management can use framing technique to relate the energy wastage, water wastage to money loss in their bonus budget to motivate employees to save water and electricity.

4.4 SOCIAL NORMS

Individuals are influenced by the behaviours of other humans. They make social comparisons and follow the behaviour of others to conform to social norms to meet socially acceptable and expected the behaviour of a group or society (Cialdini, 2003). Social norms may be behavioural expectations, rules or standards within a group or society. An individual's conformity to a certain group's behaviour can be triggered simply by merely observation and communication (Cialdini and Goldstein, 2004).

A research study used social norm approach to increase seatbelt usage by the citizens of Montana, USA. The initial data collection suggested that 85% used seatbelt but reported a perception of 65% seatbelt usage by a fellow citizen. A state wide social campaign leads to an increase in self-reported seatbelt usage (Linkenbach and Perkins, 2003). A study focusing towel recycling behaviour of hotel room guest indicates that when a sign was used to request guest to recycle towels led to 35% recycling. When the sign used social norm to indicate the most guest recycled their towels at least once resulted in the increase in compliance (44%). The sign was then changed to indicate that the previous guest recycled the towels at least once during their stay led to an increase in compliance up to 49%. This result indicates the simple yet focused social norm can influence human behaviour to a great extent (Cialdini, 2003). Research suggests that continuous reminder of the about individuals' performance among the society can help to influence the behaviour. It has been proved in an energy behaviour experiment where only 2% improvement was observed at the beginning of the experiment. However, the intervention effects indicated slump between the communications and then rose again upon receipt of next feedback (Allcott, 2011). The research on social norm also highlights that descriptive feedback on above-normal performance can backfire. In a social norm experiment focusing residential energy, households with above average energy usage decreased their energy usage after receiving the energy feedback. However, the household with below average usage increased their energy usage after a detailed energy feedback. This 'boomerang effect' was avoided by using an injunctive norm (smiley face emoticon). It is due to the human behaviour tendency to shift their behaviour towards the social norm (Ayres *et al.*, 2013). Office management team can use social norm technique to influence the office employees. The team can place posters with messages that relate to office staff. These messages could highlight the social norm of energy, water and paper conservation, and waste management in the organisation. Office management can monitor energy, water and paper usage at company and departmental level. The feedback could use smileys and colour themes to indicate the performance benchmarked at office, country or global level to motivate employees to change their behaviour. The monthly feedback would help to reinforce the message and continue the behaviour change momentum.

4.5 AVAILABILITY HEURISTICS

Behaviour research suggests that individuals draw decisions based on readily available information in the brain (availability bias). This information is usually from the family/friends and recent and frequently heard examples (Tversky and Kahneman, 1973; Gabrielcik and Fazio, 1984). This readily available information influences individual's decision-making process and its outcome. Energy saving behaviour can be influenced by providing or placing energy saving behaviour messages at places that are highly visible to the target audience. These messages can be favourable customers' testimonials, common energy saving habits and simple prompts associated with energy conservation. Simple visual and auditory reminders and prompts can have considerable positive impact on pro-environment behaviour (Bekker *et al*., 2010; Tetlow *et al*., 2014). Thaler and Sunstein highlighted the use of 'Ambient Orb' that provides a simple signal of electricity usage by the intensity of glow and colour change to indicate the energy usage lead to a decrement in peak energy consumption by 40% (Thaler and Sunstein, 2008). Similarly, visual and auditory reminders can be used to indicate water, energy and paper usage. The monthly feedback sometimes creates a 'boomerang effect'. The employees that perform well once would be less careful during the next month. Instead, office management could motivate the teams/department at weekly frequency by an e-mail or weekly announcement about company and departmental targets. The readily availability of feedback on performance could help to avoid the boomerang effect in employee behaviour. This strategy can be used as an active method to influence occupant behaviour rather than providing information to create a reactive action after the monthly behavioural energy performance.

4.6 PRIMING

Priming means activating of knowledge in memory to make it more accessible and influential in enabling new stimuli effect (Gabrielcik and Fazio, 1984; Richardson-Klavehn and Bjork, 1988; Dolan *et al*., 2012). Primes could be perceptual, action and semantic (LaBerge and Buchsbaum, 1990; Strack and Deutsch, 2004). Human behaviour can be altered if their senses are exposed to words, views and sensation (Williams and Bargh, 2008; Bargh and Chartrand, 1999). The literature suggests that sound and words can be used as prime to influence individual's behaviour. People were observed to walk slowly and exhibited poor memory of the experimental room when they were exposed to elderly related words. They words related to old age had primed the subject to behave in an associated manner (Dijksterhuis and Bargh, 2001). In another experiment, subjects were primed with subjects like collaborate, trust, and share before a public goods game. The results indicated an appreciation of the public good contribution by the subjects (Drouvelis *et al*., 2010). Similarly, sights and views also play a significant role as priming agents and influence individuals' behaviour. A happy face presented to a drinking subject influenced then to drink more than those subjects exposed to a frowning or angry face. Regarding smell, research indicates that air quality and the smell of air can act as prime and change individuals' cleanliness perception of the surrounding and influencing behaviour to conduct them to keep surrounding clean as compared to their normal behaviour (Holland *et al*., 2005; Dolan *et al*., 2012). Priming can be used to influence occupant behaviour using various strategies. Indoor surfaces (walls, partitions) can be used to develop a collage of pictures and messages to influence occupant behaviour. For example, kitchen (pantry) and washroom walls can be used to install photographs of water scare areas or situations to prime occupants to use less water. Words and motifs related to scarcity of water, energy and motivational words related to sustainability can be placed to prime occupant behaviour.

5. CONCLUSION

The research study outlines an understanding of occupant behaviour and its importance for achieving sustainability in the built environment. The energy crisis in the built environment and its relation to human behaviour can be traced back from the 1970s. Occupant behaviour plays a substantial role in energy usage in the built environment. The aim of the paper was to investigate occupant behaviour theories and their effect on building operation and energy usage in the building. Literature highlighted different types of energy-related behaviour. These are investment and habitual behaviour, purchase - usage - maintenance behaviour, efficiency and curtailment behaviour. The research study investigated the anomalies in human behaviour. Behaviour economics has been an area of interest for many research scientists in the field of psychology and economics. Behaviour economics has helped to explain many human behaviour tendencies that don't follow the rational human behaviour principles. The study reviewed behaviour economics and six behaviour anomalies that help to demonstrate a broad range of cognitive biases in human behaviour. The status quo bias is used to influence highly frequent decision-making processes by providing default option to humans and change their behaviour. Insurance and software companies have used this anomaly widely to influence human behaviour. Similarly, the framing effect has been used to frame choices/options to change the target audience/consumer behaviour. Incentives have been used in all the industry to change human behaviour. Behaviour economics also underlines the importance of social norms and various public policies are designed to use social norm to alter the conduct of the mass public. Similarly, availability heuristics and priming have been used in various individual and group level activities to influence the human decision and behaviour. The study has highlighted these anomalies that affect human behaviour. There is an enormous potential to apply behavioural economics to influence or nudge occupant behaviour in the built environment to promote energy saving action. The researcher aims to use this literature review as a base for developing behaviour change strategies to promote eco-friendly and sustainable behaviour for occupants in the office environment. This paper can also act as a good starting point for future researchers who seek to develop an understanding of behaviour economics and its application for occupant behaviour change in the built environment.

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BLACK SWAN EFFECTS ON THE REAL ESTATE ENVIRONMENT: A CONCEPTUAL FRAMEWORK

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ABSTRACT

Unpredictable events can have a major impact on real estate, yet they are often overlooked in many property decisions. This research looks at linking property market analysis to Black Swan (BS) Event theory, a term made famous by Taleb (2008) as those unpredictable disastrous events which have three key characteristics: rarity, extreme impact and retrospective predictability. The research takes the form of a narrative synthesis applying a literature review approach to define an extensive range of BS events into a conceptual framework so as to measure the impact on property markets with reference to risk and uncertainties.

For property asset managers, this is important as BS events can be related to the impact on Place/location and Space/operation. To improve the resilience and reduce vulnerability towards these events, property strategies can embrace new disaster management research and so lower the impact of Place risk, although improved connectivity makes global organisations more vulnerable to space risk failure after a major BS Event. In this paper, BS management models are funnelled to the antifragility concept, as a positive sensitivity to increases in volatility. Finally, the study offers a conceptual framework of illustrating the relationship between BS effects and its respective fragile and antifragile strategies.

Keywords: *Antifragility; Black Swan Effects; Black Swan Management; Randomness; Real Estate Environment.*

1. INTRODUCTION

In the past, key underlying macroeconomic indicators have been the driving forces behind the trend in real estate performance. This has implications of modelling property market performance using macroeconomic variables as systematic risk factors. Further, property market modelling is based on standard assumptions of mainstream economics: stable preferences are acting on a perfect market, accessible information, and homogenous products that derived from historic data. Thus, they can fail when stable assumptions cease to hold and extreme volatility occurs, as featured by the recent severe price swings associated with Global Financial Crisis (GFC). Hence, most investors accept the fact that their future performance predictions are imperfect and their investment activities will, inevitably, involve risks (Hargitay and Yu, 1993; Higgins, 2014b; Mandelbrot and Hudson, 2004; Ohman *et al.*, 2013).

These major downside risks are often outside the regular expectations and commonly referred as statistical outliers (outside ± 2 standard deviations) and also termed as risk associated with the lower tail in the normal distribution (Granger, 2010; Higgins, 2014b). Taleb (2008) coined 'Black Swan' to describe these unexpected random events that form part of our lives. Similarly, Brooks and Tsolacos (2010) identified such unpredictable, short lived events as 'noise in the market'. Further, these shocks extended into a broader depth that cover natural, man-made and hybrid disasters. Hence, this research paper aims at conceptualising BS theory in a property environment by bringing forth different authors' interpretations to a single platform.

The structure of this paper begins with a background of defining the BS concept. Section Three identifies different types of BS events along with the respective categorisation in the model/data dichotomy and natural and non-natural disaster classification. Section Four elaborates the phenomena of rare and extreme

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events aligning with two types of randomness. Then the literature review extended into analysing the impact of BS events linking into the possible management strategies on real estate environment. The last section provides the conceptual framework with concluding remarks.

2. THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE

Unpredictable events are labelled as a concrete and precise category of knowledge named 'unknown', 'improbable' or 'uncertain', but according to Taleb (2008), it is simply the lack of knowledge. For instance, before the discovery of Australia, elsewhere in the world convinced that all swans are white. The sighting of the first BS illustrates the fragility of knowledge. Taleb (2008) coined the term "Black Swan" to describe these random events which have the following three key characteristics:

> First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable (p. xvii).

These three characteristics of BS events can be summarised as rarity, extreme impact and retrospective predictability. The exposure to BS effect is having a membership in the extended disorder family: (i) uncertainty, (ii) variability, (iii) imperfect, incomplete knowledge, (iv) chance, (v) chaos, (vi) volatility, (vii) disorder, (viii) entropy, (ix) time, (x) the unknown, (xi) randomness, (xii) turmoil, (xiii) stressor, (xiv) error, (xv) dispersion of outcomes and (xvi) unknowledge (Taleb, 2012).

Similarly, Aven (2013) defines BS as a surprisingly extreme event relative to one's belief/knowledge. This surprising aspect must always be understood in relation to by whom and when. The following Figure 1 illustrates this. Let C denotes the consequences of the activity in relation to the values such as life, health, environmental, assets and the like. Risk assessment of the activity is conducted at present and as the time goes by C may be realised. If the consequence deviates from the risk assessment then it has become a surprise as illustrated in the Figure 1. Such surprising accident is a BS event which the risk analyst had not predicted before.

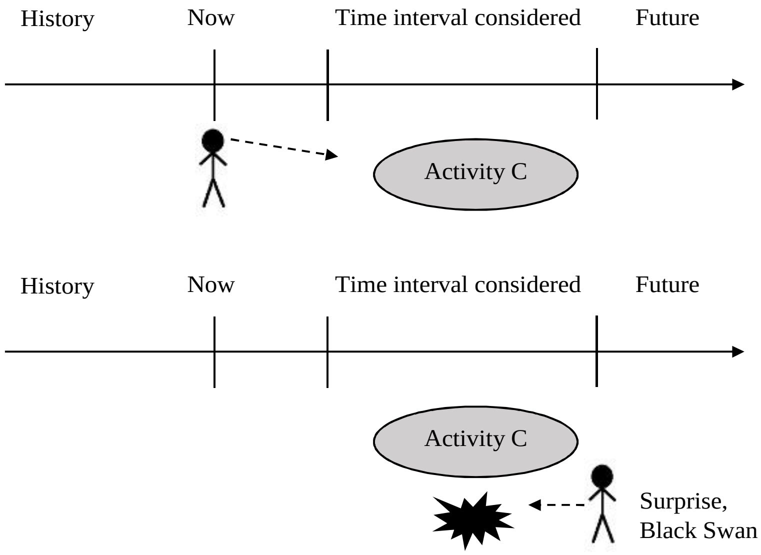

Figure 1: The Black Swans' Surprising Aspect: Micro Perspective
Source: Aven (2015)

In a macro perspective, looking at a large number of such activities, for example, a risk assessment is conducted and it is concluded probable consequences. Subsequently, one cannot say that it is a BS if such an event which included in the list of probable consequences, actually occurs. Therefore, one must be carefully interpret the perspective when discussing whether an event is a BS event.

Earlier, these rare and extreme consequences associated with BS events are included in the definition of disaster. The Oxford dictionary (2011) defines disaster as: "A sudden accident or a natural catastrophe that causes great damage or loss of life, an event or fact that leading to ruin or failure" (p. 407). Similarly, Asian Disaster Reduction Center (2003): "A serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources".

3. TYPES OF BLACK SWAN EVENTS

The term BS is used to express any of these types of events, tacitly assuming that it carries an extreme impact (Aven, 2015). There are a number of different approaches, strategies and measures that can be used to confront such events. Aven and Krohn (2014) identified three main types of BS events along with the definition by Aven (2013) as:

i. Events completely unknown to the scientific environment,

ii. Events not on the list of known events from the perspective of those who carried out a risk analysis but known to others, and

iii. Events on the list of known events in the risk analysis but judged to have negligible probability of occurrence and therefore not believed to occur.

These three types of BS events can be grouped into the three existing forms of knowledge and non-knowledge associated with risk which made famous by U.S. Defence Secretary Donald Rumsfeld. Higgins (2013) formed a framework of uncertainty surrounding BS events together with examples of such events as illustrated in Figure 2. The framework separates BS events into known knowns, known unknowns and unknown unknowns based on the availability of model and data.

Known knowns	**Known unknowns**	**Unknown unknowns**
Model and data • Famine • Y2000 computer bug	Model but no data • Earthquake • Terrorism (historical) • Global financial crisis	No model and no data (No idea) • Asteroid attack • Biological warfare

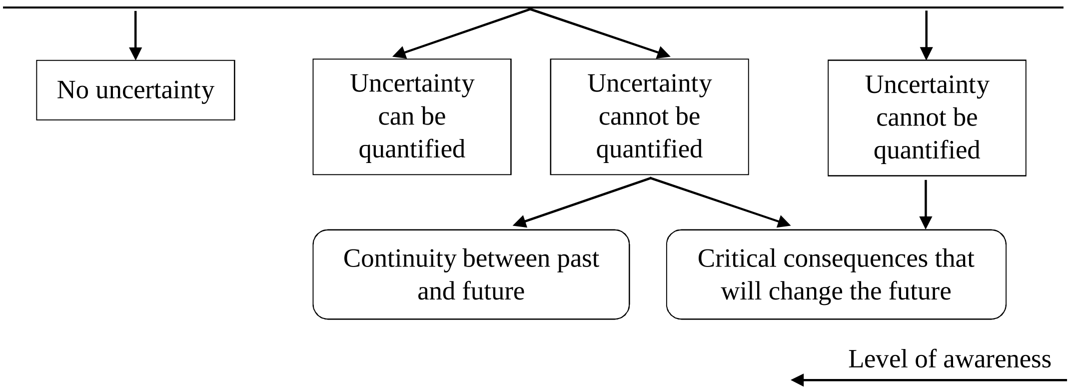

Figure 2: Distinguishing the Knowns and Unknowns: Black Swan Event Framework
Source: Higgins (2013)

The known known is where it is exactly known what could happen and when, for example year 2000 millennium bug can be measured and the disruption can be forecasted. Known unknown events can be quantifiable for example structures can be designed to withstand strong earthquakes (e.g. Structural design of the Taipei 101 tower) but when it will occur is unknown. The unknown unknown events are difficult, if not impossible to model. For instance, there was no quantifiable information prior to the terrorist attack to the World Trade Centre on September 11, 2011. Consequently, the level of awareness is increased and such events are included in the known unknown category. As a provision, new building design features can limit the impact of airborne terrorism (Aven, 2015; Higgins, 2013; Taleb, 2008). These known and unknown BS events can be again categorised into three types: natural, man-made and hybrid disasters according to the definition of disaster (Shaluf, 2007).

4. WILD VS. MILD RANDOMNESS OF BLACK SWANS

This low predictability and large impact has made the BS event a huge puzzle. However, what is more surprising is not the magnitude of the forecast errors of the impact, but the absence of awareness of such events. There are two possible ways to study the phenomena of rare and extreme events with the use of two mutually exclusive types of randomness. The first is to rule out the extraordinary events aside as outliers and focus on the normal which is the mild or Gaussian approach. The second approach is to consider the extremes, particularly if they carry an extraordinary cumulative effect which is the wild, fractal or scalable power law approach (Mandelbrot and Taleb, 2010; Taleb, 2008).

4.1. MILD RANDOMNESS AND REJECTION OF NORMALITY

In a population that follows a mild randomness; one single observation with large deviation from the normality may seems impressive by itself but will not disproportionately impact the aggregate due to averaging. The bell curve has thin tails where large events are too rare to be consequential. Having a closer look at the tails of the bell curve, the probability of exceeding multiples of σ (sigma, standard deviation) are obtained by a complex mathematical formula and the following values in Table 1.

Table 1: Probability of Exceeding Multiples of Sigma

0 σ	1 in 2 times	**6 σ**	1 in $10*10^{8}$ times
1 σ	1 in 1.63 times	**7 σ**	1 in $78*10^{10}$ times
2 σ	1 in 44 times	**8 σ**	1 in $16*10^{14}$ times
3 σ	1 in 740 times	**9 σ**	1 in $89*10^{17}$ times
4 σ	1 in $32*10^{3}$ times	**10 σ**	1 in $13*10^{22}$ times
5 σ	1 in $35*10^{5}$ times	**20 σ**	1 in $36*10^{87}$ times

Source: Mandelbrot and Taleb (2010)

With a mild type of randomness such as height and weight, this type of probability is reasonable. It should be emphasised that the ratio varies with respect to a scale in the Gaussian model where the frequencies drop rapidly in an accelerating way. Thus, Gaussian model is termed as non-scalable. On the contrary to orthodoxy, the possibilities of unpredictable large deviations are simply marginalised in the definition of normal distribution and are considered as statistical outliers. Taleb (2008) devised this normality assumption as the Great Intellectual Fraud. A concern is the frequent misuse of Gaussian distributions as it misses many risk characteristics including asymmetries in downside distributions and fat tails of loss distributions representing low-probability, high-consequence outcomes. In simple words, using the Gaussian model is like focussing on the grass while missing out the gigantic trees (Mandelbrot and Taleb, 2010). In the real terms, price changes are very far from following the bell curve where the far edges flare too high with too many big changes. Thus, the normal bell curve tails do not become imperceptible but follow a Power Law with a fat tailed distribution that can cover higher probabilities of extreme values (Casti, 2011; Higgins, 2014b; Mandelbrot and Hudson, 2004; Pate-Cornell, 2012).

4.2. REAL WORLD WILD RANDOMNESS OF BLACK SWANS

Whereas, wild randomness is an environment in which a single observation or a particular number can impact the total disproportionately. Those that are susceptible to wild randomness can only be expressed accurately using a fractal scale. Technically, fractal distribution defined in equation 1 where $P_{>x}$ the probability of exceeding a variable x is and α is the asymptotic power law exponent. Mandelbrot and Taleb (2010) demonstrates the fractal distribution of wealth in Europe as an example given in Table 2.

$$\mathbf{P_{>x} = Kx^{-\alpha}} \qquad \text{(Eq: 01 The Fractal Distribution)}$$

Table 2: A Fractal Law with a Tail Exponent (α) of 2

Richer than 1 million	1 in 62.5	$P_{>1} = 1/62.5 \times 1^{-2}$
Richer than 2 million	1 in 250	$P_{>2} = 1/62.5 \times 2^{-2}$
Richer than 4 million	1 in 1,000	$P_{>4} = 1/62.5 \times 4^{-2}$
Richer than 8 million	1 in 4,000	$P_{>8} = 1/62.5 \times 8^{-2}$
Richer than 16 million	1 in 16,000	$P_{>16} = 1/62.5 \times 16^{-2}$
Richer than 32 million	1 in 64,000	$P_{>32} = 1/62.5 \times 32^{-2}$
Richer than 320 million	1 in 6,400,000	$P_{>320} = 1/62.5 \times 320^{-2}$

Source: Mandelbrot and Taleb (2010)

The α can be changed to generate additional scenarios: lowering the α means increasing the probabilities of large deviations and increasing will reduce the chance of occurrence. For example, if the α is one, the probability of exceeding a variable will be decline by half in the above scenario. Since scalable laws do not yet yield precise forecasts, an alternative methodology should be modelled where large deviations and stressful events dominate the analysis instead of relaxing on bell curve (Mandelbrot and Taleb, 2010).

4.3. *WILD DOMINANCY OF BLACK SWANS AROUND THE GLOBE*

BS events are increasingly dominating the environment. In the first half of 2015, there were 510 natural catastrophes according to July 2015 presentation by Munich Re and the Insurance Information Institute. The five largest natural catastrophes in the first half of 2015 are earthquake in Nepal (25.04.2015), winter storm in US (16-25.02.2015), flash flood in Chile (23-26.03.2015), winter storm in Europe (30.03-01.04.2015) and sever storm in US (07-10.04.2015). Table 3 compares the natural catastrophes against the average and the top year. Amount of losses in 2015 is lower than the average but there is an increasing number of events. The highest amount of losses is marked in 2011 caused by the earthquake in Japan whereas the earthquake in Haiti in 2010 resulted in the highest number of fatalities.

Table 3: The Comparison of World Natural Catastrophes

	2015 Jan-June	**Average of the Last 10 Years 2005-2014**	**Average of the Last 30 Years 1985-2014**	**Top Year 1985-2014**
Number of all the events	510	440	330	620 (2012)
Overall losses (USD m)	35,000	95,000	64,000	302,000 (2011)
Insured losses (USD m)	12,000	27,000	15,000	82,000 (2011)
Fatalities	16,200	46,000	27,000	230,000 (2010)

Source: Munich Re (2015)

5. BLACK SWAN EXPOSURE ON REAL ESTATE

The pricing of property is based on conventional property valuation techniques as risks are commonly pooled to provide a measurement of value. Thus, property valuation techniques fail to notice the aforesaid outliers. Therefore, property decision should incorporate sufficient understanding of possible occurrence of known BS events to make a viable corporate property decision. For property asset managers, the impact of BS events can be related to the impact on place/location and space/operation. Firstly, place risks can damage the physical buildings. Secondly, the space risk associated with the economic loss for the space occupier that may spread across several unrelated locations (Higgins, 2015). The known unknown BS events relating to place and space risks are shown in Table 4.

Table 4: Place and Space Risks of Black Swan Events

	Form	Place Risk	Space Risk	Comments of Vulnerability
Natural Disasters	Seismic activity	√		Location with factors of urban growth and limited planning and building policies
	Weather related	√		Highly localised impact, coastal areas (hurricanes) and low lying areas (floods)
	Infectious virus	√	√	Variations in relation to disease, environmental condition and treatment capability
Man-made Disasters	Investment strategies		√	Insecurity of scientific approaches within unpredictable markets
	Armed conflicts	√		Interwoven with religion, social instability and economic poverty
	Violence (Terrorism)	√		Normally, specifically focussed relating to perceived compensation and rewards
	Technical (Infrastructure)	√	√	Failures in design, operation and management
	Cyber attacks		√	Critical internet infrastructure can be attacked providing failure of systems

Source: Higgins (2014a)

However, the increasing complexity of the world made up of a tangled web of relationships and other interdependent factors. This complexity not only increases the incidence of BS events but also makes forecasting even ordinary events impossible (Taleb *et al.*, 2009). Due to the connectivity, risks can reach systemic dimensions which in the worst case result in a domino effect. The modern world may be increasing in technological knowledge; in return, it is making things a lot more unpredictable. Subsequently, the role of BS is increasing due to the increase of artificial which moves away from ancestral and natural models and the loss in robustness and resulted in complications. Further, these advances making secondary space impact significantly more after a major BS event (Buhl, 2012; Higgins, 2015; Higgins, 2014a; Taleb, 2012).

6. PROPERTY STRATEGIES FOR BLACK SWAN EXPOSURE

6.1. BLACK SWAN MANAGEMENT TOWARDS ANTIFRAGILITY

Accurate predictions can be conducted in a situation where there is a strong knowledge base with a fewer uncertainties and statistical methods can be employed for standard risk analysis. However, in the real scenario, surprises and BSs may occur and therefore it is obviously not straightforward to assess and manage the BS type of risks. Hence, different approaches are recommended (Aven, 2015).

Traditionally, the most common referred approach is to use of precursors of serious events through a mix of alertness, quick detection and early response. The underlying assumption of precursors is that the reliable predictor of the future backed up by past information. However, this assumption works well only when the change is slow where there are a less presence of BSs and the elements of the system are not tightly connected. Further, it raised a question that judgements about the errors could be derived from false negatives (i.e. no indication of risk situation when one is actually present) and false positives (i.e. erroneous signals indicating some risk situation when it is actually not) (Aven, 2015; Walker *et al*., 2010).

The limitations of the traditional approaches for dealing with the uncertainty recommended new approaches under the conditions of deep uncertainty. The literature offers three overlapping (not mutually exclusive) approaches of dealing with deep uncertainty (Leusink *et al.* 2009 cited in Walker *et al.*, 2010):

i. Adaptation: change the policy in response to the change in conditions,
ii. Resistance: plan for the most pessimistic future scenario, and
iii. Resilience: make the assurance of quick recovery after a future occurrence.

In another perspective, Snowden (2003) mapped four different new approaches in the Cynefin framework to decision making in complex social environments: simple, complicated, complex and chaotic. The proposed decision making strategies are summarised below.

i. Simple/Known >> Sense, Categorize and Respond>> Best Practice
ii. Complicated/ Knowable >> Sense, Analyse and Respond>> Good Practice
iii. Complex >>Probe, Sense, Respond>> Emergent Practice
iv. Chaotic >>Act, Sense, Respond>> Novel Practice

However, a mechanism is required by which the system regenerates itself continuously rather than suffering from random events, unpredictable shocks and volatility. The focus on improvements leads to the concept of Antifragility. According to Taleb (2012), Antifragility is beyond robustness or resilience. The resilient resists BSs and remains the same but the Antifragile gets better and better as a convex response to a stressor, leading to a positive sensitivity to increase in volatility as opposed to fragility which suffers from the variability of its environment beyond a certain pre-set threshold. Figure 3 illustrates the nonlinearity of the fragility and the Antifragility. Nonlinearity comes in two kinds: concave (curves inward) and convex (curves outward). Smile is a better way to understand these two differences as expressed by Taleb (2012) where the happy face is the Antifragility with the positive convexty effect and the sad face is the fragility with the negative convexty effect (concavity).

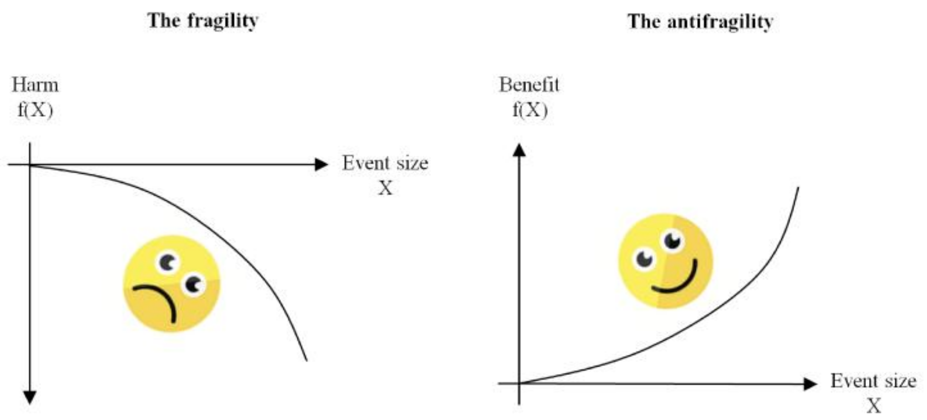

Figure 3: Nonlinearity of the Fragility and the Antifragility
Source: Taleb (2012)

This property is behind every major shift with the time such as evolution, culture, revolutions, political changes, technological innovation and likewise. The Antifragile is seen as a blueprint for living in a BS world, the key being to love randomness, variation and uncertainty to some degree, and thus also errors. Antifragility has a singular property of building a systematic and broad guide to non-predictive decision making under uncertainty where the unknown preponderates, any situation in which there is randomness, unpredictability, opacity, or incomplete understanding. For instance, the process of discovery or technological progress depends on Antifragile tinkering, aggressive risk bearing rather than formal education. Thus, Antifragility is not mere antidote to the BS; understanding Antifragility makes us less intellectually fearful in accepting the role of these events (Taleb, 2012).

6.2. *PROPERTY STRATEGIES FOR BLACK SWAN EVENTS*

Research on Information Technology (IT) project planning has identified the devastating impact of BSs and the requirement for more precise analysis of the outliers. Flyvbjerg and Budzier (2011) found that one of six IT projects outruns the budget by about 200% which highlights the true pitfall of IT initiatives. In order to mitigate the BS effect, stress testing that covers statistical outliers and extreme values is recommended. Even if the company successfully passed through the stress test, smart mangers take additional steps to avoid BSs. They split big projects into ones of limited size, complexity, and duration; implement contingency plans to deal with unknowns; and reward themselves of the best possible forecasting techniques. For example, ‘reference class forecasting’ a method based on the Nobel Prize winning work of Daniel Kahneman and Amos Tversky. These techniques, which take into account the outcomes of similar projects conducted in other organisations (Buhl, 2012; Flyvbjerg and Budzier, 2011).

For the BS Management in real estate environment, reference class forecasting can be undertaken to provide prediction-based disaster indices based on the information on similar occurrences (Higgins, 2015). In mapping place risks, the World Health Organisation (WHO) Collaborating Centre for Research on the Epidemiology of Disasters has maintained an Emergency Events Database (EM-DAT) assess various types of natural catastrophes and man-made disasters (primarily those relating to industrial and transport accidents and avoids armed conflicts and acts of terrorism) above an estimated US$100,000 since 1988. Based on the EM-DAT data, Hollnagel *et al.*, (2007) designed a prediction based Disaster Risk Index (DRI). That demonstrates the statistical evidence of the vulnerability of countries locations in which six of the top ten countries are in Africa while remainder is located in Asia.

However, according to Taleb *et al.* (2009), instead of trying to anticipate these BS events, the most appropriate response is to reduce the vulnerability to them. Risk management should be about lessening the impact of these events instead of developing sophisticated techniques that perpetuate illusions of the environment. Further, research on IT project planning can assist as to identify requirements for more precise analysis of the outliers, and suggested establishing risk management tools to reduce the complexity and decrease the variability of performance. Higgins and Perera (2016) demonstrated this by the following real estate examples within the Antifragile outlook.

i. Designing for flexibility: Rearrangement of global organisations structure and efficiency brings the workplace flexibility through through modularity, agile planning approaches and limiting the project financing multiplier. If a BS event occurs in one location, the system can be maintained in the alternative location to maintain the continued existence.

ii. Implementing safety barriers: Simple approaches to standardise language and reporting, offers a framework to avoid place risk. This one framework toolset and single vocabulary can improve knowledge sharing across multinational organisations. Another strategy is the recognition of leading cities resilience to adverse events. This forms part of Grosvenor (2014) report on resilient cities. The resilience derives from the interplay between vulnerability and adaptive capacity. Taleb (2012) coined this new disease as ‘neomania’ that makes us build BS-vulnerable systems.

iii. Corporate real estate partnership: As technical innovations create lower fixed costs, and advances in digital networks improve communications, corporate real estate strategies are changing to offer a consistent integrated service delivery with sophisticated property management IT for global coverage. The creation of operational teams that transcend geographic and temporal boundaries can offer lower costs and turnaround times. The shared information is also advantageous with improved management knowledge.

7. CONCLUSIONS AND RECOMMENDATIONS

BS events have the characteristics of rarity, extreme impact and retrospective predictability across different classes of risk categories from known to unknown. The risk management and decision making drive exclusively on known knowns. However, a large fraction of real-world risk management challenges fall in the domain of known unknowns and unknown unknowns. Due to the growing significance of these risks, BS events cannot be ruled out as outliers in the Gaussian distribution as per the mild randomness. The normal bell curve tails do not become imperceptible but follow a Power Law with a fat tailed distribution that can cover higher probabilities of extreme values. Hence, it can be emphasised that real world BS challenges are fall into the wild randomness following fractal or scalable power law approach.

The impact of BS events in real estate environment can be related to the impact on place/location and space/operation. As the strategies for these downside risk in the real estate environment, reference class forecasting can be undertaken to provide prediction-based disaster indices based on the information on similar occurrences. As per the Antifragile outlook, the rearrangement of global organisations structure and efficiency through the designing for workplace flexibility, implementing safety barriers and corporate real estate partnership can be implemented. The concept Antifragility is also made famous by Taleb (2012) which has a positive convexity effect between the size of event and the benefit from the event rather than suffering from random volatility. The aforementioned key literature finding are summarised into a conceptual framework as illustrated in Figure 4. It illustrates the relationship between BS effects with its respective strategies in the distinctiveness between fragility and Antifragility.

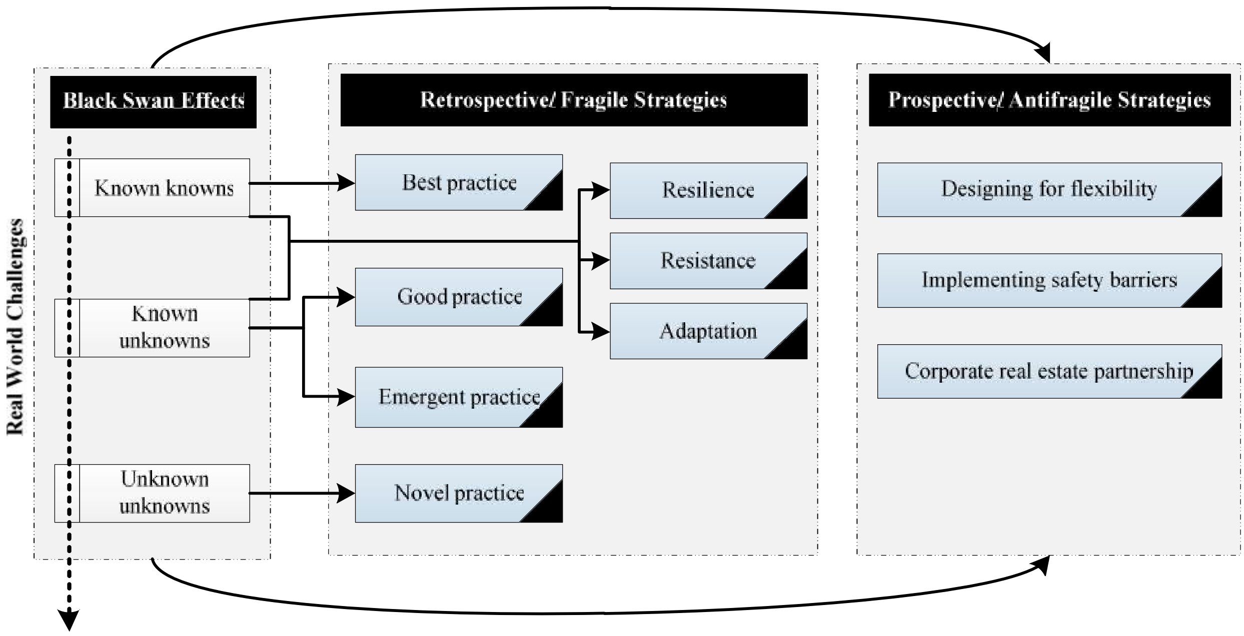

Figure 4: The Summary of Key Literature Findings

For corporate real estate decision makers, BS research embraces to identify the favourable and adverse effects on real estate decision making. BS management research agenda should be more focused on lessening the vulnerability beyond the quantitative forecasting judgements to anticipate low-probability and high-impact events.

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CAPACITY OF INFORMATION TECHNOLOGY INFRASTRUCTURE IN SRI LANKA TO SUPPORT BUILDING INFORMATION MODELLING SYSTEMS

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ABSTRACT

Building Information Modelling (BIM) is a concept, improved with Information Technology (IT) to upgrade construction, maintenance and operation of a building or an infrastructure project. Information Technology Infrastructure (ITI) is a crucial aspect in implementing BIM. Rapid improvement of ITI has benefited mostly to AEC and FM industry while enhancing the accessibility to more numerical dimensional BIM modelling such as scheduling (4D), costing (5D), operation (6D), sustainable design (7D) and safety (8D). Therefore, it is necessary to investigate on ITI in Sri Lanka for successful implementation of BIM in Sri Lankan construction industry. Thus, this research is aimed at identifying the capacity of information technology infrastructure in Sri Lanka to support BIM systems. A qualitative approach to the research methodology was proposed in order to carry out an in-depth investigation on subject matter.

Major five BIM systems and minimum ITI requirements for each BIM systems were identified through a comprehensive literature review. Existing ITI in Sri Lanka was identified from various organizations which represent IT, construction, banking and apparel sectors. Further, risks and challenges in each infrastructure were identified. By combining the literature findings and existing knowledge which was obtained through a deep analysis. Then a framework was developed to indicate the capacity of ITI in Sri Lanka to support BIM systems. From the findings of the study, the conclusion was made that the BIM implementation in Sri Lanka is possible even there are several risks and challenges bound with ITI. Ultimately, it was recommended that Sri Lanka has enough capacity to implement BIM with minimum ITI requirements.

***Keywords**: Building Information Modelling (BIM); Construction; Information Technology Infrastructure (ITI); Sri Lanka.*

1. INTRODUCTION

Now a days, Architects, Engineers, Contractors (AEC) and more professionals who involve in the construction sector adapt information technology for their day today works and businesses. Main reason of this rapid change, is the development of new software and applications that built up to cater the individuals or company's works and businesses. Jayaratna (2012) explained that IT could be used more sufficiently to design buildings as well as to minimize the cost and wastage in construction sector. In addition, Munasinghe and Jayawardena (2003) stated that Sri Lanka had been far more behind in the information technology, even the technology advanced rapidly in the world.

Similarly, Hartmann and Fischer (2007) mentioned that technology seems to be a major obstacle to widespread of utilization of BIM. Mitchell and Parken (2009) further explained the technology implications affect to the current practice of BIM and such implications were introduced such as software, hardware limitations and implementation of new technologies like Web portals, Geo-graphic Information Systems (GIS) and laser scanning. However BIM had been revised through a series of regular editions, focusing on conflicts which arise in the industry, via the application of BIM processes and supporting technology (Malow, 2009). However, Bernstein and Pittman (2004) stated that the technology was well advanced to implement BIM in the world and predicted that new approaches of BIM would create more benefits to enhance the qualities in the construction industry.

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However, information technology in the modern era is limited to some countries for a certain period of time which create some encumbrances in implementing new innovations such as BIM. Hence, it is much useful as well as much more worthy to recognize the capacity of information technology infrastructure in Sri Lanka to support BIM systems. Therefore this research focused to identify the capacity of information technology infrastructure in Sri Lanka to support BIM systems.

2. LITERATURE REVIEW

Literature review can be presented through five key areas viz. BIM, technological aspect of BIM in project implementation, BIM systems and ITI cater with BIM.

2.1. BUILDING INFORMATION MODELLING

BIM platform had been developed with the support of Information Technology Infrastructure (ITI) to compete with the conventional systems rooted in the construction world. Thus, nowadays BIM systems mainly depend on the capacity of the Information Technology (IT). But Witty (2008) expressed that the construction industry had been reluctant to embrace the benefits of IT due to the lack of technology to some regions. Further, Jayaratna (2012) stated that the construction industry really depends on the technological development and all the people were happy to join with the modern era that revolutionized by the new technology. But Smith (2014) stated that BIM implementation was relatively slow in the construction industry compared to the other industries like manufacturing and engineering even the technology underpinning BIM has been around for well over a decade.

BIM digital modelling concept consist more information rather than in conventional method. Therefore, simply BIM allows to develop an in detail design of a building virtually which is going to be truly constructible at the site. However, BIM based project delivery was not practically exist before 21st century due to immature technology and lack of will towards its development (Tulenheimo, 2015). In the beginning BIM has been acknowledge as an active, three-dimensional computer program that formed to increase the efficiency and effectiveness of the building in terms of design and construction in real time basis (Rodriguez, 2015). Subsequently, with the improvement of IT infrastructure BIM unveil the access to more numerical dimensional modelling to provide more services on a construction project. Therefore the development in IT infrastructure benefited mostly to trot out the full potential value of Building Information Modelling towards AEC and FM industry.

2.2. TECHNOLOGICAL ASPECT OF BIM IN PROJECT IMPLEMENTATION

Basically the construction team should determine the way of implementing BIM on the particular project, based on the overall strategies, weaknesses, opportunities and threads they have (Bryde et al., 2013). Therefore the construction team plays a major role in making decisions on implementing BIM for a project, such as deciding the suitable BIM system, gathering and generate project information during the course of the project, way of communication, data analysis and etc. (Arayici et al., 2012). Hence it is critical to consider the entire life of a facility when making decisions to implement BIM for a construction project. Therefore it is a must to understand the reaction of stakeholders in all facilities on implementing BIM. Hence it is important to understand how the facility owners use BIM at the initial stage and how they apply BIM for the design and construction (Kreider and Messner, 2013).

Arayici et al. (2012) explained the main focus of implementing BIM was to find out the most appropriate BIM technology for the particular project. Because some of the organizations/firms/companies have their traditional or conventional information technology infrastructure system based on their nature of the industry and ongoing business. Therefore, it is very important to recognize and understand the project stakeholder's information technology infrastructure and ensure that the required information technology infrastructure for BIM can be assisted by the project stakeholders as it drive the implementation of BIM directly (AEC (UK) Standards Committee, 2012).

Figure 1 elaborates the necessity of the technology to implement BIM for a project.

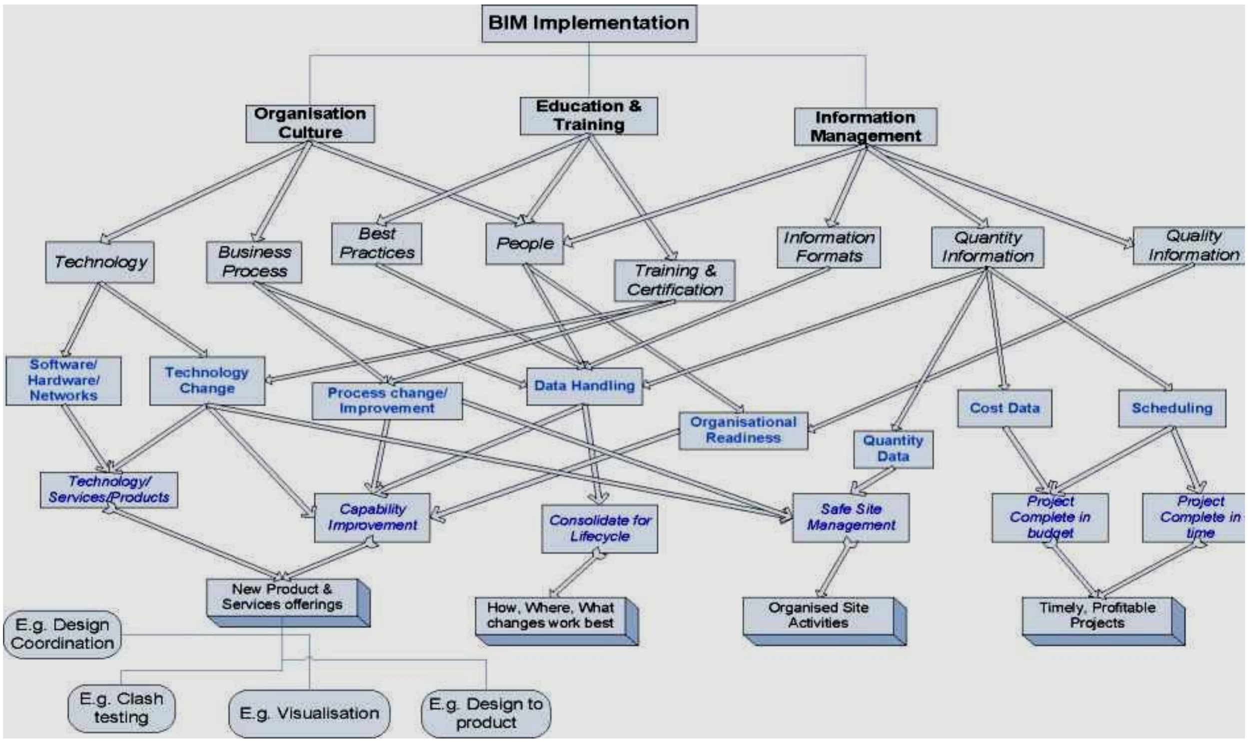

Figure 1: BIM Implementation Concept Map from Finland
Source: Arayici *et al*.(2009)

According to the Porwal and Hewage (2013), BIM maturity changes from the organization to organization and with the project basis. This change happens because of the complexity and various scope levels in a project. In comparison to the six storey building project and construction of an airport or harbour, harbour project can be much more difficult than the building project. Complexity can't be decided, even the building project can be much worse than a harbour project. It occurs mainly due to the design concept of the architect/designer. Further, cloud service is not mandatory for the BIM implementation, but cloud service can be constrained for maturity level of BIM. Sometimes, BIM maturity is also constrained by technology itself. Consequently, technological aspect of BIM is very important factor in project implementation.

2.3. BUILDING INFORMATION MODELLING SYSTEMS

Companies had developed specific software to perform each specific tasks separately that can work under BIM platform, a framework. Archi CAD, Tekla Structures, and Vector works had the design capacity to allow additional further information such as time, cost and facilities management to the building model (Sabol, 2008). It was the reason that many of the stakeholders tend to use BIM software packages rather than traditional architectural drafting tools such as AutoCAD (McNell *et al*., 2013). At the beginning, developed technique in the BIM was three dimension (3D) and then the scope of the framework was developed more comprehensively to much broader areas like scheduling, cost, life cycle management and sustainability (Czmoch and PĊkala, 2014). Therefore BIM system can be introduced as a broader technology rather than traditional software packages such as AutoCAD.

With the improvement of new technology, various companies come up with incorporating BIM tools. As a result, a wide market had been opened for the developers who are seeking BIM tools for the betterment of construction industry as well as for the BIM world. Now, BIM based consultant companies are also established as a third party developers who provides solutions for the BIM tools through developed applications. Therefore the aggressive development in the BIM sector improves the necessity of many software packages which provide more sophisticated services that incorporate with the scheduling and cost (Smith, 2014). Hence, more software packages, applications and tools relevant to BIM can be found in the world.

Table 1: Major BIM Software Developers

BIM Handbook	AGC BIM Guide
Autodesk	Autodesk
Bentley Systems	Bentley Systems
Graphisoft (Bought by Nemetschek AG)	Graphisoft (Bought by Nemetschek AG)
Common Point Inc (Bought by Bentley systems)	Nemetschek Vectorworks
Innovaya	
Synchro ltd.	
VICO Software	
AEC Bytes Survey	**BIM Wiki**
Autodesk	Autodesk
Bentley Systems	Bentley Systems
Graphisoft (Bought by Nemetschek AG)	Graphisoft (Bought by Nemetschek AG)
Gehry Technologies	Nemetschek SCIA
Tekla Corporation	Onuma
Nemetschek	Solibri
	Tekla Corporation
	VICO Software
	Gehry Technologies

Source: Ruiz (2009)

Further, comparing to the Eastman *et al.* (2011) and McNell *et al.* (2013), five major BIM systems can be selected from the aforementioned Table 1, which mostly exercised in the BIM world. Therefore, Revit, Bentley systems, Archi CAD, Tekla structures and Vector works were selected as the BIM systems to continue the research. Thus, only those five systems will be focused in this research afterwards.

2.4. INFORMATION TECHNOLOGY INFRASTRUCTURE CATER WITH BIM

People want information technology besides fuel, water, electricity, clothes and gas. IT infrastructure is a combination and integration of all the elements in computing technology. BIM also require four major coherent components to operate and function fully as explained in follows:

- Hardware: BIM system also requires various hardware components to its operation. Servers to store and share information, computers for individuals and switches, routers to interconnect each user.
- Software: Common BIM software can be identified in BIM market, developed by various companies for different purposes. BIM 3D phase Architectural and Structural software are heavily used to make the models. Tekla structures is the best identified software for the structural works.
- Network: Networking in the BIM is done though the BIM Cloud service. “Cloud” is the common word or just a metaphor used instead of internet. Cloud service help to interconnect varies BIM software applications and it is a way of storing, accessing data over the internet instead of your local storage and computing.
- User: An experienced, and skilled person who can manage system administrating, system developing, analysing and programming is significant.

3. RESEARCH METHODOLOGY

Research was mainly based on developing a framework to analyse the capacity of ITI in Sri Lanka to support BIM system and map the ITI in Sri Lanka with the requirement of BIM ITI. Descriptive personal opinions, perception, observation and views were very helpful to have an in-depth understanding on ITI in Sri Lanka. Moreover, research approach should be fitted to seek new ITI in Sri Lanka. Therefore, data had been collected relevant to the ITI in Sri Lanka from different IT professionals engaged in different industries. Hence facts led to justify the research approach as qualitative approach.

Semi structured interviews were conducted from various industries representing IT, construction, banking and apparel sectors which exercise the centralised database management system in their organisation. Transcribed interviews were analyzed using content analysis method with the aid of computer software, NVivo version 10.0 developed by QSR (Qualitative Solutions and Research Limited).

4. RESEARCH ANALYSIS AND FINDINGS

Following sections, discuss research findings of the study under the broad headings of capacity of ITI in Sri Lanka and identified risk and challenges.

4.1. CAPACITY OF IT INFRASTRUCTURE IN SRI LANKA

IT infrastructure in Sri Lanka is discussed in this section focusing on main nine elements. Information received from the IT professionals in various industries in Sri Lanka was considered for this analysis.

4.1.1. OPERATING SYSTEM

Organisations use Windows platform to run their co-business. Windows platform creates lot more privileges and services to its customers. It is the main reason behind such usage in Sri Lanka. Further, companies had to move with the new operating systems in the market, as old versions of Windows get outdate. Additionally, companies use open source operating systems such as MAC, Linux and Ubuntu.

4.1.2. CENTRAL PROCESSING UNIT

Sri Lanka is using Intel® Core™ i processor technology in many different industrial levels. They have no issues with the central processing technology due to the ‘warranty period’ provided by the agent or supplier. Therefore most of the organisations shift into new technology without hesitation.

4.1.3. MEMORY

Sri Lanka practices up to 16GB, as they are satisfied with the memory capacity which can utilise their system implementation. However, the default memory capacity was identified as 4GB. Therefore companies use only the default memory coming with the system other than the special occasions.

4.1.4. GRAPHIC CARD

Organisations are not that much depend on the graphics as they can manage their works with integrated graphics. Additionally, dedicated graphics are highly required for the professionals who deal with the designing. Other than that dedicated graphics will only be supplied at the special occasions when such requirement is required by the employees.

4.1.5. DISPLAY

Optimum display sizes use in the current industries, having high resolution. Since, display requires more space when its size gets bigger, create some encumbrances to purchase large display sizes to the companies. But now companies are more towards to purchase large displays as increases the viewing angles comparatively.

4.1.6. HOSTING METHOD

Most of the companies are practising dedicated server hosting while few of the companies adapt cloud hosting. Main reason behind adapting cloud hosting was huge space allocation for the servers and high expenditure in maintaining them annually. But when it comes to the cloud hosting, companies have to bear particular cost annually which will be the service charges agreed with the agent who provides the particular service.

4.1.7. BACKUP SYSTEM

BIM dealt with the information which is necessary to be protected from being loss. From the findings, sufficient backup system technology practises in Sri Lanka to facilitate implementation of BIM. Now Sri Lanka is more towards to the cloud backup and online backup which are working with the help of internet facility. It is a major point to enhance the quality of practising internet service practising in Sri Lanka.

4.1.8. INTERNET SERVICE

Internet facility in Sri Lanka is at an eminent stage to facilitate BIM and companies are satisfied with the current band width which provided by the each service providers in Sri Lanka. Companies are more acknowledge of getting a better service as internet is that much critical with its nature of the organisation. Mainly companies are dealing with more than one company, as they need another backup service provider at the time of a breakdown.

4.1.9. COMMUNICATION METHOD

Organisations used several methods for internal as well as for the external communication. Most companies communicate through email service. But implementing video conferencing compared with bandwidth in Sri Lanka is now not a matter to be worried.

4.2. RISK AND CHALLENGES

Processors, memory sticks and graphic cards are also very complex to repair. Therefore those items will be replaced for a new one even a single problem occurred during the warranty period. Otherwise those items will be sent to the mother company for repair. The technology behind the processors, memory sticks and graphic cards are complex to understand to a general person.

Extra items were supplied by the manufacturing companies to replace the defects. If the item get damaged in the warranty period, seller will look after all the incurring cost to recover the damaged item. It is the responsibility of supplier towards the customer to make the replacement accordingly at any cost. That’s the support given by the seller and significance of having the warranty. Otherwise customer has to handle the issues at his own cost. Thus purchasing a product without a warranty, automatically generates a huge risk, customer has to bear. Suppliers will only transfer the warranty given by the main agent in Sri Lanka who deals with the manufacturing company. Therefore extending the warranty will not be done by the each supplier due to the high risk impact. Mainly suppliers will not provide alternative hardware to that defect ones at all. Only thing that will be done by the supplier and the agent is sending it to the main agent asking company warranty.

On the other hand, internet is also one of the main infrastructures identified in ITI comprising with risks and challenges. Internal failure may be either external or internal, internal failure is manageable while external failures are not manageable within inside.

5. INFRASTRUCTURE FRAMEWORK

Infrastructure framework was mainly categorised under three sub sections such as minimum requirement of ITI for BIM implementation, identified BIM systems and identified ITI in Sri Lanka. Main purpose of the framework was to build up a supporting ITI in Sri Lanka for identified BIM systems.

5.1. REQUIRED ITI FOR BIM IMPLEMENTATION

Required ITI for BIM implementation was identified through literature review. Basically, required ITI for BIM can be categorised in to three sub sections as user system requirement, server requirement and cloud service requirement.

5.2. BIM SYSTEMS

Five major BIM systems were identified through the literature review. They were Revit system, Bentley system, Archi CAD, Tekla structures and Vector works.

5.3. IDENTIFIED INFRASTRUCTURE IN SRI LANKA

Infrastructure in Sri Lanka was identified from semi structured interviews.

5.4. SUMMARY OF THE FINDINGS

Through the literature review minimum requirement for each BIM systems were identified. Then analysis was used to identify the infrastructure level in Sri Lanka to cater with each BIM systems. Finally, supporting ITI in Sri Lanka for each BIM systems were established through the Infrastructure Framework.

6. CONCLUSION

From the findings of the study it can be concluded that, capacity of ITI in Sri Lanka suitable with the minimum requirement of ITI in BIM. Moreover additional infrastructures identified in Sri Lanka also support to implement BIM effectively and efficiently. There are suppliers and agents to supply infrastructures. But there are several risks and challenges identified in ITI which are not that much critical to implement BIM. In a case of service interruption, customer who purchases the infrastructure has to bear more risk. In such situation risk of idling time is considerably high. Though risk factor mainly deals with the system efficiency and breakdown, infrastructures are readily available in Sri Lanka which needs to implement BIM. Therefore combining the findings of the research with existing knowledge it can be concluded that Sri Lanka has the enough capacity to implement BIM in Sri Lanka.

7. RECOMMENDATION

According to the conclusion, Sri Lanka has the required ITI capacity to implement BIM without any critical problems. Even though there is no critical problems, risks and challenges with regard to the Service interruptions and Idling time are unavoidable as they are associated with technology. Mitigation and reduction are the only available solutions that can be used to overcome risks and challenges.

Sri Lankan ITI is updated with the new technologies innovated in modern era without any delay. Therefore ITI in Sri Lanka is not a significant issue to implement BIM. Moreover, implementation should be planned in respect to mitigate identified risk and challenges. It should be planned to have an adequate backup option at the system designing stage for the available risk and challenges. We can’t operate only the required system. Because operating that system create the same risk identified. It affects to the whole system, due to any single failure. Therefore a contingency plan should be established to install adequate backup system when designing the system.

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CARBON AND COST CRITICAL ELEMENTS OF OFFICE BUILDINGS: A CASE STUDY

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ABSTRACT

Buildings emit two types of carbon (and greenhouse gases) namely Operational Carbon (OC) and Embodied Carbon (EC). Operational carbon is regulated in the UK as it contributed up to 70-80% of total emissions. On the other hand, EC started gaining attention with the rise of zero carbon buildings and due to the fact that the EC is unregulated at present. However, estimating EC is not completely standardised and there is room for improvement. EC can be controlled only by vigilant building designs. Studying building closely will provide better understanding of the carbon significant elements and enable designers to make informed decisions. Accordingly, a case study of an office building located in London in the UK is selected for the study. Capital cost (CC) and EC estimates were prepared using detailed cost plan of the building. Then, the building elements were classified as per NRM1 (New Rules of Measurement 1) element classification and the most carbon and cost significant elements were identified in the case study building. Not all of the identified carbon significant elements are identified as cost significant but Substructure, Frame and Services are identified as both carbon and cost critical elements while Stairs and Ramps, Internal Doors and Fittings, Furnishings and Equipment were identified to be the least carbon and cost significant elements. Findings of the case study building inform designers about the elements that has a vast reduction potential and worth investing their time on experimenting. However, the findings are based on single case study and, hence, cannot be generalised but to be seen as an exemplar for further research.

Keywords: *Carbon Hotspots; Capital Cost; Cost Hotspots; Embodied Carbon; Office Building.*

1. INTRODUCTION

Climate change is the most serious threat to human society. It is a threat that human society has created itself. Global atmospheric concentrations of greenhouse gases (GHGs) have increased since 1750. Notably the carbon dioxide (CO_2) is the most pre-dominant greenhouse gas by volume. Emissions of CO_2 from fossil fuel combustion in conjunction with that emitted from manufacturing are responsible for more than 75% of the increase in atmospheric CO_2 since the pre-industrial 18th century (Solomon *et al.*, 2007). The construction and occupation of buildings is a substantial contributor of global CO_2 emissions, with almost a quarter of total global CO_2 emissions attributable to energy use in buildings (Metz *et al*., 2007).

The UK's commitment to reduce carbon and other greenhouse gas emissions is now a matter of legal obligation. Under the Climate Change Act 2008, emissions are targeted to fall by 26% by 2020 (by comparison with a 1990 baseline) and by no less than 80% to 2050 (Committee on Climate Change, 2013). The UK to reach its legal obligations of greenhouse gas emission reduction, a low carbon transition plan has been put into place. The plan covers the next 40 years and "the transition to low carbon can almost be read as a business plan for construction, bringing opportunities for growth" (HM Government, 2010, p.4). Still, the focus of the UK Building Regulations has been on operational energy use to date with embodied energy absent from legislative attention (Densley and Davinson, 2011).

However, in the action plans more focus was given to reduce carbon emissions during the operation of the building (known as 'operational carbon') which contributed to nearly 70-80% of total emissions from buildings until the zero carbon agenda for buildings was introduced. Eventually, zero carbon agenda implicitly emphasises the need to control the other component of the building sector emissions, namely Embodied Carbon (EC). EC is driven by process and affected by the supply chain, thus, it is difficult to

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manage. However, dual currency approach of clients and consultants highlights the importance of EC estimating and management. Therefore, it can be expected that the knowledge of cost and carbon relationship will become a valuable asset for the construction practices in the near future. Hence, the paper intends to identify the carbon and cost significant building elements in office buildings in the UK.

2. LITERATURE REVIEW

Carbon and other Green House Gases (GHG) are emitted directly and indirectly during the development and construction of buildings and the construction industry is accounted for emitting half of the UK's carbon dioxide (UK-GBC, 2016). Such emissions are primarily classified into two types such as operational carbon and EC (also known as capital carbon). Operation carbon is the carbon (and GHGs) emitted during the operation of the building (or infrastructure) as a result of fuel consumption while EC is the carbon (and GHGs) emitted during the production (includes raw material extraction, material manufacturing, transport, construction of the project), repair, replacement and demolition of the buildings (or infrastructure). The contribution of the two in total emissions varies depending on the type and the features of the building. Generally, operational carbon emissions are higher than the embodied emissions in most of the building types while there are exceptions like warehouses (RICS, 2014). Understanding the relationships between 'embodied' carbon and 'operational' carbon can assist in determining the overall optimum carbon reductions.

2.1. OPERATIONAL CARBON IN BUILDINGS

Operation carbon can be divided into two parts such as regulated and unregulated. Regulated emissions covers heating, ventilating, air-conditioning, lighting and the like and unregulated emissions includes emissions from ICT equipment, cooking and refrigeration appliances and the like. Part L of the Building Regulations of the UK has provisions to control the regulated operational carbon in buildings as the unregulated emissions are influenced by the behavior of the building users. The operational carbon emissions are expressed in mass of CO_2 emitted per year per square meter of usable floor area of the building (kg/m^2/year). As per the Part L of the Building Regulations, the operational carbon or the Target CO_2 Emission Rate (TER) for a notional building design is benchmarked and the Building CO_2 Emission Rate (BER) of the proposed building should be less than the TER for the building design to be approved. Therefore, any building should pass the regulatory requirement to be developed on a site.

The low carbon agenda in the UK demands the new building developments to be low and zero carbon by employing renewable energy sources. Low and zero carbon refer to the low and zero operational carbon (regulated) which leaves unregulated operational carbon and especially EC unattended. In fact, the UK government requires all newly built domestic buildings to be zero carbon from 2016 and non-domestic buildings from 2019 which is considered to be ambitious targets and still under debate. Yet, the UK is becoming more stringent towards operational carbon. This has increased the concern on EC because emissions from a zero carbon building will be equal to total EC emissions. As shown in Figure, operational carbon will contribute up to 70-80% of total emissions in a typical building. Then, in a low carbon building operational carbon will immensely reduce which increase the EC contribution. Further, all of the emissions result from EC in a zero carbon building (yet, it should be noted that a portion of carbon can also be emitted from unregulated operational carbon if the energy is not supplied from renewable sources). Therefore, EC emissions require special attention in a low and zero carbon building.

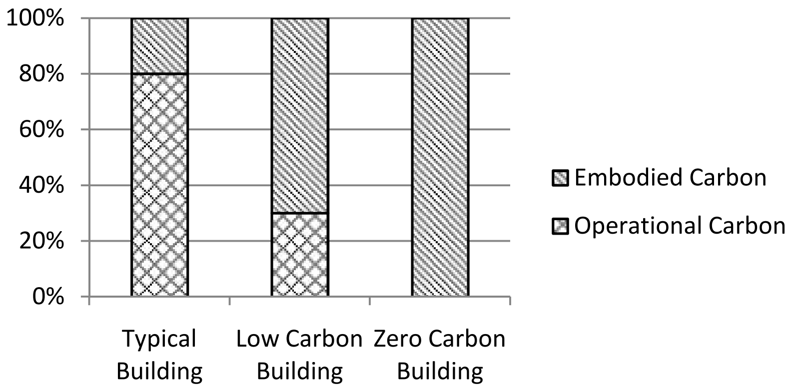

Figure 1: Significance of EC
Source: RICS (2012)

2.2. EC IN BUILDINGS

The EC is the carbon dioxide equivalent (CO_{2e}) or greenhouse gas (GHG) emissions associated with the non-operational phase of the project. This includes emissions cause by extraction, manufacture, transportation, assembly, maintenance, replacement, deconstruction, disposal and end of life aspects of the materials and systems that make up a building. Few scholars (Chen *et al*., 2001; Ramesh *et al*., 2010) categorise EC into three types such as Initial EC (raw material extraction, manufacturing, transport and construction), recurring EC (in-use EC such as repair, maintenance and replacement) and Demolition EC (EC during demolition). Further, EC can be saved due to recycling efforts of scrap materials or products after demolition which can be accounted in the carbon footprint calculation of the project; however, not all projects have this phase.

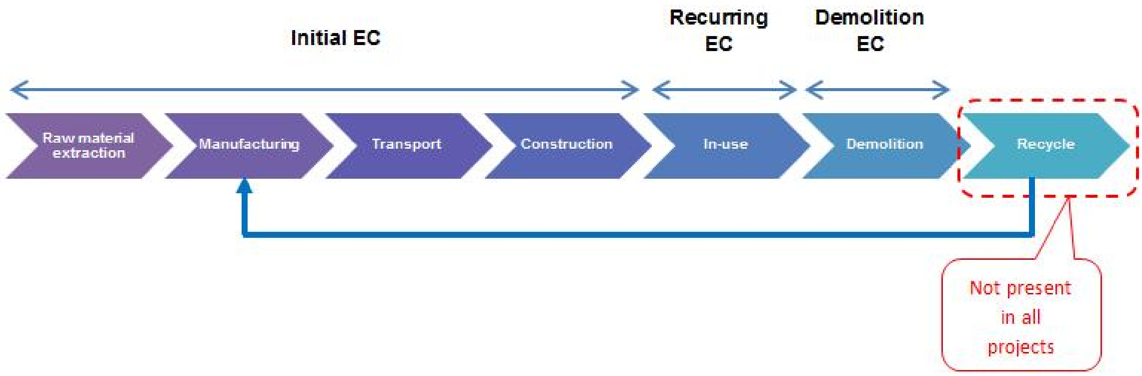

Figure 2: Classification of EC

EC can be calculated from cradle (earth)-to-gate (manufacturing factory gate), cradle-to-site (construction site), cradle-to-end of construction, cradle-to-grave (demolition), or even cradle-to-cradle (recycle, reuse and recovery). Hammond and Jones (2011) and Sansom and Pope (2012) noted that many EC datasets available are cradle-to-gate and fail to include emissions from latter stages of life cycle (such as construction, operation and maintenance and demolition and disposal) as they are project specific emissions. However, transport of materials to site can be significant for materials with lower EC emissions in other phases (Hammond and Jones, 2008). Furthermore, lesser transport distance not necessarily means lesser carbon emissions; mode of transport and type of fuel also plays a significant role other than the distance of travel (RICS, 2014; Sundarakani *et al*., 2010)

Measures to minimise EC of the building has to be taken during the early stages of the design to yield greater savings as the carbon reduction potential is very high during the early stages of design (RICS, 2014). The reduction potential decreases more carbon is committed into the project as the possible design solutions are constrained by previous design decisions. Then, during construction phase the reduction potential can be regarded as nearly zero unless there is a design change. Further, the design becomes static as the project progresses and changing the design at a later stage will result in loss of time and money. Therefore, it is crucial to identify possible EC saving options before the design develops to a greater detail. In fact, RICS (2014) states that investigating EC in different types of buildings is a completely new research avenue and there are limitations in regulatory standards or academic researches to aid the decision making at the initial stages of projects. Nevertheless, carbon hotspots are identified as an ideal way of dealing with this issue.

2.3. HOTSPOTS

'Hotspots' can be defined as the most critical or significant elements in a building which has enormous impact on project cost or EC. It can also be interpreted in this study as the building elements that are responsible for 80% of Capital Cost (CC) or EC which is derived from Pareto 80:20 rule. RICS (2014) further extends the definition by saying that the hotspots are not merely the significant elements but also the elements for which measurement data are readily available and reduction measures are possible. Hotspots vary for buildings with different functions and this knowledge can lead to greater carbon and cost savings or optimisation. Generally, foundations, frame, roof, walls, and floors are considered as carbon hotspots. Though, it is reported that the building services contribute approximately 15% of total EC, it is not widely regarded as a hotspot as measuring services at early design stages is a complex process and reduction potential may be limited (RICS, 2014). However, a study found that cladding finishes and services are to be the biggest component of recurring carbon emissions of an office building (Cole and Kernan, 1996). Hence, services and finishes cannot be disregarded when taking initial design decision as the contribution is significant. Therefore, it is important that the indication of likely EC of building services and finishes are revealed at the early stages of design to understand the carbon accountability of the project.

Table presents comparison of different studies on EC profile of office building in the UK. Accordingly, previous studies suggest that Substructure and Superstructure contributing up to 90% of the total EC. The major culprits of EC are the concrete and steel and apparently, concrete and steel are manifested in the Substructure and Superstructure of the buildings, identifying both as carbon hotspots. However, it is not possible to assert that all the superstructure elements are carbon significant as sub elemental breakdown is not given and the findings of Victoria *et al*. (2015) substantiate this claim. Frame, Upper Floor and External Walls were identified as the carbon hotspots in an office building in the study conducted by Victoria *et al*. (2015). Further, incomparability of literature findings due to the difference in element classification system adopted in presenting the results (for example, NRM, SMM/BCIS - older version, British Council of Offices 2011, own classifications) calls for a uniform classification system.

Table 1: Carbon Profile of Building Elements of Office Buildings from Published Studies

	Victoria *et al*., (2015)	**Halcrow and Yolles (Average of 3 case studies)**	**Sturgis Associates**	**WRAP**	**Davis Langdon from Clark (2013)**
Substructure	43.79%	89% (some elements are combined)	25%	18.3%	Structure - 45%-85%, Facade - 5%-25%
Superstructure	54.66%		56%	58.24%	
Internal Finishes	0.57%		Fit-out (shell and core) - 8%, Fit-out (Cat B) - 8%	8.619%	4%-25% (Internal walls included)
Fittings and Furnishings	0.05%	Not given		Not given	
Services	0.93%	3%		11.96%	2-25%
Others		8% (External works)	4% (Waste)	2.9% (External works)	

Source: Victoria *et al*. (2015)

Increasing significance of dual currency appraisal - cost and carbon - in construction projects drives the development of knowledge with regard to cost and carbon comparisons. For instance, if cost and carbon hotspots are the same then both can be attended at the same time and an optimum solution can be achieved based on the project objectives (if client is concerned about the carbon footprint of the building then choose low carbon option which might compromise on cost).

3. RESEARCH METHOD

A building case study is presented in this paper to understand the distribution of EC and CC among building elements and to draw insights in to the results. EC and CC of the building was estimated using the Inventory of Carbon and energy (ICE) version 2.0 (Hammond and Jones, 2011) which is an inventory of EC and energy data of common construction materials, UK Building Blackbook (Franklin and Andrews, 2011) which is a book containing itemized cost and EC data as per Standard Method of Measurements and manufacturer's data where necessary. Estimates were prepared using the detailed cost plan of the building applying relevant cost and carbon values per unit quantity of each item obtained from UK Building Blackbook. However, Blackbook data were based on the 2010 2Q (218) prices and a location index of 100. Subsequently, the cost was updated to 2016 1Q (276) and location index kept unchanged. Even though adjustment for price was made adjustment for EC data was not made as EC is affected by the process of manufacturing of the building materials. Unless and until the process is changed adjustment is not required to the EC data. Therefore, a crucial assumption is made in terms of the EC data that the manufacturing process considered when developing the database has not changed radically.

Then, each item was mapped as per the NRM 1 element classification, which is the latest measurement standard prevailing in the UK, as shown in Table. Afterwards items were grouped into elements such as Substructure, Frame, Upper Floors and the like. However, there were some shortcomings with the data. Cost plan of the building lacked detailed measurement of most of the services and Black book did not contain data for all services. However, benchmarks were obtained from Spon's price book (Davis Langdon Consultancy, 2014) (cost benchmarks) and an in-house carbon data from a UK consultancy practice for other services to make the estimate complete and present a holistic analysis of the building. The CC and EC values used for the other types of services are roughly £386 per m^2 GIFA and 163 $kgCO_2$ per m^2 GIFA respectively.

Table 2: Mapping Items for Finishes as Per NRM Element Classification

Item Description	Quantity	Unit	NRM Main Element Group	NRM Sub Element Group
Masonry paint; to blockwork walls	500	m^2	3	3.1
Dry lining and paint	55	m^2	3	3.1
Entrance matting	17	m^2	3	3.2
Carpet tiles	100	m^2	3	3.2
Painted soffit	74	m^2	3	3.3
Suspended plasterboard ceiling 1 x 12.5mm	37	m^2	3	3.3

Carbon and cost hotspots were analysed by sorting the CC and EC of the building elements separately form the highest to the lowest and a hierarchy of elements was produced. Then, the cumulative percentage was calculated and the elements that contribute up to 80% towards the CC and EC were identified as cost hotspots and carbon hotspots respectively.

4. DATA ANALYSIS AND DISCUSSION

Case study building is an office building located in central London and the profile of the building is presented in Table. The building is a hybrid framed building with raft foundation comprising concrete flat roof. Façade is made of pre-engineered stone concrete and glass. Combination of brick, block, dry lined partitions and glazed units forms the internal partitions of the building. Building is finished with moderate type of finishes and installed with highly sophisticated services including Building Management System (BMS). The estimated total CC of the building was £14,157,600 and the EC was 8,806,100kgCO_2.

Table 3: Case Study Building Profile

Gross Internal Floor Area (GIFA)	**11,320 m^2**
No of floors	8
No. of basements	1
External girth	148 m
Average storey height	3.6 m
Building height	29.7 m
Wall area	4,410 m^2

The CC and EC breakdown of the main elements are presented in Figure. Accordingly, it can be noticed that the superstructure of the building contributes equally towards CC (44%) and EC (49%) and superstructure is the predominant carbon and cost hotspot among the others. In terms of substructure, it contributes more than twice as CC (10%) towards EC (23%) and substructure is the second most significant carbon hotspot.

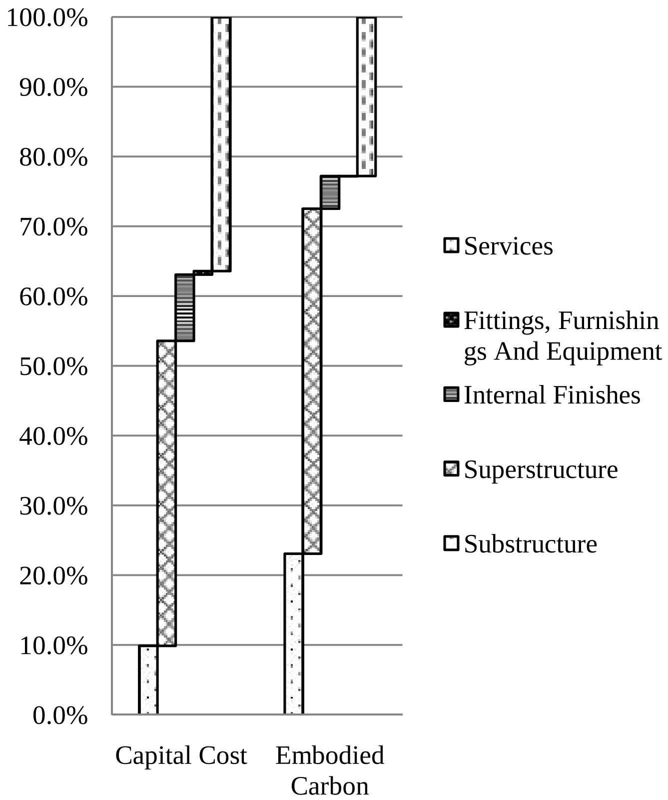

Figure 3: CC and EC Contribution by Elements

Services are the second most significant cost hotspot in the case study building contributing up to 36%. On the other hand, services and substructure both contributes almost equally towards the EC of the building. Internal finishes contributes up to 10% and 5% towards CC and EC, respectively. Fittings, furnishing and equipment are the least significant in terms of both CC and EC contributing less than 1%.

Table presents the hierarchy of cost and carbon hotspots of the case study buildings. The elements that are coloured in greyscale are the elements that contribute up to 80% of the CC and EC. The Carbon and cost hotspot analysis revealed that not all the identified cost hotspots are carbon hotspots and Substructure, Frame and Services are identified as both cost and carbon hotspot at different significant levels - Services being the most cost significant and the Frame being the most carbon significant. On the other hand, Fittings, Furnishings and Equipment, Stairs and Ramps and Internal Doors are found to be the least cost and carbon significant in the case study building. The findings inform the designers that more attention is needed when designing Substructure, Frame and Services for this kind of office buildings. EC can be reduced by sourcing materials that are recycled or with lower carbon content which again needed to be compared with the cost to arrive at an informed decision of the optimum solution for the project considered.

Table 4: Carbon and Cost Hotspots of the Case Study Building

Cost Hotspot Hierarchy	Cumulative %	Carbon Hotspot Hierarchy	Cumulative %
Services	36.4	Frame	26.2
Frame	61.8	Substructure	49.3
Substructure	71.8	Services	72.1
Windows and External Doors	77.6	Upper Floors	84.6
Ceiling Finishes	83.0	Internal Walls and Partitions	89.0
Upper Floors	87.1	External Walls	91.8
External Walls	89.8	Ceiling Finishes	93.9
Internal Walls and Partitions	92.5	Roof	96.1
Floor Finishes	94.9	Floor Finishes	97.9
Roof	96.8	Windows and External Doors	98.6
Wall Finishes	98.5	Wall Finishes	99.3
Fittings, Furnishings and Equipment	99.1	Stairs and Ramps	99.8
Stairs and Ramps	99.5	Internal Doors	99.9
Internal Doors	100	Fittings, Furnishings and Equipment	100

In addition to that CC per GIFA and EC per GIFA were also calculated for individual elements to get insights in to the findings and presented in Figure. Even though CC and EC demonstrate a similar patter when analysing at main elements level, differences can be noticed at individual element level. Clearly, Services is the most Significant cost hotspot in the building followed by Frame and Substructure while Frame is the most carbon significant element followed by Substructure and Services. This showcases that the Substructure, Frame and Services are the most carbon and cost critical elements in the case study building. Further, Figure also clarifies that not all Superstructure elements are cost and carbon significant. For instance, contribution of Stairs and Ramps and Internal Doors are almost negligible. While Windows and External Doors are found to be cost significant, EC contribution of the same is very low. The reason for this is CC of timber is high while EC of timber is very low making this enormous difference. Hence, specification of the building elements plays a major role in dictating CC and EC of the building and their relationships. In terms of Internal Finishes, Ceiling Finishes are the most carbon and cost significant and Wall Finishes are the least carbon and cost significant of the three following a similar rhythm. Fitting, Furnishing and Equipment are found to be insignificant in terms of both cost (0.51%) wise and carbon (0.04%).

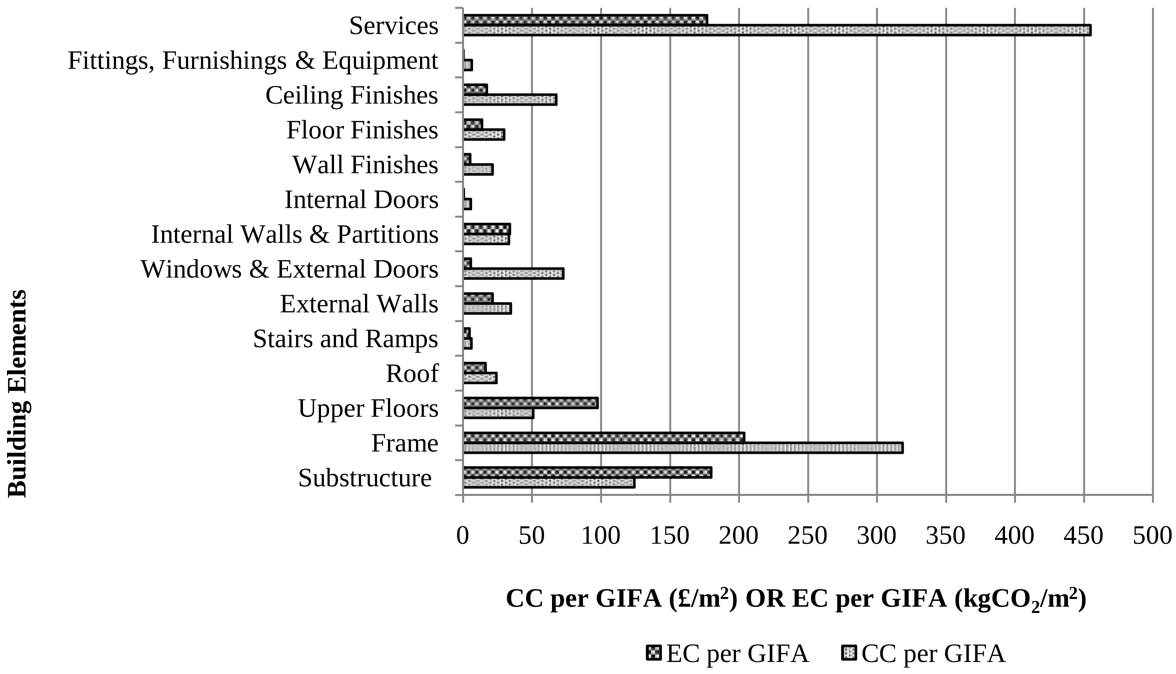

Figure 4: CC per GIFA vs. EC per GIFA by Elements

The significance of this analysis is that it informs the design team about the elements whose design has greater impact on the CC and EC of the building. For instance, in the case study building, Substructure, Frame and Services are identified as both cost and carbon critical elements. Hence, it is possible to select the optimum design solution from various possible alternatives, which does not compromise the function and aesthetics of the building element, when designing those elements in the future. Hotspot analysis also demonstrates that certain building elements are not worth investing time in optimising cost and carbon as its contribution to total EC and CC is almost negligible. Therefore, it is important that this kind of knowledge is developed and utilised during design development. However, this is based on a single case study and hence, no inferences can be drawn from the findings. Nevertheless, a foundation is laid in this paper to expand this type of research with a larger sample to arrive at generic prepositions and recommendations.

5. SUMMARY

The aim of the study was to identify the cost and carbon critical elements in the case study office building. Even though there is a general say that foundations, frame, roof, walls, and floors are to be carbon hotspots it cannot be taken for granted without thorough analysis. Also hotspots will vary for buildings with different functions and design features. Subsequently, an office building located in London was studied in detail to identify and draw insights about the cost and carbon significant elements in the building. Accordingly, the case study findings reveal that both CC and EC are significant in Substructure, Frame and Services. The Frame is identified as the most carbon significant element in the superstructure followed by Substructure, Services and Upper Floors while Services is identified as the most cost significant followed by Frame, Substructure, Windows and External Doors and Ceiling Finishes. Further, some elements impact hugely than others and some elements like Fittings, Furnishings and Equipment, Stairs and Ramps and Internal Doors have minimal impact on CC and EC compared to other elements. The implication of this analysis is that it enlightens the design team with the knowledge about the elements whose design has greater impact on the CC and EC of the building. Hence, it is possible to select the most optimum design solution from various possible alternatives which does not compromise with the function and aesthetics of the building element when designing building elements in the future.

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COASTAL ZONE ADAPTATION IN TRINIDAD AND TOBAGO: A REVIEW OF LITERATURE

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ABSTRACT

Empirical evidence supports that anthropogenic activities have brought about significant changes in our climate. In the instance of Small Island Developing States (SIDS) there is a potentially significant impact from the effects of climate change as the majority of the population resides within the coastal zone, thereby increasing potential loss of life and damage to property during climate related events. Determining vulnerability can provide an assessment of the factors that place communities at risk to the potential loss of life and property and assist in the creation of solutions towards increased resilience and adaptation.

This paper explores the literature on the coastal zone vulnerabilities of Trinidad and Tobago with particular focus on the Caroni River Basin, the most populated basin on the island. In addition to the population growth in the coastal zone, key sectors of subsistent agriculture, fisheries, cottage industries, oil refineries and manufacturing are located within the coastal zone. Therefore, this paper also highlights the myriad of vulnerabilities of Caribbean SIDS and outlines environmentally sensitive design solutions for coastal zone adaptation.

***Keywords**: Caribbean SIDS; Vulnerabilities; Climate Change Adaptation; Trinidad and Tobago.*

1. INTRODUCTION

Empirical evidence supports that anthropogenic activities have brought about significant changes in our climate. Global results of these activities include the melting of the solar ice caps, sea level rises, increased magnitude of storms, and warmer temperatures in our urban centres. In the instance of Small Island Developing States (SIDS) where the majority of the population resides within the coastal zone, the potential of loss of life and damage to property increases greatly. In Small Island Developing States (SIDS) more than 70% of the population live within 100 km of the shoreline (Creel, 2003) and population figures are expected to rise exponentially as more people move from to cities to increase their access to economic activity and government services.

Expanding coastal cities in SIDS are now resulting in the challenge of finding sufficient land to meet the needs of inhabitants, ensure their safety and prevent potential loss of property assets due to flooding and coastal erosion. In the midst of these challenges, the issue of vulnerability becomes more relevant and the limited geographical area and access to information and economic resources are central to the discussion. In Caribbean SIDS, there are gaps in information sharing which has limited the region's ability to develop a comprehensive response to climate change. Each country within the Caricom network has been keen to develop its own appropriate response, and to create a detailed regional course of action, including contingency planning, where larger islands can assist the citizenry of smaller islands.

Determining vulnerability can provide a method of assessment of the factors that place communities at risk to the potential loss of life and property. A vulnerability index is an attempt to attain a measurement of vulnerability, based on the particular demographic factors that impact the capacity of the area to become resilient. Due to the underlying qualitative nature of demographic research, these numerical indexes have inherent flaws, as averages or estimations can never completely relate the entire story of a community. They do, however, provide a guide to the conditions that may impact the vulnerability of a

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given community and should be used in conjunction with visual observation and expert interviews. Comprehensive assessment of the community can then determine the solutions towards increased resilience and adaptation.

This paper explores the coastal zone vulnerabilities of Trinidad and Tobago with particular focus on the Caroni River Basin, the most populated basin on the island. Although Trinidad and Tobago is seen as the most affluent nation in the Caribbean, its various vulnerabilities are not uncommon to SIDS in the region. Through a comprehensive literature review, this paper highlights the inherent vulnerabilities of Caribbean SIDS and recommends the development of a comprehensive coastal adaptation strategy that includes *e*nvironmentally sensitive design solutions from built environment disciplines.

2. CLIMATE CHANGE IMPACT ON COASTAL ZONES

Coastal zones can be roughly defined as the area within 200 kilometers of the shoreline (Creel, 2003). During the period of 1961 to 2003, the observed sea level rise was about 1.6 mm/year with contributing factors including ocean thermal expansion and the melting of glaciers, ice sheets and ice caps (Church *et al.*, 2007). By 2100, the global sea level rise is expected to be between 0.5m to 2.0 m (Nicholls *et al.*, 2011). SIDS, where there is an inherent vulnerability to sea-level rise, could be severely impacted by a rise of 1m (Nicholls *et al*., 2011).

The warming of the earth's temperatures is also likely to cause changes in precipitation. "A more active hydrologic cycle" is a result of an increased atmospheric water holding capacity (Easterling, 2002). This increase of the water vapour holding capacity will not only result in increased precipitation during storms, but could also contribute to larger storm surges and surface waves. It is noted that warming of the climate may not necessarily increase the frequency of these storms, but an increase in storm severity will have a significant impact on coastal regions (Church *et al.*, 2007).

As a Caribbean SIDS, Trinidad and Tobago has distinct physical and demographic characteristics that contribute to its vulnerability, particularly the high concentration of infrastructure and industry in the coastal zones. Shown in Figure 1, the centers of industry (oil, manufacturing) are in coastal zones and the impacts of climate change could therefore weaken the viability of these industries. In terms of the infrastructure, by 2100 Trinidad and Tobago could experience damage to a significant part of its GDP in terms of the damage to infrastructure at a cost of $1,892,000 (Bueno *et al*., 2008).

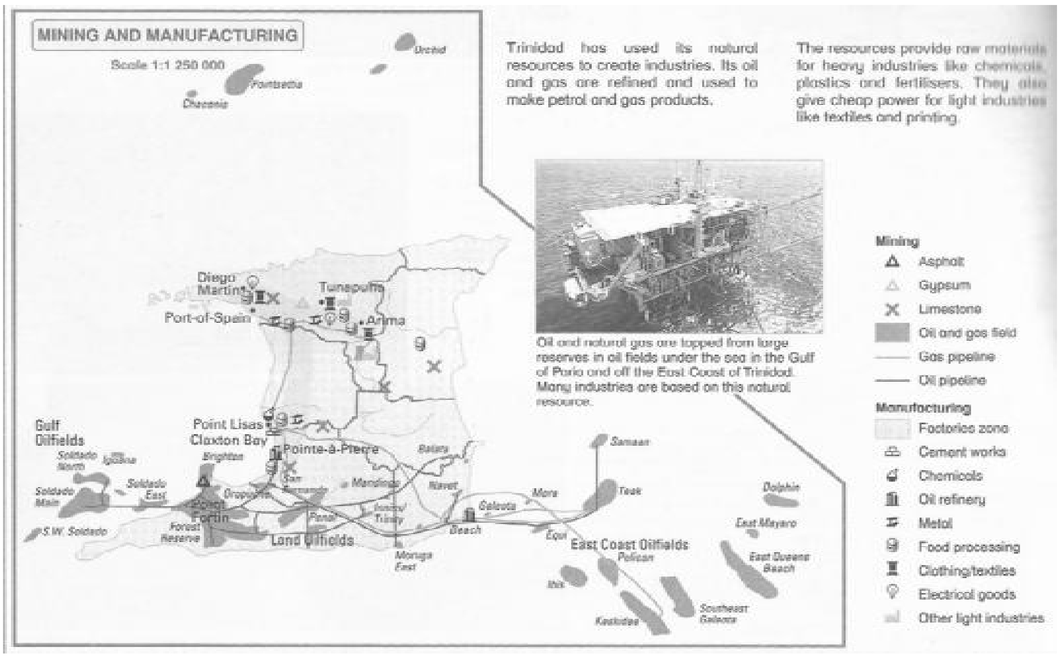

Figure 1: Coastal Industries in Trinidad and Tobago
Source: Morrissey (2007)

In Trinidad and Tobago, the Caroni basin has been identified as the most vulnerable to the impact of climate change. The Caroni basin is the largest on the island; it is a densely populated area with the growth of development encroaching on mangroves and swamp land. Concurrent development in the surrounding hills exacerbates the effect of flooding in this basin and leads to the potential damage of property and infrastructure. In addition, this area also has the largest concentration of arable land on the island, which often experiences the loss of crops due to frequent water logging of farms. Currently, flooding often impedes access to the capital city of Port of Spain, forcing the closure of government offices.

3. VULNERABILITY

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2007). This definition describes vulnerability as a function of exposure, sensitivity and adaptive capacity where exposure is the extent to which a system is exposed to an extreme event, sensitivity is how affected the particular system is to this event and adaptive capacity is the ability of the system to adapt to the effects of the extreme event (Engle, 2011). SIDS are particularly vulnerable to the impacts of climate change as the majority of industry, development and infrastructure are centralized in these hazardous zones.

However, the links between coastal management, sustainable livelihoods, and the value in building resilience to climate change effects continue to provide a significant challenge for SIDS. Higher income nations are able to develop adaptive measures at a faster rate than the middle to low income nations (Berrang *et al.*, 2010). SIDS are more likely to develop reactive measures to climate change impacts as their understanding and resources to address climate change is largely limited (Amundsen *et al.*, 2010). Developing adaptive measures to climate change is an increasing challenge for SIDS as policy and development trends are centred on building economic capacity. This challenge of coastal zone management in SIDS must be met with a combination of proper assessment and adaptive measures.

3.1. VULNERABILITY INDEXES

Scientists have made attempts to determine the vulnerability of coastal areas through a variety of means, the most significant method in terms of calculating the vulnerable physical characteristics of coastal regions is the Coastal Vulnerability Index (CVI) (Birdwell, 1994). It classifies vulnerability based on a numerical analysis of the tide range, average wave height, geomorphology, coastal slope, relative sea-level change and shoreline accretion. This index, however, does not account for the socio-economic vulnerabilities of coastal communities. Concurrently, the Social Vulnerability Index solely explores the demographic factors that may make communities vulnerable to the impacts of climate change (Cutter, 2006). There has even been an attempt to integrate the two vulnerability indexes to attempt to determine the risk to communities. The basis of analysing the vulnerability of coastal communities must comprehensively outline the built environment vulnerabilities and review the economic vulnerabilities in the global context.

Unfortunately, the SIDS are at increasing risk of the impacts of climate change due to their inherent physical, social and economic characteristics. As a result of the available land in SIDS, the urban and peri-urban and rural communities are all located in low elevation coastal zones. In 2000, 67% of the population in SIDS lived along coastal zones (McGranahan *et al*., 2007). The risks to emergency response management are greater in coastal urban centres where limited service infrastructure is prone to frequent interruptions, particularly in electricity and water. Based on current projections, it is estimated that by 2050, the sea level would be an additional 8.9cm high and by the year 2100, this would be 18cm (Bueno *et al*., 2008).

3.2. PHYSICAL VULNERABILITY IN SIDS

In low lying areas where the geological subsidence is an integral part of development, sea level rise and frequent flooding can lead to groundwater saline intrusion; impact the tidal range, increase the volume of sediment in bays and estuaries, and change the details of the shoreline (Doornkamp, 1998). The cost of providing protection from the sea level rise could be approximately 0.02% of the Gross Domestic Product (GDP) (Nicholls *et al*., 2011) and higher in nations where the infrastructure has yet to be upgraded.

Increased flooding can severely reduce the service life of the existing infrastructure resulting in early deterioration or complete failure (Mills and Andrey, 2002). Although infrastructure can be built to withstand certain environmental occurrences, the aspect of climate change that promises an increased threat of these environmental hazards, makes building for expected conditions an increasingly difficult task (Mills and Andrey, 2002). Mills and Andrey note that ‘gradual changes in sea level may be expected to damage or render inaccessible, low-lying coastal infrastructure including road and railway beds, port and airport facilities, tunnels and underground rail / subway / transit corridors’ (2002). Increased precipitation can also directly impact the frequency of slope failures and landslides while flooding can exacerbate issues related to riverine and urban storm water management.

3.3. SOCIAL VULNERABILITY IN SIDS

It is noted that connectivity is key to disaster response and adaptation (Dunno, 2011). Limited infrastructure disconnects rural coastal communities in SIDS from their urban centres. The higher transportation costs to these areas also restricts access to external markets and the flow and quality of access to information (Pelling and Uitto, 2001). Isolation from global networks and limited access to services insulate these rural communities and increases their vulnerability (Dunno, 2011). In the SIDS there are discussions around increasing ICT technology to provide stronger emergency management frameworks, but with the vulnerability of the existing infrastructure, these systems are still largely unreliable.

3.4. ECONOMIC VULNERABILITY IN SIDS

Small economies, that are heavily dependent on access to natural resources, are another feature of SIDS. In the Caribbean, the gross domestic product is dependent largely on fisheries, agriculture and tourism. Economic vulnerability increases as a result of natural disasters, since it impacts on the country’s gross domestic product, thereby hindering economic growth (Dunno, 2011). In light of the globalized diversified markets, Caribbean economies have remained specialized in areas of tourism, offshore finance and agriculture (Pelling and Uitto, 2001). Since the population has historically relied on certain industries, the transition towards economic diversity is slow. As a result, these islands are also dependent on imports. Limited exportation impedes economic growth and decreases the country’s ability to access international funding, which in turn limits its ability to invest in social development and efficient infrastructure (Dunno, 2011).

In light of globalized economies and connectivity of world markets, an economic crisis in one country can quickly impact the GDP of others. Economic vulnerability is becoming an increasing concern as countries’ economies are more open and vulnerable to international markets. For example, high food imports make developing countries less food secure when coastal regions are under threat of the impacts of climate change (Broad and Cavanagh, 2011). In the Caribbean, the vulnerabilities are more significant, as noted by Achim Steiner, as 99 percent of Caribbean tourism is along the coastline (Caribbean 360, 2014).

Due to these pressing changes, Trinidad and Tobago developed adaptation strategies centered on data collection, policy development and environmental protection-seen as an integral part of coastal adaptation. To date, these strategies are mainly focused on building capacity through citizen awareness programmes and disaster preparedness policies. The work towards adaptation, however, falls short in the active protection of natural coastal resources, managing coastal development and strengthening the capacity of industries in the coastal areas. The need to protect coastal resources and assets while developing comprehensive measures to manage growth, provides the framework for sustainable development; yet adaptation is the missing link. Case studies of the most effective ways to approach adaptation can provide guidance and strengthen Trinidad and Tobago's ability to address the impact of climate change.

4. LESSONS FOR CLIMATE WISE URBAN DESIGN

Based on the increasing vulnerabilities to climate change adaptation, countries must consider climate wise strategies to reduce vulnerabilities (Tong, 2012) to their coastal built environment. Strategies that warrant further investigation for use in Trinidad and Tobago are 'Elevated' and 'Floatable' developments 'Living Shorelines' and 'Green Infrastructure' (Tong, 2012; Erdle *et al.*, 2006; Benedict and McMahon, 2002).

'Floatable' development, also known as 'Aquatecture', allows for structures to float on the surface, reducing the vulnerability during instances of flooding or varying tides (Tong, 2012). The creation of floatable cities has even been explored to address the need for housing for growing populations in coastal zones. It also encouraged the revival of 'Chinampas' (floating gardens) as the practical need for agricultural landscapes in these aqua-communities.

'Elevated' developments are constructed at predetermined heights (Tong, 2012). This form of development was historically used for residential structures in rural, low-lying communities of Trinidad and Tobago and provides lessons for commercial development. The usability of elevated commercial structures and/or elevated connectors between existing buildings is also an option.

'Living shorelines' is the process of restoring coastal natural environments to reduce the impact of flooding and erosion (Erdle et al., 2006). This method utilizes environmental engineering strategies to 'rebuild' natural coastal zones and maintain the integrity of shorelines. Environmental engineering is still an emerging field in Trinidad and Tobago and strategies are not widely utilized.

'Green Infrastructure' is defined as an "interconnected network of green space that conserves natural ecosystems values and functions and provides associated benefits to human populations" (Benedict and McMahon, 2002). This network provides connections in three forms: a corridor, patch and matrix. The corridor is an extended connection of green space throughout urban areas, providing a reduction of the urban heat island impact. The patch integrates green spaces within the urban fabric to provide more infiltration of green space in hard surfaces. While the matrix, as its name suggests, is a mix of the aforementioned systems. The particular green space options include, but are not limited to, green roofs, private gardens, public parks, street trees and the retaining or replanting of the natural environment (Gill *et al*., 2007).

5. CONCLUSION

The strategy for determining the best way forward for Trinidad and Tobago through the extension of the region is currently centered on the recommendations for the existing strategies for coastal zone management, although local coastal management documentation reiterates the need for the creation of adaptation strategies to address the adjusting needs to climate change. However, these methods are not clearly defined and the recommendations have suggested that new policies should bolster current development trends. Based on the informal growth of communities in the Caribbean, new policies at the national level will not translate into controlling existing development trends. The general population should be provided with accessible solutions for building in vulnerable areas and reduce the vulnerability of people living in the danger zones of the coastal regions. The solutions developed in this research will be disseminated through the distribution of a pamphlet to local developmental agencies, construction companies and professional organizations within the study area to increase the population's understanding of viable methods to adapt to the impacts of climate change.

The way climate change is understood within the nation's socio-economic structure has a profound impact on assessment and adaptation. Ultimately, proper assessment can lead to a comprehensive adaptation strategy, which will encourage the preservation of natural resources and manage the impact of future development. In light of climate change impacts, environmental management and adaptation is an important consideration (Doornkamp, 1998). As a small island state, Trinidad and Tobago must consider comprehensive coastal zone adaptation solutions for the population living in such vulnerable areas as the Caroni River Basin.

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CONSTRUCTION MANAGEMENT PRACTICES INFLUENCING PRODUCTIVITY IN BUILDING PROJECTS

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ABSTRACT

The adverse effects of management related problems affecting productivity in construction projects can be reduced by implementing best management practices that are suitable for a specific project type. Previous studies identified the best practices for infrastructure and industrial projects. However, these practices could not directly be used for building projects as the management practices might vary from project to project and from country to country. Moreover, a little research has been conducted on what the best practices might be in the context of building projects in Victoria, Australia. Face-to-face in-depth interviews were conducted with nineteen experienced professionals in the construction industry and forty-seven context specific best practices for building projects such as long lead materials identification, machinery productivity analysis, short interval planning, incentive programs, dynamic site layout plan and safety policy are identified. The study revealed that some best practices that are applicable to infrastructure and industrial projects are not suitable for building projects. Therefore, implementation of the best practices identified in other contexts could not improve productivity in building projects and principal contractors involved in building construction should adopt context-specific practices to enhance the productivity of their projects.

Keywords: *Australia; Best Practices; Building Projects; Management Practices; Productivity.*

1. INTRODUCTION

Construction productivity improvement is essential for economic growth of a country. Productivity growth is also important for increasing the profit margin of contractors. Previous studies confirmed that management practices and technology are among the most important factors that have the potential to increase productivity in construction projects (Rojas and Aramvareekul, 2003). For principal contractors involved in the management of many subcontractors, the implementation of best management practices plays a vital role than the use of technology in delivering building projects within the contract time. The Victorian state construction industry is characterised by numerous subcontractors and a few principal contractors (Australian Bureau of Statistics, 2016). Multi-storey building projects in the state are managed by a principal contractor that engages various subcontractors. Thus, the use the best practices can help principal contractors to manage their subcontractors and to hand over their projects within agreed time framework. Moreover, the implementation of best practices can reduce the adverse effects of the construction productivity problems such as shortage of materials, equipment and tools; rework; breakdown of machinery; disruption of utilities; changes in design and specifications; turnover; and accidents (Makulsawatudom *et al*., 2004; Rivas *et al*., 2011; Ghoddousi and Hosseini, 2012; Hughes and Thorpe, 2014).

A review of the literature shows that management practices having the potential to improve the productivity of construction projects can be classified into six categories: materials management, equipment and tools management, execution approach, human resource management, construction methods, and safety and health practices (CII, 2013b; CII, 2013a; Nasir, 2013; Caldas *et al*., 2014). However, as these practices are identified for industrial and infrastructure projects, they might not be best practices for building projects. Moreover, since projects are unique in nature management practices that are considered best in other countries might not be best in Australia. Furthermore, there is a little research

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done on what the best management practices could be for building projects. Therefore, the objective of this research is to identify the best construction management practices that have the potential to improve productivity in building projects in the context of Victoria, Australia.

2. LITERATURE REVIEW

Best practices are defined as the most efficient ways of doing something (Helms, 2006). In construction industry context, the best practices are processes that lead to enhanced project performance when they are executed effectively (CII, 2016). Productivity is the ratio of output to input (Park *et al*., 2005). In this study, output represents the value of a completed building project in dollars and input refers to the project duration in days. Materials management, equipment and tools management, execution approach, human resource management, construction methods, and health and safety practices are reviewed in this section.

Previous researchers suggested numerous materials management practices that have the potential to improve productivity in construction projects. Bell and Stukhart (1987) suggested the implementation of efficient materials management practices such as materials planning to enhance productivity. Olomolaiye *et al*. (1987) recommended regular review of the principal contractors' cash to ensure a continuous supply of materials. Lim and Alum (1995) suggested the use of just-in-time materials delivery techniques in urban Singapore. Arditi and Mochtar (1996) found that improvement in procurement practices could lead to enhanced project productivity. Abdul *et al*. (2005) mentioned the influence of the planning of critical materials on productivity. Makulsawatudom *et al*. (2004) proposed careful inspection of the construction materials as one of the areas where productivity improvement could be obtained in the construction industry of Thailand. Moreover, the authors emphasized the importance of initiation of materials management meetings as a means to improve coordination between head office and site team. Jergeas (2009) suggested that the availability of both critical and non-critical materials should be ensured to improve productivity in oil and gas capital projects in Alberta, Canada. Grau *et al*. (2009) assessed the impact of materials tracking technologies on crafts' productivity and quantified the impact of automating, identifying and localizing engineered components on productivity in industrial projects. The results of the study indicated that materials tracking technologies can significantly improve productivity. Nasir (2013) investigated the importance of construction materials procurement team and preservation of materials in construction sites to increase productivity in infrastructure projects. Caldas *et al*. (2014) identified monitoring materials status database as the best productivity practice for industrial projects. Some of the above materials management practices might not be applicable for building projects in the context of the Victorian building industry as the majority of principal contractors are not directly involved in purchasing construction materials.

Productivity improvement can also be achieved by implementing good equipment and tools management practices. Wheeldon (2012) mentioned effective tools management systems such as the use of tools tracking technology and regular inventory of tools to enhance productivity. Arditi and Mochtar (1996) identified maintenance of machinery as one of the possible areas where productivity gain could be obtained in the construction industry of Indonesia. Stewart (2002b) suggested that to fulfil the short term equipment demand, renting is the preferred procurement option. Stewart (2002a) recommended leasing option when there are many construction projects in an industry. Marquez and Herguedas (2004) described that good record keeping helps contractors to analyse the performance of the equipment and to take corrective actions. Wireman (2005) justified the benefit of training the machinery operators in improving productivity and saving costs. Prasertrungruang and Hadikusumo (2007) suggested adopting of suitable construction equipment acquisition strategies such as renting, leasing and buying based on project scope and construction markets. Procurement procedures and plans for equipment and tools were found to be the best practices in improving roductivity in industrial projects (CII, 2013a). Conducting onsite tool maintenance was found to be one of the best practices for infrastructure projects (Nasir, 2013). The author also described that identifying tools which need maintenance, planning the time when they will be repaired, and assigning qualified personnel are important tool management practices. In the context of Victoria, since principal contractors sublet most of the construction works, some of the equipment and tools management practices might not be important to improve the productivity of building projects.

The preparation of detailed project execution plan is another potential area for productivity improvement. According to PMI (2013), a project plan is a formal and approved document used to guide project execution and control. It is used to document any assumptions and decisions about a project, facilitate communication among stakeholders, and document approved scope, cost and schedule baselines. Hadavi and Krizek (1993) concluded that higher construction productivity is obtained by implementing short-interval goals instead of long-interval goals. Arditi and Mochtar (1996) suggested that the use of the construction management (CM) project delivery system is significant to increase productivity. Jergeas (2009) found that defining clearly the scope of a project and reducing conflicting issues among contract documents are good practices to enhance project performance. CII (2013a) identified Construction Work Packaging (CWP) as the best practice for industrial projects. Construction Work Package (CWP) is an executable construction deliverable which defines a specific scope of work in detail including its budget and schedule (COAA, 2013b). COAA (2013a) recommended the assignment of a dedicated planner to improve construction productivity. Nasir (2013) suggested identification of permitting requirements and alignment of utilities such as water and power as the potential areas for productivity improvement in infrastructure projects. Caldas *et al*. (2014) identified the utilization of software in generating work packages and in developing 3D models as one of the best productivity practices for industrial projects. El-Gohary and Aziz (2014) suggested that increasing the constructability level of design is the first step in improving productivity in the construction industry of Egypt. In the Victorian construction industry, as there are numerous regulatory requirements for building projects, preparation of detailed project execution plan might be important. For instance, the practice of the identification of the type of permits could be significant for principal contractors. Thus, the implementation of some of the above practices might help the contractors to improve productivity in their building projects.

The use of good human resource management practices could also lead to improvement of construction projects' productivity. Maloney (1983) mentioned that team building practice is one of the approaches which enhance the forces acting to increase the productivity of the labour. Liberda *et al*. (2003) suggested emphasizing on team building or crew composition as important human resource management practice. Fagbenle *et al*. (2004) concluded that the productive time of bricklayers who received non-financial incentive was improved significantly. Kazaz and Ulubeyli (2007) mentioned that incentive payments, the adequacy of the workers' payment as compared to others' who are working on similar projects, the effectiveness of the remuneration on time and the arrangement of social activities are the most important factors that could increase workers' motivation. Wang *et al.* (2010)found that training for craftsmen increased construction productivity by 5%, and decreased absenteeism as well as turnover by 2.5% and 10% respectively. Hewage *et al.* (2011) concluded that the construction productivity might not be improved by only working hard and fast. According to the author, the companies should also develop the social skills of their workers. Tabassi *et al*. (2012) described that a well-organized human resource development program is an essential strategy for construction firms as human capital plays a significant role in the success of an organization. According to Hong *et al*. (2012), effective human resource management practices such as employee empowerment, training and development, appraisal system, and compensation are the principal factors for employee retention. Nasir (2013) identified the clarification of the responsibilities of employees as one of the best practices for improving productivity in infrastructure projects. Caldas *et al*. (2014) concluded that maintaining the stability of the organizational structure is the best management practice for industrial projects. Some of the human resource management practices mentioned above might not be applicable for principal contractors in Victoria. For instance, crew composition for each trade of work might not be important for principal contractors involved in managing the works of subcontractors.

Construction methods related practices are also identified as the critical factors that could enhance productivity in the construction projects. According to PMI (2013), project management methods are defined as a system of practices, techniques, procedures, and rules used by those who work in the discipline. Dynamicsite layout which refers to a sequence of layouts, each is used for a discrete time interval or certain project phase, and together covering the entire duration of a construction project is one of the techniques for productivity enhancement (Tommelein and Zouein, 1993). Arditi and Mochtar (1996) found that integration of management functions could increase construction productivity. The use of Critical Path Method (CPM) in controlling and integrating various schedules is significant for monitoring project performance (Neil and Knudsen, 1990). The project schedule controlling technique include the methods used in measuring work progress such as units completed, incremental milestone, start/finish, and manager or supervisor judgment (Attalla, 1997). The technique also includes analysing, reporting and corrective action approach. Zhang *et al*. (1999) developed a computer model to optimize the location of a group of tower cranes. Hanna *et al*. (2008) suggested that the use of second shift schedule is effective as compared to overtime and overmanning in reducing the project duration. Nasir (2013) found that project start-up, project completion, traffic control and site security plans are the best practices for enhancing productivity in infrastructure projects. Investigation of new technologies for construction methods is recommended as one of the mechanisms to increase construction productivity (CII, 2013a). Caldas *et al*. (2014) suggested that the implementation of the integrated schedule is the best management practice for improving the productivity in industrial projects. In cities such as Melbourne, Australia, building construction projects are carried out in confined spaces. Thus, some of the above-mentioned practices such as machinery positioning strategy might be important to enhance productivity in building projects.

Finally, health and safety practices could also improve productivity in construction projects. Sawacha *et al*. (1999) found that organizational policy on safety is the most significant factor that could influence the safety performance of construction projects in the UK. Hinze and Wilson (2000) confirmed that conducting alcohol and substance abuse program is one of the mechanisms to achieve zero accidents on construction projects. Dai *et al*. (2009) mentioned the impact of health and safety training on productivity. Jergeas (2009) found that neat and clean work environment and safety training are essential to ensure safety and productivity in construction projects. Preparation of the workplace health and safety (WHS) management plan according to the relevant code of practices is essential for productivity and safety of construction workers (Safe Work Australia, 2012). Safe work method statements (SWMS) or job safety analysis for each task is the practice that could ensure the safety of workers and leads to enhanced productivity. According to Safe Work Australia, SWMS sets out the tasks in a logical sequence, identifies the potential hazards and describes the measures to control them (Safe Work Australia, 2012). The occurrence of accidents in building projects in Victoria could lead to the closure of the site and productivity could be influenced. Thus, adopting best practices for safety and health might help principal contractors to increase their projects' productivity.

3. RESEARCH METHODOLOGY

Interviews were used to investigate the context-specific best management practices since they could vary from country to country and from project to project. Constructivist paradigm is adopted as there is no single best management practice that is accepted universally. Different construction industries have their own best practices which can be investigated by collecting qualitative data that helps to understand how each practice is implemented, why some of the practices are not suitable in some industries and other related issues. Accordingly, in-depth face to face interviews which took an average of one and half hours were conducted with nineteen professionals having construction industry experience ranging from five to forty years in Australia. The participants have been working as a general manager, construction manager, project manager, project coordinator, project engineer, site engineer, contract administrator, supervisor and cost manager. Semi-structured interview questions were prepared for sixty-nine management practices which were identified from the literature. The questions include: Does the practice exist? How do local contractors practice it? Is this practice best in improving the productivity of building projects? What other practices enhance the productivity of building projects? The interviews were audiotaped, transcribed and analyzed. Data analysis reached a saturation point and best practices for building projects were identified. Saturation refers to the point where a new respondent provides a similar reason for accepting or rejecting a particular management practice.

According to Rose *et al.* (2015), qualitative data analysis consists of three concurrent flows of activity: data reduction, data display, and conclusion drawing. Data reduction is a form of analysis that sharpens, sorts, focuses, discards, and organizes data in such a way that final conclusions can be drawn (Miles and Huberman, 1994). Writing summaries, coding, and making clusters are common methods used in the data reduction process. The latter two methods of reducing the collected data are more suitable when the research is entirely inductive nature.In this research context, writing a summary is used as it is suitable to sum up the responses of the interviewees regarding a particular management practice. The reduced data is displayed using matrices, graphs, charts and networks (Miles and Huberman, 1994; Rose *et al*., 2015). In this study, matrix technique is used as it is convenient to exhibit the summaries of the responses in matrix boxes. Once the data is displayed, theconclusion from qualitative data is drawn by noticing the patterns of similarities and differences between categories and/or processes, clustering, making contrasts and comparisons and noting relations between concepts (Rose *et al*., 2015). According to the author, the final three approaches are more appropriate if the researcher attempts to develop a theory from qualitative data only. However, in this research context, qualitative data was collected to be used as an input to the quantitative research and the first strategy that is noticing the pattern of similarity between the interviewees' responses about a specific construction management practice is used to drawn a conclusion.

An Excel spreadsheet in the form of a matrix was prepared to match the responses of an expert and management practices (refer Table 1). A summary of what each respondent has described about a particular management practice was written in boxes and a conclusion was drawn. Similar iterative procedures of qualitative data analysis such as transcribing, summarizing and concluding were used for all the interview results. The succeeding interview was not conducted until the previous one was analysed using the three procedures. The similarity between the successive summaries was identified to find a saturation point. After analysing the outcome of the fifteenth interviewee, similar explanations for the management practices were observed. Although the saturation point is reached at fifteenth interviewee, additional interviews were conducted until the nineteenth participant for the sake of confirmation. Finally, the practices that were described as suitable were included in the list of best practices for building projects. For the sake of brevity, all the data is not included in this paper. Sample data analysis for the practice "machinery positioning strategy" is indicated in Table 1 below. In the Table, the last two respondents R_{18} and R_{19} described that construction machinery positioning strategy is a best practice and explained similar factors such as the weight of materials, the floor area of a building, and the presence of nearby objects to determine the optimal location of a crane. Similar reasons were providedafter the fifteenth participant, and the practice was concluded as applicable for building projects in Victoria, Australia. By using similar techniques, forty-sevencontext-specific best management practices were identified and twenty-two practices are excluded from the list of the best practices.

Table 1: Interview Data Analysis Template

Construction Management Practices	**Respondents (R)**								
	R_1		**... R_{17}**		**Respondent(R_{18})**		**Respondent(R_{19})**		**Final Conclusion**
	S	**C**	**S**	**C**	**Summary(S)**	**Conclusion(C)**	**Summary**	**Conclusion**	
52. Construction Machinery Positioning Strategy					"We sit down and work through a site layout details.It is interrelated with many things such as traffic control plan; access points; the way materials could easily get into the site; the size or the footprint of the job; crane types and number requirements; and the location of the cranes and other issues.We locate cranes for the maximum flexibility; we position them to get as much coverage as we can. Thus, integrating and developing a strategy for positioning cranes is critical for productivity."	The practice is applicable	"The critical machinein our site is a crane, and its location is planned by considering the weight to be loaded, the street, distance of placement and the nearby buildings. The crane needs to reach the street; it needs to reach the heaviest lift; it needs to reach the entire site. There might be another building that is taller than the building under construction, and the crane should not hit that building. All these factors are taken into account when positioning a crane and it is a best practice."	The practice is applicable	**The practice is applicable**

4. RESULTS AND DISCUSSION

4.1. MATERIALS MANAGEMENT PRACTICES

Six best practices for construction materials are identified. These include procurement procedures and plans for materials, long-lead materials identification, monitoring materials status database, materials delivery schedule, material inspection process, and material inspection team. However, practices such as procurement team, on-site materials tracking technology, and post receipt preservation and maintenance are considered to be not significant to improve the productivity of building projects in Victoria.

The interviewees described that formation of a procurement team is entirely the responsibility of subcontractors and the practices is not significant for principal contractors. This could be due to the characteristics of the Victorian construction industry which is dominated by a few large contractors and numerous small companies that could supply and install construction materials. According to Australian Bureau of Statistics (ABS), at the end of 2015 financial year, the proportion of companies involved in building construction were 99.15% for firms employing 0-19 workers, 0.78% for firms employing 20-199 workers, and 0.06% for firms employing over 200 workers (Australian Bureau of Statistics, 2016).

On-site materials tracking technology is not considered as a best practice for building projects. There are different reasons provided by the respondents. The first one is that construction materials are not usually stored on building project sites due toshortage of storage spaces in the cities such as Melbourne, Australia. The materials are brought to the sites when they are required and placed near their installation areas. The other reason is to reduce the damagedue to multiple handling. The respondents described that they preferred to bring materials one day before their installation date. Thus, the tracking system is not required as the materials are not kept on building sites and the probability of missing their location is low.

Preservation and maintenance of materials are not considered as the best practices for construction materials in the context of building projects in Victoria. The participants described that it is the last option to choose this management practice. They explained that the practice is recommended for projects that have sufficient on-site storage spaces. However, as most building projects in cities such as Melbourne are carried out in restricted spaces the practice is not suitable to increase productivity. Some respondents also described that contractors could incur additional cost due to the loss of productivity if they implement this practice.

4.2. EQUIPMENT AND TOOLS MANAGEMENT PRACTICES

Three best practices for construction equipment and tools are identified. Procurement procedures and plans for construction equipment, construction equipment productivity analysis, and construction equipment maintenance are found to be applicable for building projects. However, tools related practices such as site tools management strategy, tools tracking systems and on-site tools maintenance are not considered as best practices.

The interview results indicate that tools management practices have less importance for building projects from principal contractors' point of view. This could be due to the nature of the industry in which smaller firms execute activities that involve tools. According to Australian Bureau of Statistics, 78% of the building construction works are executed by small and medium firms (Australian Bureau of Statistics, 2013). The principal contractors employ a few laborers and purchase a fewtools. The interview participants described that they do not usually employ skilled workers such as carpenters, plumbers, electricians, plasterers and other tradesmen. They have a few laborers that do ancillary works such as cleaning the site for the sake of safety and other minor works that could not be subcontracted. According to the interview, on some projects, from a total of two hundred skilled and unskilled labourers only twenty of them belong to a principal contractor. The number of the principal contractors' labourers could be as low as five based on the scope of the building projects. Thus, there is no need to implement management practices which are related to tools.

4.3. *EXECUTION APPROACHES*

Ten best practices for project execution approaches are found for building projects. These are short interval planning, well-defined scope of work, use of software for planning, dedicated planner, construction work packages, design readiness for construction, utilities alignment, contract strategies, model development, and permitting requirements.

The interview results revealed that the decision to prepare short interval plan is important for productivity. The plan shows the details of daily activities and the resources required for their execution. Some respondents described that short interval plan helps to focus on specific tasks that should be executed on a specific date. Furthermore, the respondents discussed that a well-defined scope of works which has references to drawings, specification, and other contact documents also has a positive impact on productivity. Some of the interviewees suggested the preparation of templates for the scope of works based on the previous work experience.

The employment of dedicated planner also has a positive influence on the productivity of building projects. However, the level of complexity and scope of a project determine the need to assign a dedicated planner. Some respondents explained that certain construction companies assign a dedicated planner for large projects such as hospital buildings. Others described that a project manager is responsible for planning tasks and dedicated planner is not required for small building projects. However, all interviewees explained that dedicated planners have sufficient productivity data which helps them to prepare better construction schedules. Thus, assignment of the dedicated planner is considered in a list of best practices.

Reviewing designs for construction purpose is found as one of the potential areas where productivity gain can be obtained. Interview participants described that for some items, how much time it takes to install can be more important than the actual cost of the material. They suggested that if principal contractors focus on design management and conduct constructability reviews, extra costs will be minimized and productivity can be improved. Utility alignment is also becoming an important practice for building construction projects in Victoria, Australia. According to the interviewees, utility adjustment is a significantissue because of the restrictions set by local authorities in connecting to old networks such as water, electric, sewer and other infrastructures. Contractors operating in the City of Melbourne are required to prepare Construction Management Plan that addresses issues such as public safety, amenity, and site security; operating hours; noise and vibration controls; air and dust management; storm water and sediment control; waste and materials re-use and traffic management (City of Melbourne, 2005). Before commencement of any construction activity, the plan should be approved. Thus, the practice of identification of regulatory requirements is important for building contractors to reduce initial project delay.

4.4. *HUMAN RESOURCE MANAGEMENT PRACTICES*

The finding of this study revealed that crew composition, skills assessment and evaluation, employees training,career developmen, non-financial incentive program, financial incentives programs, social activities, maintain stability of organization structure, clear delegation of responsibility, retention plan for experienced personnel, and exit interviews are the best productivity practices for building projects.

Interviewees explained that since most principal contractors do not employ skilled labourers focusing on the composition of crews for different trades of works is not significant. However, the formation of good management crew which comprises of project manager, site manager, supervisors and others is important for principal contractors. Some respondents described that certain construction companies include the name of key personnel in the subcontract agreements. Skill assessment and evaluation is another important element that could influence productivity in building projects. Some of the interview participants described that before the commencement of any construction activity, a project manager should organize the project crew by assessing the skills and experience of the employees. They suggested that the project managers should be able to understand the strength and weakness of the crew members. Some interviewee explained that the site staff could also be assigned directly from a head office. Respondents described that the principal contractor’s project manager or other project team member could check the skill and experience of a particular subcontractor. These can be done by requesting the recommendation letters from the previous employers and assessing other evidence such as pictures of the previously completed projects.

Employee training is also an important practice for building projects. Some respondents described that there are various changes such as new safety and health regulations in the construction industry and workers should be trained before starting to work in construction projects. Others added that employees can acquire technical skillsthrough practice, but they need to get training since legislations and regulations could change from time to time. Thus, training is considered as an important practice in the context of building projects in Victoria. The interview participants discussed that maintaining the stability of the organizational structure of a project is also an essential practice. They explained that unstable project organization could lead to loss of knowledge about a specific project. Therefore, controlling the staff turnover by using different motivation techniques is essential.

4.5. CONSTRUCTION METHODS

Ten elements under construction methods category are identified as best practices for construction methods to enhance productivity in building projects. These are integrated schedule, work schedule strategies, schedule execution and management, dynamic site layout plan, traffic control plan, site security plan, machinery positioning strategy, project start-up plan, project completion plan, innovations and new technologies.

Construction schedule which integrates works, materials, equipment and financial schedules has a positive impact on the productivity of building projects. Integration of the program is essential to monitor the material delivery, to evaluate the type of equipment to be used for a particular task, to assign the number and type of crew, and to organize any information that is required for execution of an activity in one place. Interview participants described that if more information is gathered in one place, the project team will have a better chance of understanding the project details. The research participants also explained that best-performing contractors link all the schedules together. These contractors integrate procurement, long lead materials delivery schedule and project status to the main work schedule. Developing working hours strategy is another important management practice that influences productivity. There are various working hour restrictions imposed by the authorities in Victoria and contractors are required to develop a strategy to reduce project delay. For instance, the Environment Protection Authority of Victoria (EPA) has a guideline to control noise from building projects. Accordingly, the normal work hours are restricted to 7:00am to 6:00pm during weekdays and 7:00am to 1:00pm on Saturdays (EPA, 2016).

Dynamic site layout plan is found to be one of the best practices for construction methods. Some of the participants described that although the practice of adopting dynamic site layout is necessary, it should be planned ahead to be effective. They explained that experienced contractors include their site logistics plan in a tender document. The proposed changes in the site layout plan are communicated to the prospective subcontractors. Construction machinery positioning strategy is another important practice that influences productivity in building projects. According to the interview results, the location of the critical machine or crane is determined by considering the major factors such as the maximum weight of an object to be lifted; distance from the street and nearby properties; and the floor area of a building. Some interviewees described that the crane needs to reach the street; it should lift the heaviest material; it has to cover the entire site; it should not hit the existing building or other property while maneuvering. Thus, careful analysis of the position of a crane using either 2D drawings or 3D models is an important practice to conduct the constructionworks smoothly.

4.6. HEALTH AND SAFETY

Based on discussion with interviewees, formal health and safety policy, task safety analysis, housekeeping, hazards analysis, zero accident techniques, health and safety training programs, and toolbox safety meetings are found to be the best practices for health and safety in building projects in Victoria. However, substance abuse program is not considered as a best practice. All respondents described that drug testing program is not practiced in most projects. Some participants suggested that for building construction sites, it is not necessary to have drug and alcohol testing policy as the program is not included in the employment agreement.

Safe Work Method Statement (SWMS) is found to be the best practice for safety and health in building projects. Interview participants described that SWMS is prepared by conducting safety analysis for a particular task. Accordingly, the task is broken down into manageable activities; potential hazards are identified; controlling techniques for minimizing or elimination of the risks are proposed and the responsible person is assigned. Moreover, preparation of SWMS is a regulatory requirement in the Victorian construction industry. According to Occupational Health and Safety Regulations 2007, any contractor must not perform high-risk construction works unless a safe work method statement is prepared and the works should be executed according to the statement. The regulation stipulates that if there is non-compliance with SWMS, the contractor must stop the work immediately which leads to loss of productivity. Moreover, the interviewees described that safety training needs to be carried out as regulations might change and employees need to be updated with the latest information. According to Work Safe Victoria, all persons performing construction works require proof that they had completed construction induction training regarding occupational health and safety issues in construction projects (Work Safe Victoria, 2016). Thus, preparation of clear safe work method statement is an important practice for principal contractors in Victoria. Toolbox safety meeting is also found to be the best practice for safety and health. Some respondents described that the meetings are typically conducted regularly in the presence of subcontractors' employees. Other interviewees explained that on some building projects the meeting is not scheduled. It is conducted when executing risky tasks such as lifting heavy precast panels and erecting of tower cranes. However, there is a short daily pre-start meeting and employees are briefed about the nature of activities on a particular day.

5. CONCLUSION

From the findings of this study, it is concluded that building projects have their own specific best management practices. Forty-seven context-specific best practices that are categorized under materials management, tools and equipment management, execution approach, human resource management (HRM), construction methods, and health and safety are identified for building projects in Victoria, Australia. Most of the tools and equipment practices that are obtained from the literature are not suitable for building projects where as the majority of the practices under HRM categories are found to be applicable in the context of Victoria. This study contributes to the body of knowledge by identifying and verifying best management practices for building projects from the perspectives of principal contractors. Based on the finding of this research, the authors are investigating the relationship between productivity and management practices using quantitative data. Researchers in other countries can prioritize the best practices for building projects in a different environment based on the findings of this study. Best practices from subcontractors' perspectives need further research as this study focuses on principal contractors' management practices only. Finally, the principal contractors in Victoria, Australia can implement the identified practices to improve productivity in their building projects.

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CRITICAL SUCCESS FACTORS FOR CONSTRUCTION OF GOVERNMENTAL PROJECTS IN EGYPT

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ABSTRACT

The identification of Critical Success Factors (CSFs) for construction projects enables appropriate decision making to achieve the project objectives. Limited studies focused on the CSFs in previous researches particularly in Egypt. Therefore, this paper aims to explore the CSFs necessary to achieve Governmental Projects objectives in Egypt. A number of CSFs have been determined through a comprehensive literature review. These factors were grouped under five main groups: project aspects, owner, contractor, consultant, and environment. A questionnaire was developed to facilitate systematic data collection in this study. Experts with an overall average of 20 years of experience in the construction industry were invited to participate in the survey. The results of this survey were ranked based on their degrees of importance in relation to success using the relative importance index. The results can be used as a guideline to successfully handle construction projects in Egypt as well as in other developing countries.

Keywords: *Construction Management; Critical Success Factor; Egypt; Governmental Projects.*

1. INTRODUCTION

Different types of construction projects have been achieved in Egypt with extreme delay or cost overrun which mainly considered unsuccessful projects. On the other hand, many projects in a broad range of sectors have been successfully achieved. Deep investigations in construction projects in Egypt were performed by the authors during May 2014 to December 2014 concentrated on construction of the governmental projects. The investigation includes 85 projects of different types such as: Infrastructure, residential, and commercial about 29% of the projects were succeeded finished on time within specific budget. However, 20% of projects failed to achieve budget, and 51% failed to achieve the planned schedule, as shown Figure 1.

A number of factors combine to determine the success or failure of an infrastructure project in terms of its objectives (i.e., cost, time, and quality) (Zhang, 2005). The identification of key success criteria in the construction industry would allow construction executives and project managers to appropriately plan resource allocation (Chua *et al*., 1999; Toor *et al*., 2008). Consensus on key success criteria will allow monitoring of project outcomes effectively and provide an ongoing framework to assist in tracking key project results (Chan *et al*., 2001; Toor *et al*., 2008). The CSFs can be identified based either on quantitative measures (Chua *et al*., 1999) or on expert opinions (Chua *et al*., 1999).

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The aim of this paper is therefore to identify CSFs related to the construction of Governmental Projects in Egypt. It is worth mentioning this paper greatly benefited from literature and the immense data collected through questionnaire surveys that were administered to a large group of qualified experts in construction projects in Egypt.

Following the introduction to this paper, the second section provides the background information relating to the CSFs in construction projects. In the third section, the research methodology is described. Then, the fourth section presents the results of this paper. After that, the results and findings are discussed in the fifth section. Finally, the sixth section draws summary of this study.

2. Critical Success Factors in Construction Projects

CSFs have been traced back to the 1960s (Rockart, 1982) and since then, it has been widely applied by many authors to identify CSFs in construction management. CSFs describe a procedure that attempts to make explicit the key areas that are essential for management success (Boynton and Zmud, 1984). Rockart (1982) defines Critical Success Factors (CSFs) as: 'those few key areas of activity in which favourable results are absolutely necessary for a manager to reach his/her goals'. Several studies have been conducted in literature to explore critical success factors (Chan and Kumaraswamy, 1996; Hwang *et al*., 2013; Andersen *et al*., 2006; Toor and Ogunlana, 2009), thus highlighting the importance of CSF study. For instance, Hwang *et al*., (2013) explored the CSFs for public-private partnership (PPP) projects. Yong and Mustaffa, (2013) identified 46 critical success factors in the local Malaysian construction industry. Tang *et al*., (2012) investigated the CSFs for international market entry.

Qiao *et al*, (2001) established eight independent CSFs in BOT projects in China such as appropriate project identification; stable political and economic situation; attractive financial package; acceptable toll/tariff levels; reasonable risk allocation; selection of suitable subcontractors; management control; and technology transfer. While many CSFs have been identified, in literature theirimportance relative to one another has received less attention. All are nominally regarded as 'critical' but, as some must be more important than others, it is sensible to attempt to rank them, particularly in terms of the attention that should be given to them in the development stages of projects. Chua *et al*. (1999) maintain that success of a construction project is determined by four aspects, namely: project characteristics, contractual arrangements, project participants, and interactive processes. Among the earlier, project characteristics the most common in literature. Project characteristics include external (e.g., political and economic risks, impact on public efficiency of technical approval authorities, adequacy of funding, and site limitation and location) and internal characteristics (e.g., constructability, pioneering status, and project size). Project characteristics contribute to certain project risks, including financial risks and schedule delays (Diekmann and Girard, 1995). Despite the enormous literature on CSFs, there are very little mentioned studies to identify CSFs in the Egyptian construction industry, particularly governmental projects.

3. Research Methodology

In the first stage, a comprehensive literature review was conducted to establish the foundation of this paper. In the following stage, extensive historical data has been reviewed and investigated of 85 succeed and failed governmental projects in Egypt. Based on the aforementioned stages; a list of CSFs has been developed in order to get the opinion of the experts in the Egyptian construction industry.

In the following stage, a questionnaire survey was demonstrated to collect the opinion of experts in the construction industry. Questionnaire survey has been recognised as the most cost-effective and most popular means of collecting information (Gravetter and Forzano, 2012). The questionnaire consisted of two main sections. The first section included questions about general background of the respondents. In the second section, the respondents were asked to rate the relative significance of the CSFs using a scale of 0-5, where, 0 being not applicable, 1 being not significant, 2 being fairly significant, 3 being significant, 4 being very significant, and 5 being extremely significant. The five-point scale has been widely used in construction management studies (Shen et al., 2001; and Sun et al., 2008) because it yields better dispersion than the three-point scale (Curtis and Carey, 2012).

A total of 114 questionnaires were sent out, between January and April 2015. All potential respondents were contacted before hand to make sure that they are willing to take part. A total of 50 complete questionnaires were returned, representing a response rate of 43.8 %, which is acceptable according to (Moser and Kalton, 1971; and Ott and Longnecker, 2010). About 28 of the responses were from contractors, 14 responses were from consultants, and 8 responses were from governmental authorities.

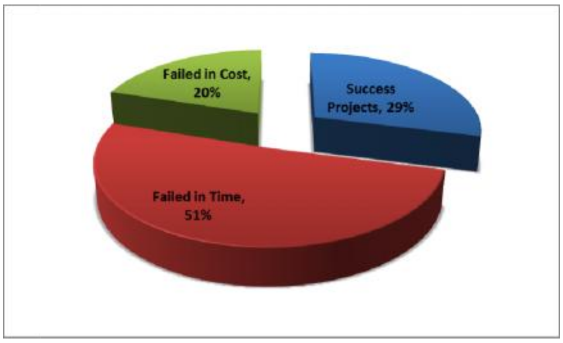

Figure 1: Distribution of Percentage Success and Failed Projects

4. SURVEY RESULTS

The main purpose of the aforementioned investigation is not to just identify a list of CSFs but to ascertain the key CSFs that can significantly influence the delivery of construction governmental projects in Egypt. Hence, in many researches which seeks to determine the most important factors, only the top ten ranked ones were chosen as key factors (McIntosh and McCable, 2003; Tam et al., 2004). In this research it is assumed the most CSFs based on the calculated relative significance index. Fourteen CSFs were considered as significant, where SI > or = 80%, following section explain how the relative significance index were calculated for each CSF.

4.1. SIGNIFICANCE INDEXES OF CRITICAL SUCCESS FACTORS

It is useful to analyze the relative significance of the CSFs (Zhang, 2005). The relative significance indexes of the each CSF are calculated separately. The following simple formula is developed to convert linearly the 0-5 scale used in the questionnaire survey to a 0-100 scale with 0 representing the lowest and 100 the highest significance. This means that “5”, “4”, “3”, “2”, “1” and “0” have significance indexes of 100, 80, 60, 40, 20 and 0 respectively.

Significance index $Si = \frac{Ri0x0+Ri1x20+Ri2x40+Ri3x60+Ri4x80+Ri5x100}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5} = \frac{20Ri1+40Ri2+60Ri3+80Ri4+100Ri5}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5}$

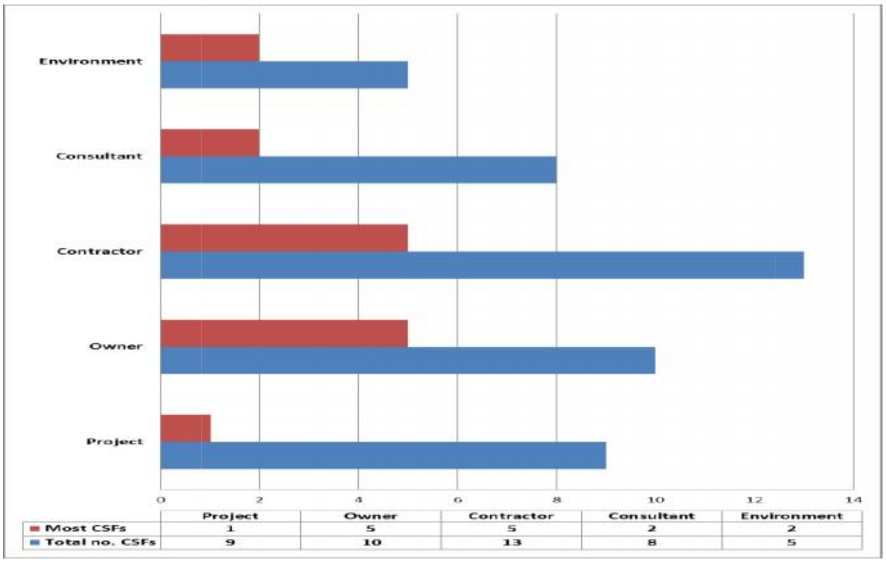

Figure 2: Number of Most Significant CSFs vsTotal Number of CSFs in Each Group

Where Si = significance index for the i^{th} factor;

Ri0= number of responses as "0" for the i^{th} factor;

Ri1= number of responses as "1" for the i^{th} factor;

Ri2= number of responses as "2" for the i^{th} factor;

Ri3= number of responses as "3" for the i^{th} factor;

Ri4= number of responses as "4" for the i^{th} factor;

and Ri5= number of responses as "5" for the i^{th} factor.

The significance indices and the rank of the CSFs were based on the responses appear in Table 1. Out of 45 CSFs, only 15 CSFs are considered as most significant 33% as shown in Table 1. Figure 2 is showing number of most significant CSFs versus total number of CSFs in each Group.

Table 1: The Significance Indexes and Rank of the CSFs

Success Factor	SI	Rank	Overall Rank
Group1 : Project			
Accuracy of the contractual duration of the project	87.2	1	5
Clarity terms of the contract	78.4	2	19
The existence of detailed study of the project to ensure there are no conflicts or differences between the various project documents	78	3	20
Clarity and determine the scope of work of the project	54.4	4	35
Suitablecontract for the project type	52.8	5	36
Place implementation of the project (easy access - the availability of basic materials - Security ... etc.	48.4	6	41
The application of technology or implementation of a new style for the first time applied	46.8	7	42
The existence of the project next to sensitive sites and as important as the military districts, embassies, sovereign bodies	46.6	8	43
How over the public accept the project	34.8	9	45
Group 2 : Owner			
The availability of project budget and easily extracts exchange procedures.	96.8	1	3
Continuous monitoring and effective control	86.8	2	6
Harmony and good coordination between the departments involved in the project to achieve the project objective	86.4	3	7
Flexible policies to manage the project	81.2	4	12
Relative power and authority	80.8	5	13
Capability to change subcontractors in case of backwardness	77.2	6	21
Continuity and poise organizational structure during the period of implementation of the project	70	7	31
Independence from the regulators.	52	8	37
The relative importance of the project for the top-level decision-making	51.2	9	38
Ease of communication between the different levels have Owner	50	10	39
Group 3 : Contractor			
Availability of financial capacity	100	1	1
Sufficient experience and capability of technical personnel	99.6	2	2
The ability to provide adequate raw materials required quickly	85.6	3	8
Adequate plant and equipment to do the work properly	80	4	14

Success Factor	SI	Rank	Overall Rank
Ability to control and organize the contract	80	5	15
Adequate of labor skill and labor's Experience	75.2	6	22
Good assessment of pre-qualification	75.2	7	23
Cost overrun due to planning estimation	72.8	8	25
Capability to manage subcontractor.	72.4	9	26
Capability of Trouble shooting	72	10	27
Performed projects of the same type and scale	64.8	11	32
The ability to respond quickly to change order of the project	60	12	33
The familiarity with owner procedures	57.2	13	34
Group 4 : Consultant			
Competency and commitment of consultant proposed team	84.8	1	9
Relevant experience in the implementation of projects	84	2	10
The ability to good communication between the contractor and the owner through the implementation of the project	79.6	3	16
Technical background	78.8	4	17
Ability to coordinate and trouble shooting	74.4	5	24
Undelay in performing testing and inspection by the consultant	72	6	28
The ability to respond to changes that occur during project	70.8	7	29
Continuity and poise organizational structure during the period of implementation of the project	70.4	8	30
Group 5 : Environment			
Political environment	88	1	4
Economic environment	83.2	2	11
Technical approval authorities	78.8	3	18
Technological environment	49.6	4	40
Social and physical environment	41.6	5	44

5. RESEARCH FINDINGS AND DISCUSSION

The result of survey questionnaire from the project parties perspectives (owner, consultant, and contractor) which listed the most CSFs in the construction of governmental projects in Egypt imply that;

CSFs related to owner group: This group percentage the high percentage group of success group with total percentage 50%.The results showed that "the availability of project budget and easily payment procedures" is the most important success factor under the owner group. This was due to, in case of unavailability of project budget, it will directly affect on the contractor cash. Consequently, it may cause negative impact on the project performance or sometimes work suspension.

The second CSF under the owner group is "Continuous monitoring and effective control". Therefore the owner should have sufficient technical staff with extensive experience enabling them to manage and control in all project stages. In addition, the owner should have adequate monitoring and control system. The monitoring and control system could produce reports, Key Performance Indicators (KPIs), and dash board, all can provide the decision maker a precise status that enabling to take effective decisions.

The third ranked CSF is "Harmony and good coordination between the departments involved in the project to achieve the project objective". It is mandatory for the owner's entity to maintain the performance of the project. Also, any conflict between different departments will lead to a decrease in the project performance. Furthermore may lead to work suspension.

The fourth ranked CSF is “Flexible policies to manage the project”. Internal regulations in the governmental authorities have to be adequate to facilitate the low interpretation to solve and clarify the misunderstanding issues, thereby avoid any losing or waiting time.

The fifth ranked CSF is “Relative power and authority”. Most contracts states that acquiring the required approval and permits are the owners’ responsibility. The approvals and permits risk in a matter of concern for the contractors working in the Egyptian construction industry (Orabi, 2003). The owner may have adequate relative power and authority to avoid the delay of those approvals from the governmental authorities.

CSFs related to Environment group: This group represents the second highest percentage success group with total of 40%. The results showed that “Political environment” is the highest CSF in this group. This factor is out of project parties’ control but it affects the project success. Many causes related to the political environment may lead to a project failure such as: political instability, revolution, strikes, corruption, regional war, and civil war. Furthermore, the economical environment is vulnerable to the political environment. Hence, instability of political environment will lead to instability in economical environment.

The second CSF under this group is “Economical environment”. Likewise this factor is out of project parties’ control and may cause failure to the project. There are many causes related to economical environment such unexpected inflation of construction material, unavailability of foreign currency, unexpected increasing in currency exchange, and implementing additional taxes, etc.

CSFs related to contractor group: This group represents the third highest percentage success group with total of 38%. The results showed that “Availability of financial capacity” is the highest CSF under contractor group. The contractors working in construction projects suffer from lack of cash which could affect their ability to finance their acquired projects and thus affect their performance (Zabel, 2007).

The second CSF under this group is “Sufficient experience and capability of technical personnel”. The contractor should have sufficient experience in similar type of the projects. In addition, the competent of contractor’s staff that will enable the contractor to carry out the works properly and effectively. Hence, if a contractor cannot provide adequate experience, the project performance will be extremely affected.

The third ranked CSF is “The ability to provide adequate raw materials required quickly”. The contractor should have solid database of credible supplier to provide him the required material on time and with required specifications. Any delay of material procurement will cause negative impact on the project performance.

The fourth ranked CSF is “Adequate plant and equipment to achieve the work properly”. Construction projects in Egypt are suffering from equipment quality risks. This is due to inadequate equipment management plans, inefficient equipment, and unqualified equipment’s operators (Zabel, 2007). Hence contractor should have sufficient equipment/plants that required to achieve the project properly.

The fifth ranked CSF is “Capability to control and organize the contract” the contractor has to develop proper monitoring and control systems that will enable him to monitor the performance of the project. In addition the contractor could implement quality assurance and control that lead to effective decision making and proactive management.

CSFs related to consultant group: This group represents the fourth highest percentage success group with total of 25%. The results showed that “Competency and commitment of consultant proposed team” is the highest CSF under the consultant group. The consultant should have extensive experience and relevant technical background to enable him to solve the technical issues properly. Furthermore the consultant could direct the contractor to the right way. In addition, the consultant has to lead the relation with the client in a proactive way.

The second CSF under this group is “Relevant experience in the implementation of projects”. The consultant should have relevant extensive experience to the same type of the project, to enable him to solve the technical issues properly. Therefore, it will help the project owner to identify the potential significant risks relevant to the project.

CSFs related to project group: This group represents the fourth highest percentage success group with total of 11%. The results showed that "Accuracy of the contractual duration of the project" it is the most of CSF under the group. The under estimation of project duration lead to develop a tight project schedule contains high percentage of critical activities. Thus, it will cause cost overrun and will affect quality of the performed work. Moreover, it may cause disputes between project parties and may lead to a project failure.

6. SUMMARY

Deep understanding of CSFs is essential in order for construction governmental projects to take proper success management strategies. This research paper has systematically examined CSFs affecting the construction of governmental projects in Egypt. In this paper, 45 CSFs were evaluated and ranked according to their significance index. Forty five CSFs have been identified through literature review, questionnaire survey, and historical review of construction projects in Egypt.

These CSFs are further analysed, distilled, coded, and finally categorized into five main CSF groups: (1) Project, (2) Owner, (3) Contractor, (4) Consultant, and (5) Environment,

The performed analysis shows that fifteen CSFs have S.I ≥ 80%, which considered most significant CSFs. Brief discussion for each factors of the most significant CSFs were presented to help the decision makers of the construction governmental projects in Egypt to recognize the root causes of the most significant CSFs.

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DEVELOPING A FRAMEWORK TO ENSURE SAFETY OF MAINTENANCE WORKERS IN SRI LANKAN COMMERCIAL BUILDINGS

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ABSTRACT

Maintenance is one of the most important and critical activities in every high rise commercial building. Maintenance activities often comprised of risk increasing factors and different kinds of potential hazards. Significant numbers of maintenance workers may be exposed to a variety of risks when doing their job. The safety of the maintenance workers should be prioritized in every maintenance work. It is mandatory to provide a safe working environment for their workers. Organisations and maintenance workers are not adhering appropriate safety practices to safeguard their lives and properties. Initiated regulations and standards are not specifically designed for the building maintenance activities. Therefore, this research intended to address this issue by developing a framework to ensure safety of maintenance workers in commercial buildings. Initially, a comprehensive literature review was carried out on the subject matter. Based on the nature of the study, data collection was carried out in two phases. A case study approach was used to gather existing information on maintenance works carried out under different categories, their related hazards. Semi structured interviews were conducted with a professional who is in the management level of the maintenance department in each selected case study. Expert survey was then carried out with three industry professionals to gather information about appropriate suggestions to ensure the safety of maintenance workers. The study highlighted key categories of maintenance works as confined space works, hot works, works at height, works involve with electrical equipment and works involve in using dangerous substance. These activities involve with different kinds of potential hazards such as physical, chemical, biological and psychological. The exposure level of the maintenance workers to the hazards is significantly high in this work environment. The study identified safe procedures to follow during different maintenance tasks.

Keywords: *Maintenance Works; Occupational Safety and Health; Safety and Health Measures.*

1. INTRODUCTION

In recent years, maintenance of a building has considered as one of the vital functions within any organization (Milczarek and Bienko, 2010). A proper maintenance is necessary for reducing its life cycle cost and for achieving expected life time of assets within its optimum performance (Hon *et al*., 2011). According to Booty (2006), maintenance of facilities and properties in any organization has a direct influence on the effectiveness of its functions. Maintenance can be considered as the most essential activity to perform required function from any physical item effectively (Blaise *et al*., 2014).

Maintenance associates with different types of work tasks in various sectors, different work phases and different kinds of working environments (Milczarek and Bienko, 2010). According to Vatn and Aven (2010), maintenance can increase the reliability and hence the safety of the equipment though failures and accidents often occur while execution of maintenance activities. Accordingly, workers who carry out maintenance operations in any work environment may directly interact with various hazards (Blaise *et al*., 2014). Grusenmeyer (2014) reported that the accidents exposure level of maintenance staff is higher than the production staff. European Agency for Safety and Health at Work (2010) emphasizes that maintenance activities has been contributed to the 10%-15% of fatal Occupational accidents from the 15%-20% of all accidents in Europe in 2006. Inappropriate walking or working surface, working while a machine is in motion, dangerous working practices, misinterpretation of instruction and accidental engine

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start-up are some of the causes for severe and fatal accidents in maintenance operations (Lind and Nenonen, 2008).

The safety of the maintenance should be prioritized in every industry and as well as it is mandatory to provide a safe working environment for their workers and subcontractors (Hadidi and Khater, 2015). Safety is ensured by the combination of management, workers and equipment (Raouf, 2004). International and local legislation and standards have been introduced for different work conditions. There is less attention for applying safety procedures in different maintenance works in buildings. Although maintenance is treated as a critical and risky operation according to occupational Safety viewpoint, the risk towards maintenance workers have been much less examined (Lind and Nenonen, 2008). Hence this study aims to develop a framework for ensuring safety of the maintenance workers in commercial buildings. The following objectives are set to reach the above aim,

1. To identify the different types of works carried out by maintenance staff,
2. To identify the health and safety hazards involved in maintenance works, and
3. To identify suitable safety procedures for maintenance work.

2. LITERATURE REVIEW

2.1. MAINTENANCE OF BUILDINGS

Success and continuity of the organization is influenced by efficiency and effectiveness of its maintenance functions (Cooke, 2003). According to Lai *et al*. (2008), it is essential to conduct properly organized operation and maintenance services for ensuring proper building performance and for preserving the economic rent pay for the buildings. The British Standards Institute defined maintenance as, "A combination of all the technical and associated administrative activities required to keep equipment, installations and other physical assets in the desired operating condition or to restore them to this condition" (Muchiri *et al*., 2010, p.8). Reason (1997) described the term maintenance as activities including unscheduled repairs, inspections, planned preventive maintenance, together with calibration and testing. Different types of maintenance are used by organizations based on their need. Dhillon (2006) categorized maintenance as,

- Preventive maintenance - actions carried out according to a schedule which is planned, specified and in a periodical condition to keep equipment and items in a required working condition by the process of reconditioning and checking.
- Corrective maintenance - unscheduled and unforeseen maintenance or repair to equipment and items to return them to the required state, carry out when after maintenance persons or the users identifying the failures and deficiencies.
- Predictive maintenance - correctly diagnosing the present condition of the equipment and items during its operations by using modern measurement and signal processing techniques.

The nature of the maintenance work has changed in recent times with variety of tasks, working conditions and technologies (Cooke, 2003). Lai *et al*., (2006) noted a wide range of maintenance works of building components such as roofing, façade and internal finishing as well as engineering services such as electrical, air conditioning, plumbing, fire services, lifts and escalators and drainage. Southwark Council (2008) categorized work activities take place in maintenance with consideration of safety aspects where the special attention should be there for the safety of maintenance workers and can be summarized as follows,

- Confined space works - totally or partially enclosed place which is not suitable to workers occupancy, entrance and exit is restricted due to the location and means, consisted with risks to safety and health of the worker because of the work to be carried, materials used, location and hazards (Canadian Centre for Occupational Health and Safety, 2012)

- Hot works - operations which have the possibility of producing heat, flames and sparks (Ontario Ministry, 2006). Hot work include the works such as welding, chipping operations, works with spark introducing tools and cutting operations (Weissman, 2008)
- Working at height - working at height is a situation which any person is carrying out the work at aheight of more than two meters/six feet: due to that height there is a possibility to fall if necessary safety precautions are not provided (The Employers' Federation of Ceylon, 2015).
- Excavation works - works carrying out with the purpose of creating an open face, cavity or hole with the use of any tool, machine or another thing for removal of soil or rock from a site to form an open face, hole or cavity. Machinery or explosives can be used during excavation works (Safe Work Australia, 2015)
    - Maintenance works on lifts, conveyors and hoists
    - Works on high voltage electrical equipment or on other electrical equipment
    - Works involving the use of hazardous/dangerous substances

Work tasks, work period and working environment vary in maintenance works according to the jobs carried out (Vinnem *et al*., 2012). It is obvious that maintenance activities always comprise with risk increasing factors (Kelly and McDermid, 2001). According to nature of the work, maintenance can be identified as a high risk activity as the work is consisted of several hazards (Lind and Nenonen, 2008). In addition, a significant number of accidents are related to maintenance activities and especially to corrective maintenance (European Agency for Safety and Health at Work, 2010). Accordingly, the next section discusses the prevailing hazards and risks of maintenance works.

2.2. EXISTING HAZARDS IN BUILDING MAINTENANCE

Lind *et al*., (2008) described hazards in work place as hazards relating to the working methods, working environment and machinery. Both British Standard (2004) and OSHAS 18002 (2007) identified the term hazards in a similar way as, “Source or situation with a potential for harm in terms of death, ill health or injury, or a combination of these”. In British Standard 8800 (2004) hazards are categorized under following four categories,

- *Physical hazards* - any factor existing in the environment which has the potential of causing the harm without necessarily touching it (Sutton, 2015).
- *Chemical hazards* - any mixtures, substances, and materials which are categorized as dangerous and having risk (Marshall, 1987).
- *Biological hazards* - any biological substance or organic matter which affect in a bad manner to the health of human (Stitt-Fisher, 2015)
- *Psychological hazards* - the workplace stressors and other violence (Pryor and Capra, 2012)

Table 1 shows the identified hazards in all four categories. Lind *et al*. (2008): Neitzel, *et al*., 2008: Zhao, *et al*., 2015; Cowles (2001); Phoon (1997) and Sedlatschek (2011).

Table 1: Existing Hazard in Maintenance Work

Type of Hazard	Existing Hazards in Maintenance Work
Physical Hazards	▪ Electrical: capacitors, high voltage, static ▪ Mechanical movement: rotating elements such as flywheels, unexpected startups, computerized auto-start ▪ High pressure fluids ▪ Oxygen deficient atmospheres, Radiation ▪ Fire/explosion; Extreme heat/cold, Noise, Vibration ▪ Work at Height; Weather, Ergonomics ▪ Slipping, tripping, falling ▪ Lifting and holding heavy loads
Chemical Hazards	▪ Dusts and Fibers such as asbestos, silica, respiratory sensitizers

Type of Hazard	Existing Hazards in Maintenance Work
	▪ Dangerous substances such as chlorine, hydrogen ▪ Toxic, oxidizing, explosive, flammable, corrosive substances ▪ Hydraulic fluids, oils, acids, alkalis, organic solvents
Biological Hazard	▪ Pathogenic bacteria such as salmonella and legionella ▪ viruses, parasites, moulds and fungi
Psychological Hazards	▪ Time pressure; Long hours; Shift work ▪ Poor work organization; Unsocial working hours

Moreover, solid, gas or liquid which have the possibility of occurring harm to the persons can be identified as hazardous substances (Work Safe Victoria, 2015). The hazards which worker is exposed may lead to risk of causing work related injury and accidents. The factors affecting for increasing the risk of injury is wider than simply unsafe acts and unsafe conditions existing in workplaces (Keyserling and Smith, 2007). Hadidi and Khater (2015) mentioned that the occupational risk from the potential hazards in maintenance work is much higher than other sort of routine work, in-house workers, outsource parties and sub-contractors involve in maintenance work and they expose to variety of risks. Raouf (2004) noted that maintenance policies and safety performance has direct impact on the effectiveness of functions. Companies need to adhere appropriate health and safety management systems to prevent and diminish accidents by identifying and selecting the most essential hazards and by managing the hazards and the preventive measures (Vinnem *et al*., 2012).

2.3. Occupational Safety Health Legislations and Standards Influence to Maintenance

Some of the international and local standards and polices are initiated to eliminate the hazards by providing appropriate safety procedures.

- International Labour Organization (ILO) Conventions

ILO deals with all labour issues by providing guidelines on Occupational Safety and Health management systems. ILO - OSH (2001) has provided conventions for radiation protection, occupational cancer, working environment; (noise, vibration and air pollution), exposing to asbestos, using of chemicals at work and prevention of major industrial accidents.

- BS Occupational Health and Safety Assessment Series (OHSAS) 18001:2007

BS OHSAS 18001 (2007) standard emphasized the requirement of occupational health and safety (OH&S) management systems in workplaces. The standard enables organizations to establish an Occupational Health and Safety policy, planning (for identification of Hazard, risk assessment and determining controls, Legal and other requirements) implementing and operation, checking and obtaining corrective actions under the management responsibilities and their commitment to OH&S management system. OHSAS 18001 aims to confirm a firm's Occupational Health and Safety Management System (OHSMS) which helps to develop and sustain a safe workplace while securing workers from accidents and illness (British Standards Institution, 2013). The objective of the OHSAS 18001 standard is to uphold the good practices in the area of occupational health and safety through the methodical and planned management systems support (Chang and Liang, 2009).

- Factories Ordinance No. 45 of 1942

Factories Ordinance has made provisions for ensuring the safety, health and welfare of persons working in the factories and other workplaces which the provisions of this ordinance apply. According to The Employers' Federation of Ceylon (2015) below mentioned provisions are most affecting to maintenance works.

- Requirements of building services Examination and reporting the results of examinations
- Regulations for accidents notification and dangerous occurrences notification
- Requirements for providing effective and suitable PPE such as screens, shields, goggles or spectacles as necessary.

- Requirements for notification of industrial diseases occurring in any factory
- Requirements to securely fence the flywheel or prime mover
- Requirements for fencing, using driving belts of the transmission machinery
- Regulations for the use of other machines
- Requirements to provide suitable ear defenders for those who are exposed to noise above upper limit
- Investigation into case of death by accident or industrial disease
- Provisions for protection from radiation and vibration

Even though the ordinances and standards exist, those have given a less attention for the specific task of maintenance. Hence the intention of this study is to investigate the safety procedures of maintenance workers in buildings.

3. RESEARCH METHODOLOGY

An extensive literature review was conducted to identify the types of maintenance works and existing safety and health hazards of the maintenance works. The study needs to investigate the existing maintenance works, its associated hazards and appropriate safety procedures for the maintenance works in Sri Lankan commercial buildings. The study used a qualitative approach. Naoum (2013) described that the type of the research approach selected for any research is determined on the type of the study, purpose of the study and information availability for the study. By using a qualitative approach the researcher will be able to study whole population as individuals or groups and could be able to identify beliefs, understandings, opinions and views of people (Fellows and Lui, 2003). Naoum (2013) mentioned that the qualitative research approach includes experiments, case study research, surveys, enthnography, ground survey and action research. Based on the nature and purpose of the study, data was collected through two phases.

In first phase, data were gathered to investigate existing maintenance works and hazards of the maintenance works. According to Crowe *et al*. (2011), when there is a need to do an in-depth investigation of an issue, phenomenon or event of interest, in its natural real-life context the case study approach is specifically useful to employ. Hence, the case study approach was used with the aid of semi structured interviews. Five case studies were selected and a professional who is in the management level of the maintenance department in each selected case study, were interviewed. The selected five high rise commercial buildings were located in the western province of Sri Lanka. Selected buildings have more than twelve stories and have more than 15 workers as maintenance staff. The details of the case studies are presents in Table 2.

Table 2: Details of the Case Study

Criteria	Case A	Case B	Case C	Case D	Case E
Years of establishment	20	30	13	21	4
Stories of the building	37	32	23	12	12
Number of maintenance workers	55	60	25	17	15
Details of the interviewees and experience	Senior manager, facilities management 20 years	Maintenance Manager 6 years	Senior manager operations and maintenance 8 years	Engineering manager 7 years	Maintenance engineer 2 years

The data were gathered under following topics and are presented in findings section.

i) Maintenance works in commercial buildings

ii) Related hazards of maintenance work

In second phase, the objective was to determine suitable safety procedures for the maintenance workers in identified maintenance tasks. Hence, experts' opinion was required. The data were collected through semi structured interviews by focusing the experts for the purpose of obtaining suggestions to enhance the safety of maintenance workers. Three experts were interviewed. Interviewees were selected based on their experience and their knowledge on the Occupational Safety and Health. The details of the experts are presented in Table 3. Collected data was subjected to the content analysis.

Table 3: Details of the Experts

Criteria	Expert A	Expert B	Expert C
Designation	Formal Chief Factory Inspection Engineer	Director General: National Occupational Safety and Health	Occupational Safety and Health Consultant
Work experience	Over 40 years	Over 20 years	Over 20 Years

4. DATA ANALYSIS AND FINDINGS

4.1. MAINTENANCE TASKS OF COMMERCIAL BUILDINGS

This section identified existing maintenance tasks of commercial buildings. Gathered data were categorised according to the literature findings of Southwark Council (2008). Figure 1 shows the maintenance tasks of commercial buildings in Sri Lanka.

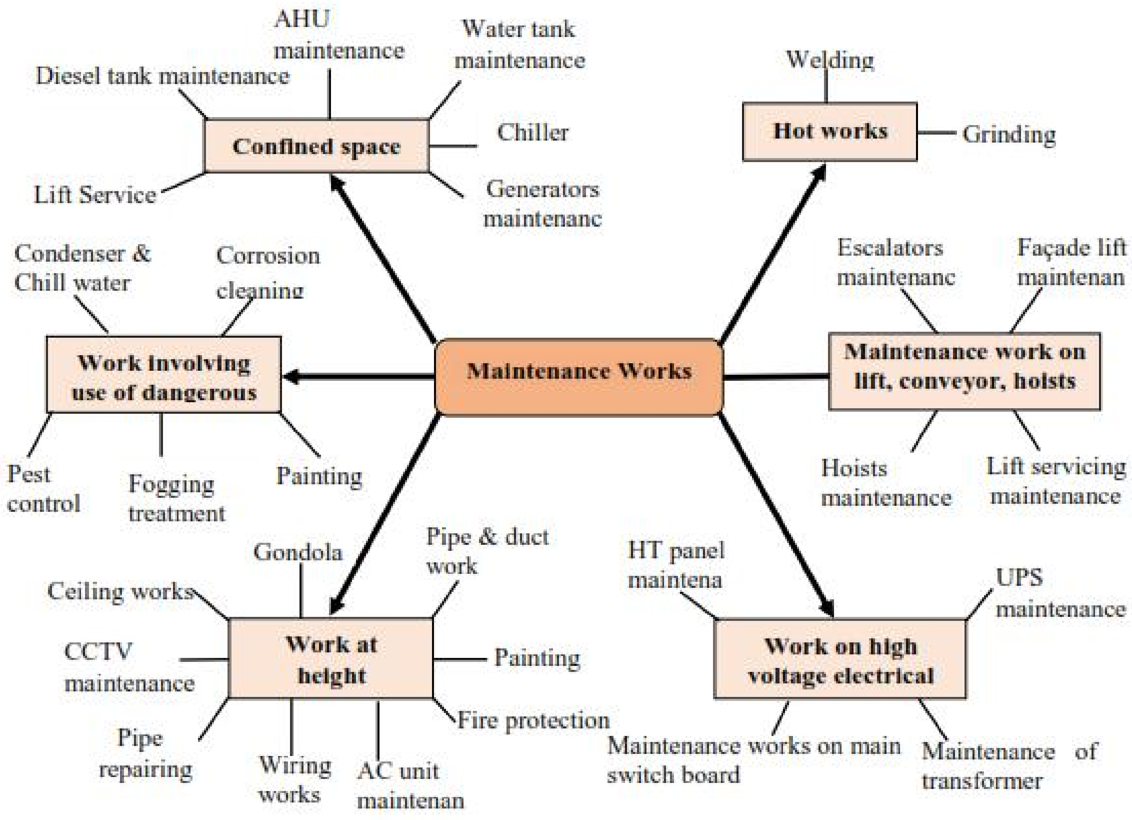

Figure 1: Maintenance Work of Commercial Buildings

It was revealed that many maintenance works carried out in confined spaces in commercial building are common to each other. Majority of the interviewees have mentioned that maintenance works of water storage tanks, diesel storage tanks, generators, Air Handling Units, chillers and lifts can be considered under confined spaces category. The interviewees have mainly emphasized welding work and grinding work under hot work category. It was identified that welding work is done very frequently by the maintenance staff in commercial buildings. As selected buildings are high rise buildings, gondola work became a major one of the significant and risky maintenance works in commercial buildings under height category. Further, ceiling works, painting, CCTV maintenance, split Air Conditioning (AC) maintenance, maintenance of fire protection and detection systems, duct works are classified as working at height. Also pipe and valve replacing maintenance works can be categorized under the maintenance works carried out at height. According to the findings, excavation work are very rarely carried out in commercial buildings. The escalator and elevator servicing and maintenance come under the category of maintenance works on lifts conveyors and hoists. All the respondents agreed escalator and elevator servicing and maintenance as their main maintenance activity which is done by an outsourced party. Further, maintenance of hoists like façade lift is included in this category. Maintenance work relating to medium voltage switch gear, maintenance of transformers, maintenance of capacitor banks, motor control panel, bus duct, oil circuit breakers, distribution boards, High Tension (HT) and Low Tension (LT) panel board maintenance such as cleaning and testing, and UPS maintenance are categorized by all respondents as the maintenance of high voltage electrical equipment and other electrical equipment. Chemicals usage for corrosion cleaning, chemical treatments of HVAC system, painting, fogging and pest control were highlighted as maintenance works involved in hazardous and dangerous substances. Five commercial buildings which were selected conducts similar maintenance activities as their daily operations.

4.2. MAINTENANCE RELATED HAZARDS

The hazards which related to above identified maintenance works have been analysed. Finally the relationship between maintenance works and their related hazards were summarized. Table 4 shows maintenance works and the potential hazards.

Electrical hazard, high pressure fluids, fire, explosion and extreme heat, vibration, falling, ergonomics were highlighted as physical hazards by the interviewees. All five case studies come up with dust, fibres and respiratory sensitizers, Dangerous substances, explosives, flammable and corrosive substances, acids, and alkalis and organic solvents as chemical hazards in their work place. Pathogenic bacteria such as legionella and fungi highlighted as biological hazards. Time pressure and long hours work were indicated as psychological hazards of the maintenance workers. Interviewees highlighted the number of work related hazards in their context, giving various examples.

Table 4: Maintenance Works and their Related Hazards

Maintenance Work	Specifically Related Hazard	Common Hazards
Confined space works	Oxygen deficient atmospheres	Noise, vibration, Dust, Ergonomics, time pressure, long hour works, biological hazards
Hot works	Fire, explosion and extreme heat	
Working at height	Falling	
Maintenance work on lifts, conveyors, hoists	Falling	
Work on high voltage electrical equipment or other work on electrical equipment	Electrical hazard	
Work involving the use of hazardous/dangerous substances	All chemical hazards	

4.3. SAFETY PROCEDURES FOR CARRYING OUT DIFFERENT TYPES OF MAINTENANCE WORK CATEGORIES

According to the statements of experts appropriate safety procedures should be taken when carrying out maintenance works in confined spaces, works relating to hot works, works on lifts, conveyors and hoists, works in high voltage electrical equipment or other electrical equipment and works involving the use of hazardous or dangerous substances. Safety procedures for aforementioned areas are described in following sections.

Maintenance Works in Confined Spaces

According to the findings, three experts highlighted the requirement of work permits for carrying out maintenance works in confined spaces. As an example expert A stated that "*as these confined spaces are* *high risk areas; should have a work permit form to fill before working in confined spaces*". Expert C stated "*some organizations use a general risk assessment form for the confined spaces also and if there are many confined spaces there should be a risk assessment form which is specific only for confined spaces*". According to the findings, this work permit is issued by the health and safety officer of the organization based on the usage of the space, PPE requirements, lighting levels and etc. Expert B indicated that the location of the confined spaces, exit routes, emergency escape procedures power supply to the equipment are important to consider in such spaces. Further, expert C indicated that there should be a pre-determined way to communicate in an emergency situation. Moreover, findings emphasised that the work permit is issued for particular individual work and when the work is completed the permit should be closed. It was indicated by expert C as "*due to the changes such as working environment, worker and time, each and every work carried out in confined spaces need to have a separate permit to work*".

Maintenance Works Relating to Hot Works

The experts emphasized that obtaining the work permit as a safety and health measure for carrying out hot works. Expert B added as *"if the hot work is a routine maintenance work that work can be carried out according to Standard Operating Procedure (SPO) or if the hot work is carried out as non-routine work, work permit is required"*. Gathered data indicated that when carrying out maintenance work relating to the hot works it is essential to make sure that the work is carried out by a competent worker. Further, suitable fire extinguishers should be available at a nearest place and the working environment should be continuously ventilated. Further, gathered data indicated that the workers should use all the PPE required for carrying out hot works such as face shield, insulated gloves or gauntlet gloves and cotton cloths. In addition, expert A indicated that before starting the work, all the equipment and tools should be inspected and tested for leakages to ensure whether those are in good condition or not. Further, the respondent indicated that working environment also should be inspected to make sure that the area is free from combustible materials. Moreover, expert B specified that workers should have a clear knowledge about emergency precautions and emergency escapes in case of fire.

Working at Height

The experts emphasized the requirement of training and competence for the maintenance workers who involve in the maintenance works at height. Experts described that it is necessary to consider the nature of the work and workplace in which work is taken place at height, duration of the work, frequency of the work and height of which the worker works. These factors help to select means of access to the work place and to recognize the hazards involve in working at height. As an example expert B stated that "*if the duration of the work at height is short and if the risk level is low for that kind of works ladders can be used*". Further, expert C emphasized that "*if the work is taken place in the outside of the building it is necessary to consider about the weather condition*". In addition, three experts have highlighted the importance of using proper PPE such as safety harness, safety helmet and eye protections according to the nature of the work. Workers use permanent and temporary equipment as means to access to high working areas. Findings of data emphasized that those equipment should be in good condition and if those equipment are temporary they should be tight well at the bottom and the top to prevent from any movements. Moreover, expert A indicated that if the size of the workplace at height is small it is required to provide fall protections such as a guard rails, fall arrests or safety nets.

Maintenance Works on Lifts, Conveyors and Hoists

The experts emphasized that the maintenance work should be carried out by trained and competent workers. Further, they highlighted the necessity of conducting a risk assessment and identifying the possible hazards. Further, findings revealed the importance of proper power supply to the lift, conveyor or hoists. Experts A and C emphasized the requirement of lock and tag out the switches. If the maintenance work is carried out in a confined space such as in a lift core, sufficient ventilation and illumination should be provided. Here also findings indicated the requirement of using proper and relevant PPE according to the type of work such as safety helmets and body harnesses.

Work on High Voltage Electrical Equipment or Other Electrical Equipment

Two experts described about maintenance works on de-energized electrical equipment and energized electrical equipment. Expert B emphasized that "*sometimes it is not possible to de-energize the electrical* *equipment for maintenance works*". According to the experts' opinion, it is essential to identify whether the electrical equipment can be de-energized or not before starting the maintenance work. If the equipment can be de-energized power supply should be disconnected and have to lock and tag out. If the equipment cannot be de-energized it should be ensured that safety precautions have been taken. And also it is essential to do a risk assessment and identify the possible hazards. Further, experts emphasized specially that a competent person should be appointed to the maintenance works on electrical equipment and relevant PPE have to be used such as non-conductive gloves, clothes and protective shoes. Further, tools and equipment used for the maintenance work should have non-conductive handles. Finally the work should be carried out according to the Standard Operating Procedures (SOP) or should obtain a work permit.

Work Involving the Use of Hazardous or Dangerous Substances

Expert B highlighted 'if *possible, eliminate the use of hazardous or dangerous substances or substitute them with the substances which are not highly hazardous*". According to the experts, chemicals in the work place should be labelled by indicating the type of chemical and Material Safety Data Sheet (MSDS) should be available for each chemical. In addition, expert A indicated the necessity of record keeping of hazardous substances. Moreover, findings revealed about the need of risk assessments and preparedness for the emergencies. The experts' opinion is that all workers should aware on hazards related to the work and its safety procedures. Further, experts indicated that if the work is highly hazardous, a work permit should be obtained for the work and if not the work can be carried out according to the SOP.

5. FRAMEWORK TO ENSURE THE SAFETY AND HEALTH OF MAINTENANCE WORKERS

According to the findings of the research, a framework was developed for enhancing the Safety and Health of maintenance workers. The framework mentions the safe procedures of carrying out the identified six major maintenance tasks in commercial buildings. Mainly it is important to state that the framework is developed by indicating the most important and fundamental safety and health actions to be taken when carrying out maintenance works. The developed framework is illustrated in Figure 2.

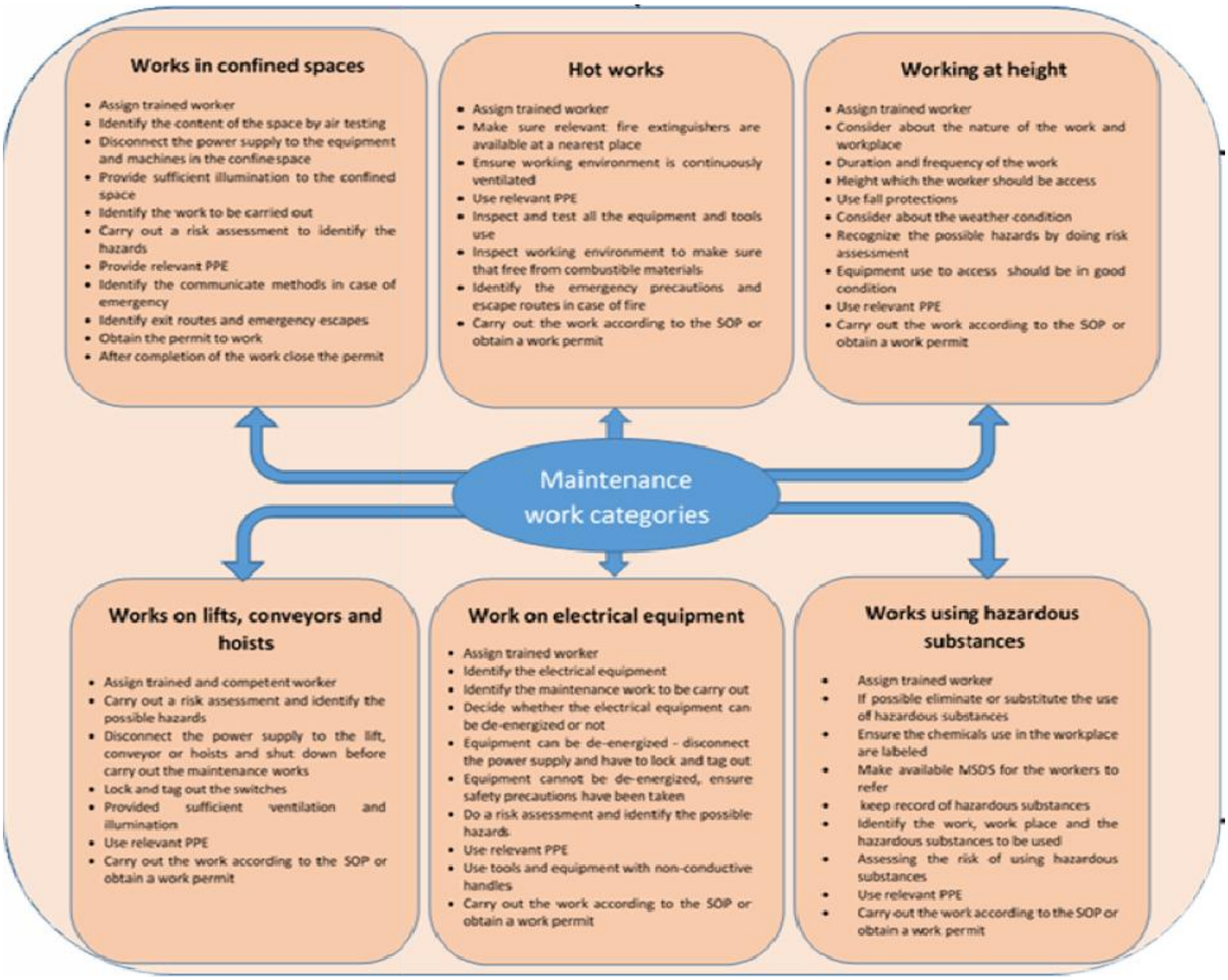

Figure 2: Framework toEnsure the Safety and Health of Maintenance Workers

6. CONCLUSIONS AND RECOMMENDATIONS

Maintenance in the buildings has received high importance as a non-core activity which mainly affects to the core business of the organization. Maintenance works are often exposed to hazards that can be harmful to the maintenance workers as well as work environment. The study highlighted key categories of maintenance works as confined space works, hot works, works at height, works involve with electrical equipment and works involve in using dangerous substances. Aforementioned maintenance activities involve with different kinds of potential hazards such as physical, chemical, biological and psychological. The exposure level of the maintenance workers to the hazards is significantly high when comparing to the other working population in buildings. As a result of that a considerable number of fatal accidents, non-fatal accidents and other health and safety issues are occurring through maintenance works to the maintenance worker. Therefore, the study identified health and safety procedures to follow during different maintenance tasks. It was identified the fact that most of the organisations have given less priority for the health and safety of maintenance worker. On the other hand, maintenance workers themselves are ignoring the safety practices while conducting their maintenance operations. This will result in great risks to their lives as well as the organisation.

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DEVELOPMENT OF A PROFESSIONAL DOCTORAL PROGRAMME IN BUILT ENVIRONMENT TO ENHANCE SOCIETAL RESILIENCE TO DISASTERS

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ABSTRACT

Integrating disaster resilience into education is a key factor for reducing the adverse impact of future disasters. This paper in this context presents the methodology of developing an innovative professional doctoral programme (DProf) that integrates professional and academic knowledge in the built environment to enhance societal resilience to disasters. The DProf programme addresses the career needs of practicing professionals, particularly those in, or who aspire to, senior positions within the construction industry and caters for the researching professional. In developing the DProf programme, a detailed market needs analysis for built environment stakeholders to increase societal resilience to disasters was conducted capturing inter-disciplinary needs across a range of stakeholders and countries. A series of semi-structured interviews on current and emerging market needs with members of six built environment related stakeholders, namely, local and national governments; community; NGOs, INGOs and other international agencies; academia and research organisations; and private sector facilitated the aforementioned analysis. Qualitative data analysis techniques were employed in analysing the interview data. The findings of the interviews revealed the current and emerging needs and skills of the six stakeholders related to built environment professionals towards enhancing social, economic, technological, environmental and institutional dimensions of disaster resilience of societies. These findings were used to develop the appropriate learning outcomes and the content of taught and research components of the DProf programme.

Keywords: *Professional Doctorate; Disaster Resilience; Built Environment.*

1. INTRODUCTION

The need to improve the capacity and capability of the built environment professionals' in enhancing disaster resilience of societies was highlighted by Siriwardena *et al*. (2013); Thayaparan *et al*. (2015); Perera *et al*. (2016) among others. They suggested the need of continuously updating the skills and knowledge of construction professionals, in order to contribute effectively to disaster resilience. The professionals in the construction sector play an important role in disaster resilience and management and it is, therefore, important to design educational and training courses to enable them to successfully fulfil this role (Witt *et al*., 2014). This is corroborated by Bosher *et al*. (2007) that risk and hazard awareness training needs to be integrated systematically into the professional training of architects, planners, engineers, developers, among others. In addition, the Sendai framework for disaster risk reduction (2015-2030) has identified the need for enhancing the capacities of relevant stakeholders and industries. The framework suggested to "build the knowledge of government officials at all levels, civil society, communities and volunteers, as well as the private sector, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction, including the use of existing training and education mechanisms and peer learning" (UNISDR, 2015).

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Thus, the role of Higher Education Institutes (HEIs) in enhancing the disaster-related knowledge and skills of construction professionals is highly recognised (Thayaparan *et al*., 2015). For instance, HEIs are expected to contribute to both theory and practice in the development of societal resilience to disasters through the development of curricular and modules to update the knowledge and skills that employees have obtained in the past. Against this backdrop, doctoral education is identified as one of the methods in upgrading the knowledge of the construction professionals in this regard.

Professional doctorates emphasise the importance of a connection with practice through the research topic (Lee *et al*., 2000). For instance, UKCGE (2002) describes professional doctorate as "a programme of advanced study and research which, whilst satisfying the university criteria for the award of a doctorate, is designed to meet the specific needs of a professional group external to the university". Council of Australian Deans and Directors of Graduate Studies (1999) describes the professional doctorate as "a program of research and advanced study which enables the candidate to make a significant contribution to knowledge and practice in their professional context [and] … more generally to scholarship within a discipline or field of study". Fenge (2009) asserts that central to the heart of the DProf is professional practice, which encompassed the developing of professional knowledge and a focus on developing practice. Thus, professional doctorates can be distinguished from other types of doctoral degrees based on its specific focus on knowledge-in-use for professional practice (Lester, 2004).

Doctoral degrees have been part of HEIs ever since the first was conferred by the University of Paris in the middle of the twelfth century (Noble, 1994). Thereafter the doctorate was adopted at universities across Europe (Bourner *et al*., 2001). For six centuries, professional doctorates in theology, law and medicine were pre-eminent. By contrast, the modern Doctor of Philosophy, the PhD (or DPhil), originated at Berlin University in the early part of the nineteenth century. It then spread across the German universities, attracting students from many other countries, notably the USA (Gregory, 1995). The 1990s was the decade when the professional doctorate came to England (Bourner *et al*., 2001). In the USA, the first Doctor of Philosophy was conferred in 1861 (Yale University). About 60 years later, the Doctor of Philosophy degree finally came to Britain (Simpson, 1983; Winfield, 1987). In 1920, the first Doctor of Philosophy degree was awarded by an English university (a DPhil in science by the University of Oxford). At about the same time, the first professional doctorate (a Doctor of Education-EdD) appeared in the USA, being awarded at Harvard University in 1921 (Bourner *et al*., 2001).

In 1990, the Australian Higher Education Council of the National Board of Employment, Education and Training advocated that Australian universities should develop professional doctorates. By 1996, 29 universities had introduced professional doctorates, and over half of Australia's 38 universities had developed EdDs (Bourner *et al*., 2001). As at 1996, professional doctorates were available in education, business, law, psychology, health sciences, humanities, design, and architecture (Poole and Spear, 1997). In 1992, England introduced professional doctorates about 60 years after the USA at a traditional and research-oriented institution, the University of Bristol (Westcott, 1997). The same 1992, the Doctor of Engineering (EngD) was started in the UK, at the University of Warwick, the University of Manchester Institute of Science and Technology (UMIST) / the University of Manchester and the University of Wales (Bourner *et al*., 2001). The 1990s saw English universities offering professional doctorates in a range of subjects, as presented in Table 1.

Table1: Trend of Professional Doctorates across Subjects at 1 January 1998 in the UK

Subject/Title of Award	**Short Form of the Title Most Often Used**	**Number of Universities**	**Number of Programmes**
Doctor of Education	EdD	24	29
Doctor of Medicine	MD	18	20
Doctor of Clinical Psychology	DClinPsy	17	19
Doctor of Business Administration	DBA	9	9
Doctor of Engineering	EngD	8	8
Doctor of Psychology	DPsych	4	4

Subject/Title of Award	Short Form of the Title Most Often Used	Number of Universities	Number of Programmes
Doctor of Educational Psychology	DEdPsy	4	4
Doctor of Musical Arts	DMA; AMusD	2	2
Doctor of Architecture	DArch	2	2
Doctor of Veterinary Science	DVet Med; DVSc	2	2
Doctor of Dental Science	DDSc	2	2
Doctor of Public Health	DrPH	1	1
Doctor of Counselling Psychology	DCounsPsy	1	1
Doctor of Occupational Psychology	DOccPsych	1	1
Doctor of Clinical Science Psychotherapy	DClinSci Psychotherapy	1	1
Doctor of Psychoanalytic Psychotherapy	DPsychPsych	1	1
Doctor of Theology	ThD	1	1
Doctor of Fine Art	Dart	1	1
Doctor of Work-based Learning	DProf	1	1
		Total	109

Source: Bourner *et al*., (2001)

As shown in Table 1, 109 professional doctorate programmes in 19 subjects were available in English universities at the start of 1998. Since 1998, there has been a continued growth in the most popular areas for professional doctorates including education, clinical psychology, and business administration together with new additional professional doctorate programmes in finance, pharmacy, social work, humanities, and built environment. It can be deduced that the growth in professional doctorates has not been confined to a few subjects but has encompassed a wide and growing range of subjects.

The proliferation of professional doctorates has been remarkable in the USA, UK, and Australia. In the last decade, it has begun to attract the attention of higher education scholars and researchers (Kot and Hendel, 2012). For instance, a number of studies have been published on professional doctorates in the UK (Winter *et al*., 2000; Bourner *et al*., 2001; Hoddell *et al*., 2002; UKCGE, 2002; Scott *et al*., 2004; Lester 2004; Park 2005; Powell and Long, 2005). In Australia (Maxwell and Shanahan, 1997; Maxwell and Shanahan, 2001; Evans, 2002; McWilliam *et al*., 2002; Maxwell, 2003; Neumann, 2005; Stephenson *et al*., 2006; Lee *et al*., 2009). However, no studies have been conducted across the globe to present a broader picture on the expansion of professional doctorate programmes in disaster resilience in the built environment. It is against this backdrop that a major initiative on a professional doctorate in disaster resilience in the built environment was launched by the EU-funded research project, CADRE (Collaborative Action for Disaster Resilience Education) aims to develop a professional doctorate to integrate the professional and academic knowledge of the construction in developing societal resilience to disasters.

This present study builds on the work by Malalgoda *et al*. (2015); Malalgoda *et al*. (2016); Perera *et al*. (2015); Perera *et al*. (2016) that identified the current and emerging needs and skills, and knowledge gaps of construction professionals and other stakeholders including communities affected by disasters towards enhancing social, economic, technological, environmental and institutional dimensions of disaster resilience of societies. This study, therefore, presents the methodology of developing an innovative professional doctoral programme (DProf) that integrates professional and academic knowledge in the built environment to enhance societal resilience to disasters. It is believed that this study would be of great value to HEIs considering in offering a professional doctorate programme in disaster resilience. Also, the methodology used to develop the professional doctoral programme (DProf) in this study can be applied to any professional doctorate programme in HEIs and thus, benchmark future studies.

2. THE NEED FOR PROFESSIONAL DOCTORATES IN DISASTER RESILIENCE IN THE BUILT ENVIRONMENT

Disaster resilience and management is a multi-disciplinary subject area and multi-stakeholder efforts are required for successful implementation. The main stakeholders include national and local government institutes; NGOs, INGOs and other international organisations; academia; the private sector; and community. These stakeholders demand a certain level of knowledge and skills to fulfil their organisational needs in developing societal resilience to disasters. Thus, it is important that capacity is developed for modern design, planning, construction and maintenance that are inclusive, interdisciplinary, and integrative. In achieving this, it is proposed to develop an innovative professional doctorate to integrate professional and academic knowledge in the construction industry to enhance societal resilience to disasters. By developing a professional doctorate (DProf) programme, it is expected that issues such as complexity and multi-disciplinary nature of the subject; lack of industry involvement; and lack of research and development activities on disaster management by built environment professionals could be successfully addressed. This section highlights the significance of DProf programme to construction professionals in developing societal resilience and therefore several salient features are identified as follows:

Contribution to theory and practice: Within the context of disaster resilience and management, more applied research is required in order to develop the construction industry with necessary capacities to plan, design, build and operate resilient structures to increase societal resilience to disasters. One of the aims of a DProf programme is to integrate professional and academic knowledge in the selected discipline. It will provide opportunities to the candidates to undertake the research in the workplace and to select a topic, which has a direct effect on improving the professional practice, related to the host organisation where successful completion normally leads to professional and/or organisational change. It will, therefore, strengthen not only the academic knowledge and cooperation between the universities and industries but also the concerns, capabilities, and expectations of the relevant stakeholders related to disaster resilience and management. As such, professional doctorates are very much appropriate to the construction sector in developing societal resilience to disasters. It will make a research-based contribution to practice within the context of upselling construction professionals with disaster resilience expertise.

Career needs of practicing professionals: One of the main disadvantages of traditional doctorates is that it is not very attractive to the practicing professionals. For instance, traditional doctorates more often contribute to the theory of knowledge and as a result, is not much popular with the practicing professionals in the construction sector. This is corroborated by Bourner *et al*. (2001) that professional doctorates are attractive to those who aspire their own personal development and a commitment to furthering the cause of their profession. Therefore, developing a professional doctorate will address the career needs, and will upgrade the knowledge and skills of practising professionals working to make societies more resilient to disasters. It is expected that DProf programmes will attract learners from the construction industry to develop solutions to their labour market demands through doctoral studies.

Collaboration: DProfs promotes collaboration between HEIs and industries, which are key stakeholders in disaster resilience and management. The collaboration is further supported by facilitating cross-institutional supervisory teams and working groups. It is expected to improve the quality and relevance of DProf programme through active cooperation between HEIs and partners from outside academia, including construction professional bodies, local/national/international bodies, and social partners.

Customisable: In serving the needs of various stakeholders, it is proposed to develop a professional doctorate with a generic framework, which enables a wide range of professionals from the public, private and voluntary sectors to negotiate programmes that are customised to the needs of their own professions and organisations (Doncaster and Thorne, 2000) serving to reduce the risk of disasters. It is expected that all construction professionals serving all of the stakeholder groups attached to disaster resilience and management will benefit from the developed programme.

Lifelong learning and continuous professional development: The DProf is intended to be a form of in-service professional development. Construction professionals will, therefore, benefit from the proposed professional doctoral programme, which will provide opportunities for learners to access lifelong, learning in increasing societal resilience to disasters. Therefore, developing an innovative professional doctorate will address the requirements for lifelong learning and will enhance not only academic knowledge but also the concerns, capabilities, and expectations of the relevant industries and communities. In turn, this will create the necessary intra Industry, Community, and University feedback and feed-forward mechanisms to enable effective lifelong learning.

3. PROGRAMME DEVELOPMENT METHODOLOGY

Development of the programme involves a substantial level of research activities to study and analyse market needs in order to capture the labour market requirements for disaster resilience and its interface with the construction industry and its professionals. The first phase of research involved capturing the needs of five stakeholder groups associated with disaster resilience and management as well as current and emerging skills and ultimately competencies, applicable to built environment professionals towards enhancing societal resilience to disasters (Malalgoda *et al*., 2016; Perera *et al*., 2015; Perera *et al*., 2016).

The data collection and analysis framework of the study is presented in Figure 1.

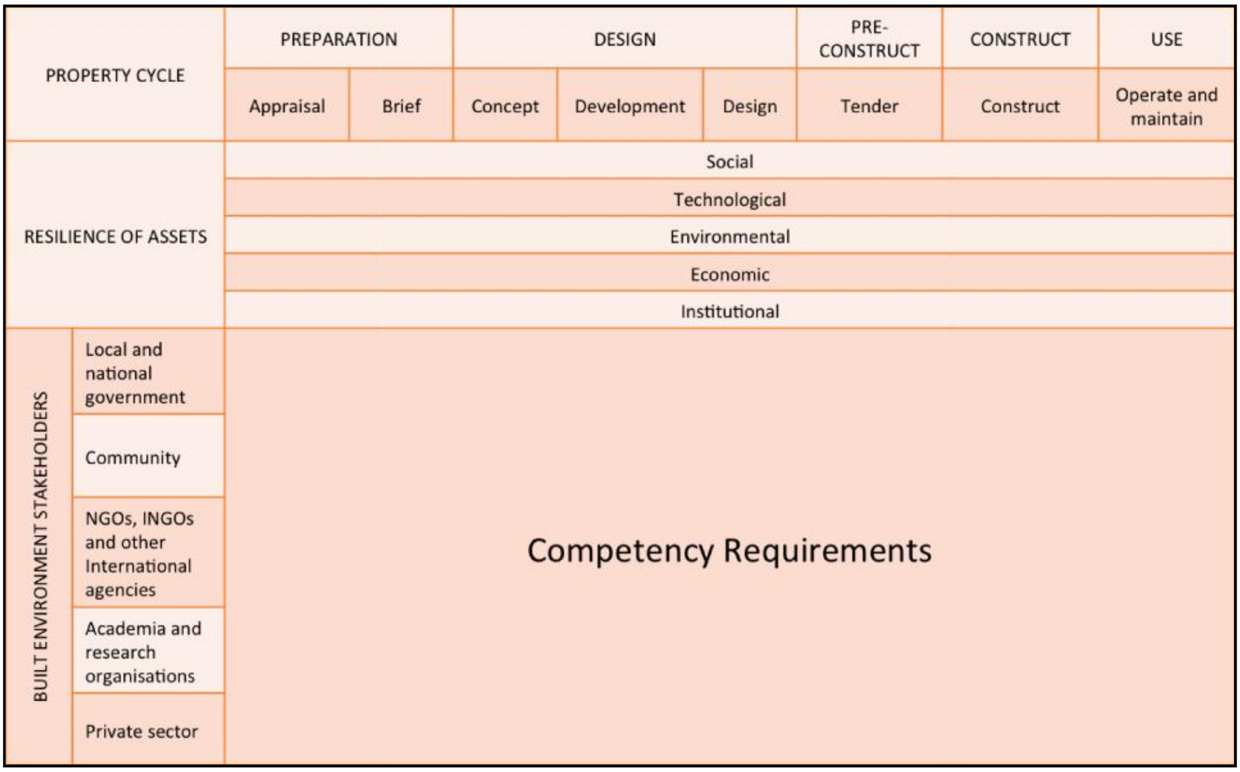

Figure 1: Framework for Data Collection and Analysis

As shown in Figure 1, the initial framework is a three-dimensional framework consisting the following parameters.

Built environment stakeholders: National and local government organisations; Community; NGOs, INGOs, and other international agencies; Academia and research organisations; and Private sector.

Dimensions of resilience: Economic Resilience; Environmental Resilience; Institutional Resilience; Social Resilience and Technological Resilience.

Stages of property lifecycle: Preparation Stage; Design Stage; Pre-Construction Stage; Construction Stage and Use Stage.

The framework was developed through an extensive consultation process and was refined with the emerging literature findings and with the opinion of stakeholders who has been interviewed to capture the labour market demands in the construction industry to increase societal resilience to disasters. Eighty-seven semi-structured interviews were conducted with national and local government organisations; community; NGOs, INGOs and other international agencies; academia and research organisations; and the private sector in all five partner countries. The details of the interviews are presented in Table 2. The interviews were aimed at capturing the needs of five stakeholder groups associated with disaster resilience and management as well as current and emerging skills and ultimately competencies, applicable to built environment professionals towards enhancing societal resilience to disasters.

Table 2: Interviewees Profile

Stakeholder group	Number of Interviews	Nature of Interviewee
National and local government	20	Managerial level employees at government agencies and council employees engaged in disaster management and resilience planning
HEIs and research organisations	21	Senior academics and researchers working in the field of disaster resilience
Private sector	19	Senior employees from private sector companies such as directors and managers of insurance companies and construction companies
Community	15	Community representatives comprising disaster affected community members, recovery coordinators, and former and current council members
NGOs/INGOs	12	Representatives of Disaster Management related INGOs and NGOs such as programme managers, research officers and technical advisors
Total	**87**	

Separate interview guidelines were prepared for each stakeholder to match their circumstances. The interview guidelines were prepared to capture the above issues and the guidelines and a study brief were sent to the interviewees prior to the interview. At the start of the interview, the interviewer introduced the research topic and the aims and objectives of the study in order to give a clear picture of what is expected from the interviewee. This allowed the interviewees to answer the questions more appropriately.

During the interviews, the interviewer asked questions based on the interview guideline, however, the process allowed the interviewee to elaborate on the other issues which were relevant to the study. This process allowed interviews to progress in a more proactive manner where the interviewer was able to capture data more relevant to the study. The interviews lasted between 55 minutes and 80 minutes. Most of the interviews were audio recorded using a digital voice recorder with the consent of the interviewees. Audio recording helped the researchers to transcribe interviews accurately and provided the opportunity to fully concentrate on the interviewee during the process. In addition, all key points were written down during the interview in order to avoid any issues arising from technology failure. All the interviews were then transcribed using MS word and this process allowed the researcher to use direct quotations from the interviewees when presenting the data; all of which increased the reliability and validity of the research findings.

The data gathered from respective interviews were subsequently analysed by the CADRE project partners that conducted them. The analysis was done using NVivo (version 10). The themes that emerged from the interviews conducted within each stakeholder group were collated. Similar nodes were merged after combining all the nodes created by respective partners. The themes were presented under two main headings i.e. Needs and Skills. The category “Needs” covers the stakeholder requirements that emerged from the interviews as well as the demands specifically made by interviewees. Also, what the interviewees believe should be in place while professionals relate with them to enhance societal resilience were categorised under the heading “Needs” in the analysis. During the interviews, some set of skills were displayed by professionals while serving to reduce the threats posed by natural and human-induced hazards, and some that are desired by interviewees emerged. These set of skills were categorised under the heading “Skills” (See Malalgoda *et al*. (2016); Perera *et al*. (2015); Perera *et al*. (2016) for details).

The interviews generated a long list of needs and skills with respect to the property lifecycle stages under the respective dimensions of resilience. Finally, the identified needs and skills were combined ‘like-for-like’ to produce the broader level of knowledge gaps in disaster resilience.

4. DISCUSSION

The knowledge gaps identified through the interviews could be broadly categorised into two groups. They are built environment specific knowledge gaps and knowledge gaps which are commonly related to any discipline in disaster resilience. Some of the key knowledge gaps identified are, Governance, legal frameworks and compliance; Business continuity management; Disaster response; Contracts and procurement; Resilience technologies, engineering and infrastructure; Knowledge management; Social and cultural awareness; Sustainability and resilience; Ethics and human rights; Innovative financing mechanisms; Multi-stakeholder approach, inclusion and empowerment; Post-disaster project management; and Multi-hazard risk assessment.

These knowledge gaps form the basis for the initial programme specification for the proposed DProf programme. Based on these, a structured DProf programme will be developed to reflect how the construction sector and its professionals can contribute to achieving resilience. In addition, these study findings will be used to develop the appropriate learning outcomes and the content of taught and research components of the DProf programme in disaster resilience.

5. CONCLUSIONS

The professional doctorate in disaster resilience in the built environment is designed for practitioners associated with disaster resilience in the built environment. The programme is offered to learners from the construction industry, to develop solutions to their labour market demands through doctoral studies. This is an alternative form of doctorate, which allows students to contribute to knowledge and practice without undertaking a traditional research degree. The degree will facilitate students to reflect on a different element of their professional career while making a substantial contribution to the improvement of their professional practice. Successful completion of the degree will lead to professional and/or organisational change that is often direct rather than achieved through the implementation of subsequent research findings. The programme will address the career needs, and will upgrade the knowledge and skills, of practising professionals working to make communities more resilient to disasters, and particularly those in, or who aspire to, senior positions within their profession. The education and training delivered will be more relevant to the world of work, which is vital for the labour market and for people's employability. It will further broaden and deepen the employees' understanding of the disciplines in which they are studying, upgrade their skills, promote inter-disciplinary working, and provide them with appropriate transferable skills. It is believed that this study would be of great value to HEIs considering in offering a professional doctorate programme in disaster resilience. Also, the methodology used to develop the professional doctoral programme (DProf) in this study can be applied to any professional doctorate programme in HEIs and thus, benchmark future studies.

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DISPUTE AVOIDANCE MODEL FOR SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Construction disputes have become a major hindrance for the performance of construction projects. Most of the practices in construction projects have contributed to avoid disputes while serving its own purposes. It is still hard to find a construction project with no disputes due the existence of root causes for disputes. Many steps have been taken to introduce effective dispute resolution mechanisms giving more concern on cost, time and enforceability of the solution, which still contain many drawbacks in practical applications. This ways to 'prevention is better than cure' and thus the concept of dispute avoidance being emerged. The research therefore aims to develop a dispute avoidance model for Sri Lankan construction industry.

Primarily, literature review was done in order to find the issues related to dispute and factors contributing to dispute avoidance. The review revealed that risk allocation, selection of contractors, quality of documentation, time management, and procurement method could contribute to dispute avoidance. A survey research approach was adopted and questionnaires were issues to the professionals who have experience in dispute management in Sri Lanka. The collected data was analysed statistically using t-test. The research proposed 'Dispute Forecasting Session (DFS)' as dispute avoidance model for Sri Lanka. The research revealed that DFS need to be carried out middle of the briefing stage, in between pre and post contract stage and beginning of post contract stage of the project. Further the research identified the participants to DFS in terms of each stage of construction project; in briefing stage client and consultant; in pre contract stage client, consultant and neutral third party; in post contract stage contractor, consultant, nominated subcontractor and neutral third party. In addition, the research participants identified the activities to be performed in each stage of projects in order to avoid deputes. Finally the research suggests to utilise the DFS dispute avoidance model which will forecast construction disputes, thereby avoiding the foreseen construction disputes in Sri Lankan construction industry.

***Keywords**: Disputes; Dispute Avoidance; Dispute Forecasting; Dispute Resolution.*

1. INTRODUCTION

The Construction projects are identified as one-off endeavors consisting of many unique characteristics (Zou *et al*., 2007). As depicted in Emson Eastern vs EME Developments (1991) case, it is not virtually possible to achieve the same degree of perfection due to the said unique nature. Complexity nature of construction industry creates disputes which affects detrimentally on the construction projects (Edwin and Henry, 2005). According to Fenn *et al*. (1997), an incompatibility of interest leads to a conflict and it will turn as dispute. To avoid the conflicts or to minimise the conflicts, it is a must to identify the causations of the construction disputes thoroughly. Common categories in causes for disputes can be classified broadly as, owner related, contractor related, design related, contract related, human behaviour related, project related and external factors (Cakmak and Cakmak, 2014).

Ineffective management of disputes may cause project delays, undermine team spirit, increase project costs, and thereby damage business relationships (Cheung and Suen, 2002). Kumarswamy (1997) convinced that separation of the destructive conflicts and constructive conflicts could minimise disputes caused by unresolved conflicts. However, industry practitioners utilise Alternative Dispute Methods and

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litigation process for resolution of those disputes once they occur. With the emergence of the Alternative Dispute Resolution methods, the construction industry marked a significant preference instead of litigation due to the principal reasons of speed, cost, expertise, privacy and practicality (Jannadia et al., 2000). Stipanowich (1997) demonstrated that ADR procedures are established prior to the emergence of the disputes and therefore the rules must be more flexible while giving them more freedom to handle conflicts. Such revolutions in the subject of construction dispute management have lead the way to the new era which is in concern of dispute avoidance rather dispute resolution

According to 'prevention is better than cure', a growing awareness could be witnessed in the construction industry on the proactive rather than reactive measures (Gerber, 2000). This trend has led to utilise several models for dispute avoidance. Accordingly Gerber (2000) identified three main Dispute Avoidance Procedure models currently being practised in the industry namely; Dispute Resolution Advisor, Dispute Adjudication Board and Dispute Review Boards.

Many researchers convince that preparation of construction contracts should incorporate techniques which avoid disputes. Jannadia *et al*. (2000) emphasised that dispute avoidance methods in terms of contractual administration are namely; allocating fair contract risk, drafting dispute clauses, team building, provision of a neutral arbitrator and binding arbitration. Key areas in the scope of construction dispute avoidance are discussed as risk allocation, selection of contractors, quality of documentation, roles of the parties, cost management, nominated sub-contractors, time management, variations, claims administration, dispute resolution, alternative contract strategies, quality assurance and training (National Public Works conference and National Building and Construction Council, 1990). Even though several DAP models are in practice, it is important to develop a dispute avoidance strategy applicable for the Sri Lankan construction industry. Most of these key areas are yet to be investigated in order to develop a convenient dispute avoidance strategy under Sri Lankan context. Therefore the research aims to develop a dispute avoidance model for the Sri Lankan construction industry.

2. LITERATURE REVIEW

2.1. DISPUTE AVOIDANCE IN CONSTRUCTION INDUSTRY

Over the time owners, contractors, design professionals and other stakeholders in the industry who are engaged in construction claims, have realised the hours and dollars involved in attorney and expert fees, court costs, loss of staff time and additional overhead expenses incurred due to dispute resolution do not improve the value of the project. But they result in reduced bonding capacity, loss of good will, loss of privacy and other opportunity costs associated with it (Adems, 1996). In support of this, a survey carried out in Australian construction industry emphasised that, most of the industry practitioners are not satisfied on the dispute resolution methods used as they are not effective in terms of cost, outcome, time and process (Australian Constructors Association, 2006). Adems (1996) further highlighted that most of the construction disputes are predictable and the consequences of the dispute resolution processes are undesirable. This circumstance emerged the question, can more effective methods be found to avoid the disputes?.

Avoidance of disputes has been addressed throughout past several years in both industry and project specific levels. This concept is supported by the basic maxim that 'prevention is better than cure' (Cooperative Research Centre for Construction Innovation, 2007). Further it is identified that the industry has been repeatedly encouraged to embrace modern concepts of dispute avoidance. The reason because, these techniques has placed an emphasis on early involvement to the decision making process by the stakeholders. The fundamental principle with respect to dispute avoidance being that the likelihood of occurring disputes will be significantly reduced if a pro-active environment can be created in which change management an accepted tool (Cooperative Research Centre for Construction Innovation, 2007).

It was revealed that any construction contract begins with many dispute preventive measures which has made the topic dispute avoidance a vast area of study. It was stated that all most all contractual practices in a construction project serves the consent of dispute avoidance while serving their own purpose.

2.2. FACTORS CONTRIBUTING TO DISPUTE AVOIDANCE

This section mainly focuses on developing the activities for the conceptual framework in developing dispute avoidance strategy.

Risk Allocation

Construction projects are subjected to many risks from their nature. The key driving risk which causes disputes is the construction related risk. Accordingly in any building construction project, buildability exists on the underground conditions. Disputes arising as a result of underground conditions hinder the progress of the project at the very initial stage of the project, hence leading to damage the relationships throughout the construction period. All possible risks need to be identified at the initial stage of the project and allocate them in advance not to the party who has the obligation to bear it, but to the best party who can bare the risk.

Selection of Contractors

It was identified that assessing the past performance is mandatory while giving a same weight on the market trends. Even though the tender evaluation process comprises of the said activity, fore seeing the attributable conflicts must be done when selecting the contractor. Market pattern here referred is, how the industry has identified the contractor in performing the cost, quality and time targets of past projects. So it is better to identify the concern of the client among the three pillars of cost quality and time, thereby selecting the suitable contractor for the evaluation criteria.

Selection of Nominated Contractors

A standard form of contract for subcontracting has not yet come in to practice in Sri Lanka. Further existing subcontract agreements which are in practice have major drawbacks which are contradictory with the main contract. It is better to allow the Main contractor to nominate the list of subcontractors that they prefer along with the tender document. It can be considered in the tender evaluation. Also, getting the main contractor involved in the selection process of nominated subcontractors would be a practical solution to avoid disputes.

Roles of the Parties

All the standard contracts in practice have given a higher emphasis on roles of the parties which have already contributed to dispute avoidance in large. It was emphasized that the fact that in many circumstances such as in variation handling and claims management, if Engineer’s role is played absolutely in an impartial manner, disputes can be further avoided. Many disputes tend to occur directly and indirectly as a result of delayed payments by the Employer. Therefore the Employer’s role also significantly contributes to dispute avoidance.

Quality of Documentation

A significant root cause of disputes is quality of documentation. Need to specify a quality standard from the inception stage of the project was identified as a key success factor of a project. Contribution of inaccurate Bill of Quantities also cause construction disputes in projects. However, claiming the loss through litigation or through professional indemnity insurance is not in the Sri Lankan practice. This results in construction projects to allocate such risks to the contractor. Therefore, the contractor tends to price that risk in a higher rate as a variation. Such situations are the dispute causing factors, which needs more concern. The industry practice of copying and pasting the set of particular conditions in the contract, could also lead to disputes. Moreover it reduces the quality of documentation while creating unexpected disputes in a project.

Time Management

It was identified that time management must be considered since the briefing stage of a project. Therefore realistic planning and programing is to be done at the pre-contract stage by the contractors when submitting the tender documents. Time management should also engage in reviewing the work programme in shorter intervals and thereby ensuring the key milestones are not affected.

Quality Assurance

Quality in construction context refers to the capability to establish requirements with conformance to the pre defined quality standard. Requirements will be predefined by client in contract agreement and the requirements consist of characteristics of products, processes, and services (Leong *et al*. 2014).

Further according to Leong *et al*. (2014), it is evidenced that implementing quality management system to ensure quality, also can improve communication problems; minimize mistakes, rework, and material wastage while having better control of subcontractors and suppliers.

Procurement Method

Procurement method is a factor which is identified as a crucial factor in dispute avoidance. The decision taken on the key procurement approach leads to the success of the project. Employers take the decision on payment method as lump sum having less accurate set of drawings and specifications in their hand which will be a major cause of disputes, while some others go for measure and pay having far accurate and complete set of information about the project and unnecessarily take risk of disputes. Therefore, major concern on procurement method must be taken before the design stage in order to determine the requirement of design detail at the tendering stage. However, the approach selected at the inception stage must be reviewed once the design stage comes to an end.

Team Building

Team building is another dispute avoidance approach in construction projects, which can be instituted at the very beginning of the project (Jannadia *et al*., 2000). Team building as a management strategy would reduce adversarial relationship among project participants. Moreover budget overruns and the schedule extensions are identified as two common problems, which can be greatly influenced by team building (Williams, 1998).

3. METHODOLOGY

Initially, a comprehensive review of dispute avoidance in construction industry was carried out using existing journals, book and conference articles. The literature review fulfils the purpose of gaining depth knowledge in causes of disputes, prevailing dispute resolution techniques and contract administration methods in dispute avoidance and contributing factors of dispute avoidance. Using the comprehensive review of literature, questionnaire was developed. Questionnaire survey was conducted among the experts in dispute management in the Sri Lankan construction industry in order to identify the parties to DFS, stage of project in which DFS to be performed and the significant activities for DFS. A total of 35 questionnaires were issued and 32 were returned. Out of 32 respondents, 39% are from contracting firms and 61% are working in consultancy organisations. Questionnaires were issued to twenty (20) Quantity Surveyors, eight (08) Project Manager and four (04) Arbitrators. In terms of experience of the respondents, 59% are with 6-10 years of experience, 23% of them are having 11-15 years of experience and the rest are with more than 15 years of experience in handling disputes in Sri Lankan construction projects.

t-test was used to analyse the collected data. The t-test was used to find the significant activities, which are to be performed during Dispute forecasting Session. In order to determine the most effective set of activities,‘t’ test was carried out. ‘t’ values were calculated and the respective ‘P’ values were obtained (see Table 1).

‘t’ values were calculated according to the Eq: 01, and the P values were derived from the ‘t’ table.

The test statistic was calculated as:

$$t = \frac{\bar{x} - \mu}{\sqrt{s^2 / n}} \qquad \text{(Eq: 01)}$$

t is a Student t quantile with n-1 degrees of freedom

x bar is the sample mean

s² is the sample variance

n is the sample size

μ is the specified population mean

Decision Rule

H_0 - Sample mean less than or equals 4.

H_1 - Sample mean is greater than 4

Considering the above null hypothesis (H_0) and alternative hypothesis (H_1), the decision rule is developed as follows.

df = n - 1

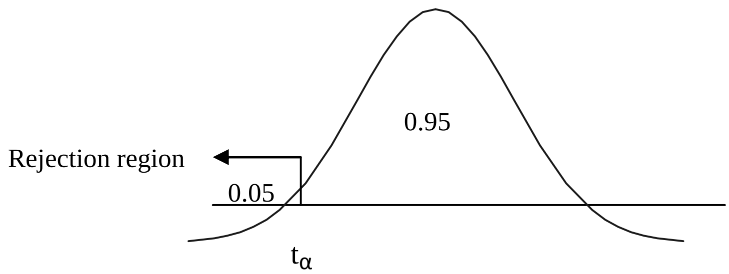
df - Degree of freedom

n - Sample size

Hence, df = 32-1, df = 31.

Using a 95% confidence level with a single-tailed test with 31 degrees of freedom (df), it was expected the distribution to look as follows.

P- Significance of calculated probability



Accordingly, if P > 0.05, the decision was taken to accept null hypothesis (H_0) and if P < 0.05, the alternative hypothesis (H_1) was accepted.

4. DATA FINDINGS AND ANALYSIS

4.1. DISPUTE FORECASTING SESSIONS AS A STRATEGY

'Dispute Forecasting Session' is expected to be developed as the dispute avoidance model applicable for the Sri Lankan industry. The respondents were asked indicate 'Yes' where they agree with dispute forecasting sessions as a strategy for dispute avoidance and 'No' where they disagree. All the respondents agreed that dispute forecasting sessions can be implemented in order to avoid disputes in Sri Lankan construction industry.

4.2. SEQUENCE TO CONDUCT DISPUTE FORECASTING SESSIONS

A project can be identified in three major stages namely; briefing stage, pre-contract stage and post-contract stage. Respondents were asked to suggest the stages in which dispute forecasting need to be done. Each stages of project again divided in to four; beginning, middle, in between two and periodical. Figure 1 shows the sequence of conducting dispute forecasting session against the stages of construction project.

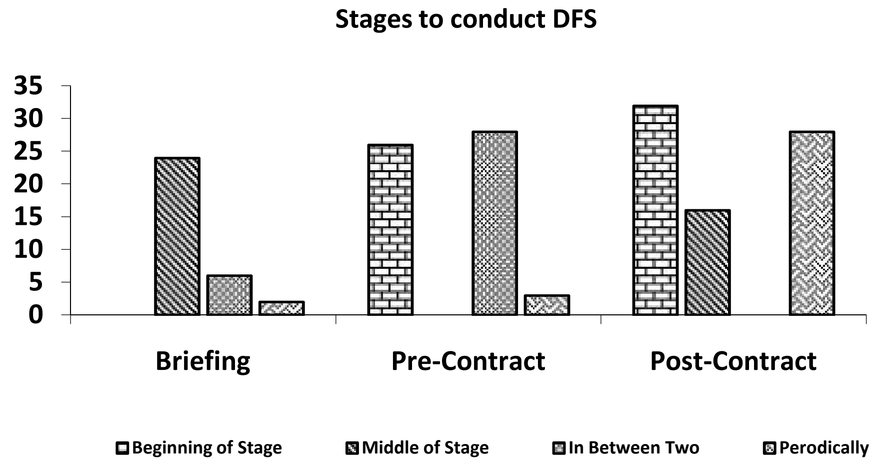


Figure 1: Sequence to Conduct DFS

According to Figure 1, 75% (24 out of 32) of the respondents proposed that Dispute Forecasting Sessions need to be conducted at the middle of the project briefing period and 18% of the respondents proposed to conduct in between briefing and pre-contract stage. Only two professionals indicated that DFS should be conducted periodically throughout briefing stage. Majority of the respondents indicated that DFS should be carried out beginning of the pre-contract stage and in between pre and post contract stages. Few respondents (3 out of 32) preferred to carry out DFS periodically during pre-contract stage. In terms of post-contract stage, all the respondents indicated that DFS need to be done at the beginning of the stage. 88% and 50% of the professionals revealed DFS should be performed middle of the stage and periodically respectively.

4.3. PARTICIPANTS FOR THE DISPUTE FORECASTING SESSIONS

The research intended to find the participants for the dispute forecasting sessions at the main three stages of a construction project. Thus, the research participants were asked to suggest the parties important for the particular stage among the parties to contract; client, consultants, contractor, nominated sub-contractors. In addition to parties to contract neutral third party was also included in order to determine whether employing an external party other than the parties to the project is essential for the success of the Dispute Forecasting Sessions or not. The data gathered are presented in Figure 2.

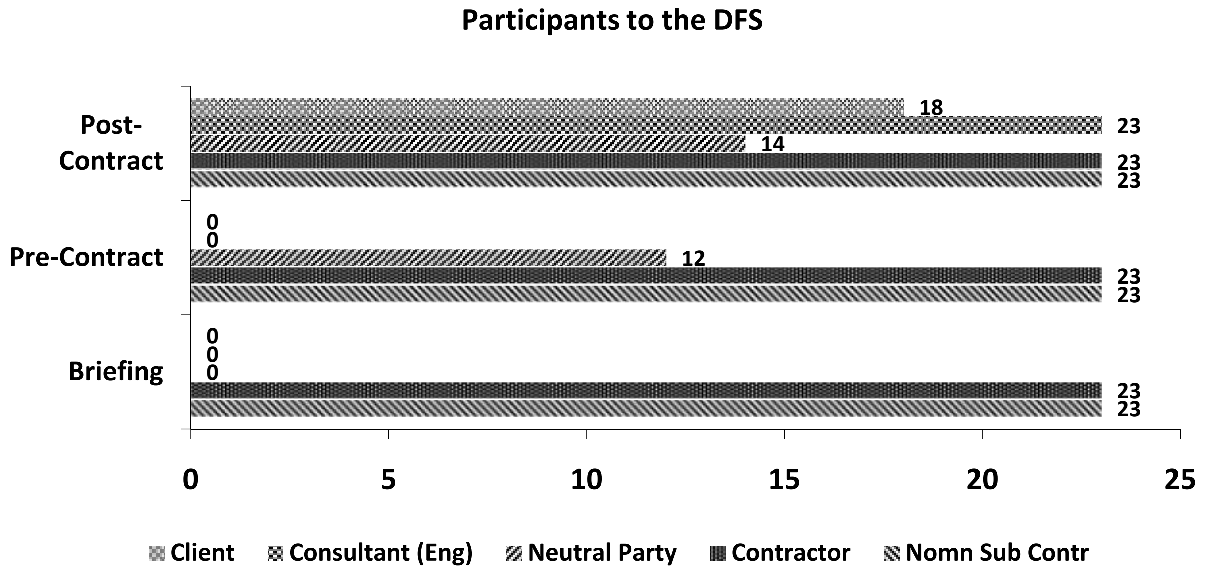


Figure 2: Participants to the DFS

According to the responses it is highlighted that participation of both client and the consultants are mandatory for the DFS at the briefing stage. None of the respondents indicated a neutral third party as a participant at briefing stage. In terms of pre-contract stage, client and the consultants are expected to participant in DFS by the majority of respondents (72%). 37% of the respondents indicated a neutral third party as a participant for DFS during pre-contract stage. Since the activates in the pre-contract stage significantly contribute to disputes, getting the viewpoint of a third party will attain better results in forecasting disputes. However, the results show that the dispute forecasting session can be conducted without the presence of a neutral third party according to 63% of the respondents.

Participation of the client, the consultants and the main contractor are depicted an equal importance during post contract stage by 72% of respondents of each. Nominated subcontractors are also been elected by 56% of the respondents which figures a significant importance. A total of forteen (14) respondents suggested a neutral third party for the sessions at the post-contract stage, which has an increase level of important compared to the pre-contract stage. According to the research participants, the impartial role of the Engineer to the project can be used as a substitution to the neutral third party. This will reduce the additional expenditure on the Dispute Forecasting Sessions.

4.4. Proposed Activities to the Dispute Forecasting Sessions

Factors leading to dispute avoidance are identified through the review of disputes and the related issues across the construction industry. The factors were then developed as activities. These activities were developed focusing dispute avoidance and proposed as a framework to be followed in the Dispute Forecasting Sessions during the stages of a construction project. A total of twenty nine (29) activities were proposed to be performed as 5 in the briefing stage, 12 in pre-contract stage and 11 in the post-contract stage. Activities were in line with each factor leading to dispute avoidance shortlisted in the literature review.

Mean values of the 32 responses for each variable were calculated to identify the hypothesis mean for the variables, which was then considered as the null hypothesis. Most significant variables were recognised with the 't' test values with reference to the above null hypothesis. Distribution of the mean values are shown in Figure 3.

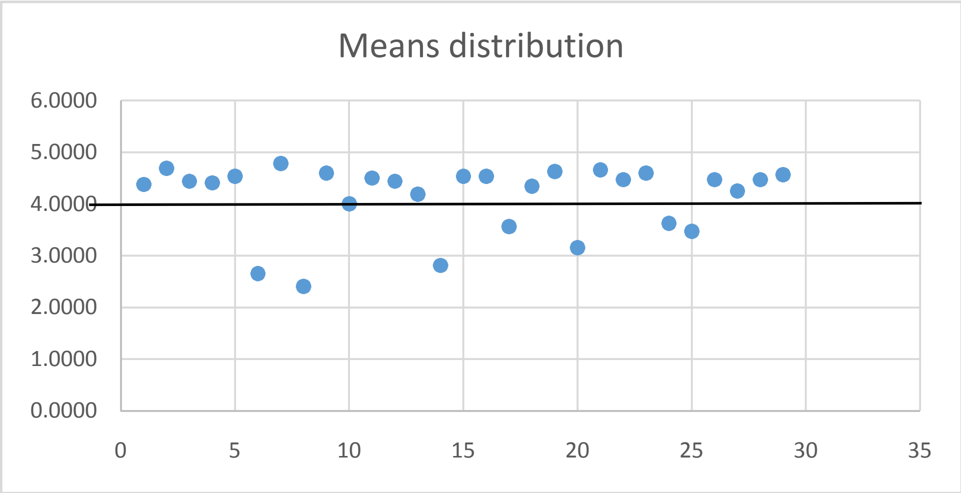


Figure 3: Distribution of Means

According to Figure 3, means of the data set have behaved more in a similar nature. 72% of the means were more towards 4 and between 4 and 5. Considering the spread of the means of the variables, it was decided to obtain 4 as the hypothesis mean of the population.

Table 1: Corresponding 't' Values and 'P' Values

Factor Leading to Dispute Avoidance	Activity		't' value	'P' value	Significant Activity
Risk Allocation	(a) Give more priority on financial risks due to changes in government policies	Briefing stage	4.31	0.000	√
	(b) Identify the construction risks of the project, giving key concern on sub-soil conditions.	Pre-contract stage	8.25	0.000	√
	(c) Allocation of the risk to the best party who can mitigate it.		4.91	0.000	√
	(d) Suggest alternatives solutions to avoid or mitigate risks	Post-contract stage	3.73	0.000	√
Quality of Documentation	(a) Specify a quality standard to be followed throughout the project.	Briefing stage	4.18	0.000	√
	(b) Recheck the accuracy of major cost significant items in the BOQ.	Pre-contract stage	-13.93	1.000	
	(c) Tailoring the Particular conditions of the contract according to the project rather copying and pasting from a similar project.		10.52	0.000	√
	(d) Check the compliance with the documentation quality standard.	Post-contract stage	-18.06	1.000	
	(e) Review the documentary errors which may lead to disputes.		6.73	0.000	√
Selection of Contractors	(a) Give emphasis on market patterns	Pre-contract stage	0.00	0.500	
	(b) Evaluate work in hand of the bidders		5.56	0.000	√
	(c) Evaluating recently completed projects with proof.		4.91	0.000	√
Selection of nominated sub-contractors	(a) Propose alternative designs and specifications to have a variety of sub-contractors without getting limited to few specialised work items.	Pre-contract stage	1.53	0.068	√
	(b) Propose the list of potential sub-contractors in the tender document by the Employer.		-9.10	1.000	

Factor Leading to Dispute Avoidance	Activity		‘t’ value	‘P’ value	Significant Activity
	(c) Evaluating the main contractor's suggested list of sub-contractors to be nominated by the Employer.	Post-contract stage	5.29	0.000	√
	(d) Getting the Main Contractor involved in the selection process of the nominated sub-contractors.		5.92	0.000	√
Selection of Procurement Methods	(a) Get the decision on the key two payment approaches, measure and pay or Lump Sum basis	Briefing stage	-2.36	0.988	
	(b) Check the extent of the design details available and review the applicability of the decision taken on measure and pay or lump sum basis.	Pre-contract stage	3.23	0.001	√
	(c) Preparation of a realistic cash flow forecast	Post-contract stage	7.18	0.000	√
Roles of the Parties	(a) Suggest and appoint an individual to handle the project	Briefing stage	-4.19	1.000	
	(b) Set out a guideline for the Engineer to get decisions without consent of the client.	Pre-contract stage	7.69	0.000	√
	(c) Highlight the impact of Engineer’s impartiality	Post-contract stage	5.23	0.000	√
	(d) Evaluate the effect of timely payments by the Employer.		6.73	0.000	√
Quality Assurance	(a) Specify the Methodology to be used for quality assurance	Pre-contract stage	-2.82	0.996	
	(b) Review the applicability of the Quality assurance criteria on practical situations.	Post-contract stage	-4.47	1.000	
Time Management	(a) More precise decision on project key milestones.	Briefing stage	4.67	0.000	√
	(b) Evaluate the reliability and build ability of the project plan.	Pre-contract stage	3.21	0.002	√
	(c) Monitor Planning and programing in shorter intervals	Post-contract stage	3.69	0.000	√
	(d) Review and reset the new project milestones if necessary		5.63	0.000	√

The activities which obtain a positive ‘t’ values and which lies on the 0.95 region of the curve shown in methodology are selected as the most significant activities. The activities carrying a value less than 0.05 for the ‘P’ value lies on the range of marked 0.05 on the curve. Therefore using 95% confidence level that the population means of the selected activities through the statistical test is equal or more than 4. According to the above decision rule, activities identified as the most significant and ticked (√) in above Table 1.

Finally the research developed a dispute avoidance model in terms of DFS for Sri Lankan construction industry as showed in Figure 4.

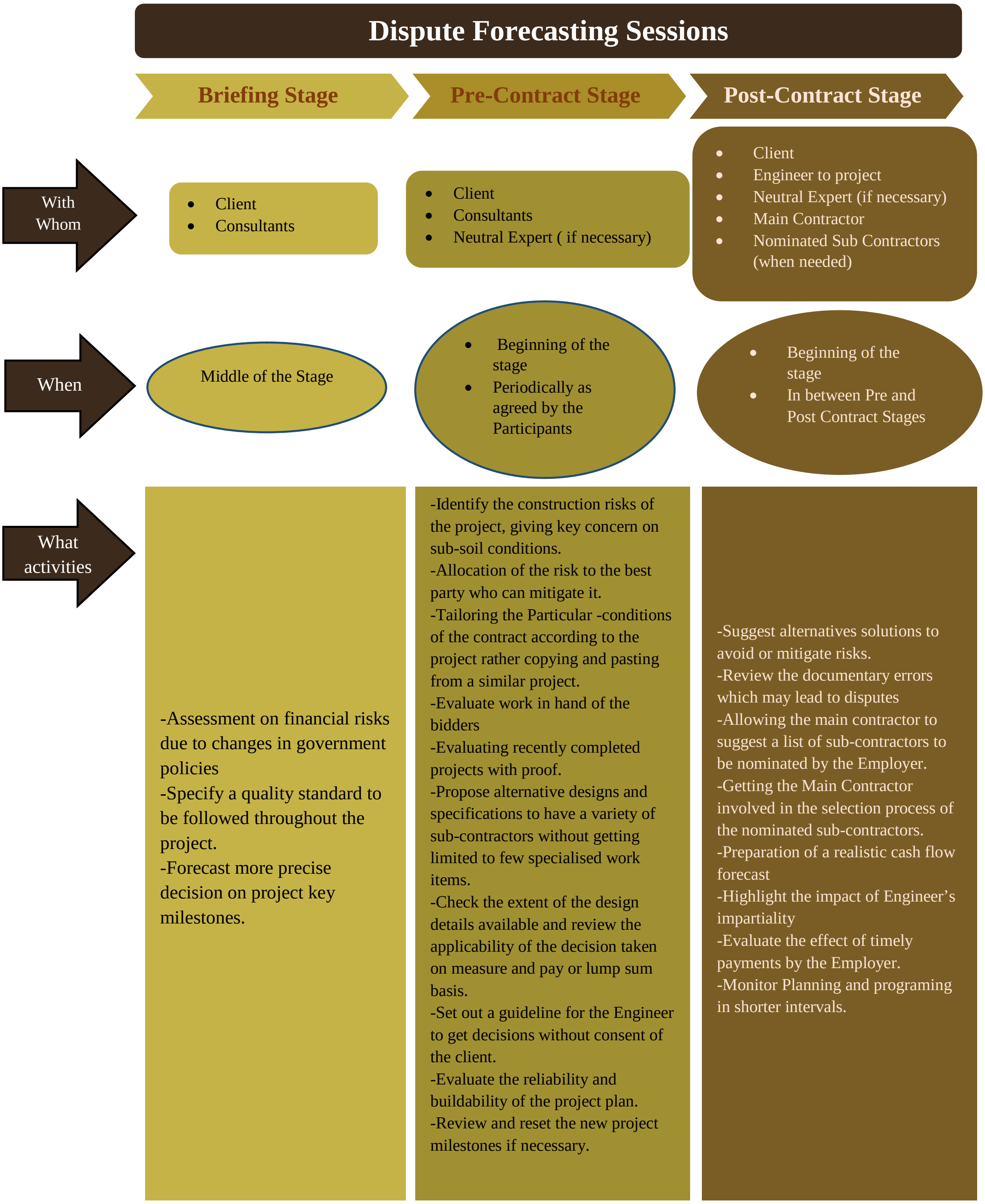


Figure 4: 'Dispute Forecasting Session' Model

The finding of the study finally presented the model for 'Dispute Forecasting Session' in Figure 4. The model addresses three major aspects; the details of parities to be involved in DFS, the stage in which DFS need to be carried out and the activities for DFS. A Dispute Forecasting Session is first to be held at the middle of the briefing stage with the participation of the Client and the Consultants. The key concerns of the members of the DFS at this stage shall be the Risk Allocation, Quality of Documentation and Time management. Figure 4 indicates that during pre-contract stage of the project DFS should be conducted at the beginning. Client and Consultants remain in the DFS while a neutral expert can be appointed if necessary. The concerns at the briefing stage drags up to this stage. In addition, the selection of contractors, nominated sub-contractors, and procurement method and roles of the parties are also considered in pre-contract stage. During the post-contract stage, the parties such as Client, Engineer, main Contractor, nominated Sub-Contractors and a neutral expert are involving in the process of DFS. The sequences of conducting the DFS are, at the beginning of the post-contract period and periodical Dispute Forecasting Sessions depending on Engineer's decision. The concerns which are looked at the briefing stage and the pre contract stages are continued to this stage except the selection of the contractors. Thus, the model proposes DFS as a strategy to diagnose the dispute causing symptoms of the project process and taking relevant remedial actions to overcome them in order to avoid disputes with Sri Lankan construction projects.

5. Conclusions and Recommendations

Disputes are widespread in the construction industry. The review of literature identified the factors contributing to dispute avoidance such as risk allocation, selection of contractors, selection of nominated contractors, roles of the parties, quality of documentation, time management, quality assurance, procurement method and team building. The research found that developing a dispute avoidance model as "Dispute Forecasting Sessions" could help to minimise disputes in Sri Lanka. The model includes the details of stages of project, participants for DFS, activities to be performed during DFS. The research participants revealed that DFS need to be carried out middle of the briefing stage, in between pre and post contract stage and beginning of post contract stage of the project. Further the research identified the participants to DFS in terms of each stage of construction project; in briefing stage client and consultant; in pre-contract stage client, consultant and neutral third party; in post-contract stage contractor, consultant, nominated subcontractor and neutral third party. The research developed activities to be performed in DFS using the contributory factors of dispute avoidance found in literature review. For example under the factor 'risk allocation', 'Give more priority on financial risks due to changes in government policies' identified as significant activity to be performed during briefing stage. Finally the research provides a model as 'Dispute Forecasting Session' in order to avoid dispute effectively in Sri Lanka. Therefore the research recommends that the industry practitioners could adopt this model during the stages of construction projects and thereby dispute could be minimised in Sri Lanka.

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EFFECTIVENESS OF ALTERNATIVE DISPUTE RESOLUTION METHODS USED IN THE HIGHWAY CONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

Effectiveness of dispute resolution affects immensely for success or failure of construction projects. This document consists of a literature review about alternative dispute resolution (ADR) methods including negotiation, mediation, Dispute Adjudication Board (DAB), ad-hoc adjudication, arbitration and ten critical factors affecting to effectiveness of ADR methods such as cost, speed, relationships, fairness etc. After decades of use there is no clear detailed analysis about used alternative dispute resolution in highway projects for their effectiveness and efficiency. In order to fulfil this gap, this research is conducted to evaluate effectiveness of used ADR methods regarding ten critical factors.

The research methodology adapted was qualitative within multiple case studies from disputes arisen in Expressway Construction projects. The primary data collection techniques used in this study were ADR documents and semi structured interviews. Content analysis was used to analyse these documents and cross case analysis to compare cases findings to each other. The research findings revealed that ratings for critical factors fluctuate from case to case significantly. In the discussion of research findings, key attributes identify which was the cause for fluctuations. So one cannot simply say this or that factor affects most to the success and this ADR method is best way to deal with disputes. According to study it's not fair to deal with every dispute in the same manner, so categorization of disputes concerning key attributes needed for improved efficiency of ADR methods.

Guidelines developed include steps, tables and flowcharts for using ADR methods effectively. These findings and guidelines are presented in a logical, systematic and a sensible way to identify the ideal ADR method for a given dispute rather than relying on subjective decisions. It is hoped that these findings and guidelines will be useful to the stakeholders in future highway projects and can be adapted to the whole industry.

Keywords: *Alternative Dispute Resolution; Critical Factors in Dispute Resolution; Expressway Construction Projects; DAB;Cross Case Analysis.*

1. INTRODUCTION

Harmon (2003) the intricacy and magnitude of the construction work often lead to complex disputes. Highway construction in last decade in Sri Lanka was huge leap in road construction creating high magnitude construction work. Since highway construction projects are multibillion projects with very complex infrastructure developments, there will be disputes which cannot be settled without more formal methods such as Mediation, Arbitration and Adjudication. In FIDIC (1987) which was Bidding Document of Most Expressway projects in Sri Lanka speaks about arbitration while FIDIC (1999) focused about DAB for resolving disputes. Both suggest strict steps to follow for every kind of disputes.

Cheung *et al*. (2002); She (2011); Gunasena (2010) identified ten factors to evaluate effectiveness of ADR methods which can be adopted to Sri Lankan highway sector to identify problems in used ADR methods and evaluate effectiveness of the process. The aim of this study is to identify critical factors affecting to effectiveness of the ADR methods. Further, research intends to evaluate attributes of Disputes which affect to critical factors in order to make necessary suggestions to improve.

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1.1. NEED OF SEPARATE STUDY FOR HIGHWAY CONSTRUCTION PROJECTS

Road network should be efficient in order to maximize economic and social benefits of a country. These infrastructures play a primary role in achieving national development and contributing to the overall performance and socioeconomic well-being of the community (Sengupta *et al*., 2007). Highways play a significant role in the any country's economy. Hence, developing countries like Sri Lanka tend to construct many highways (Priyantha *et al*., 2011).

Priyantha *et al*. (2011) identify increasing number of highway construction in Sri Lanka and related problems like conflicts, variations, claims and disputes are multiplying in those projects. Our nearest country, India faces huge lockdown in highway sector according to Parikh and Joshi (2013). "123 highway projects out of a total of 406 awarded so far by the National Highways Authority of India (NHAI) since 2000 are caught in the arbitration tangle. 103 cases are being settled at the DAB formed by the NHAI, while the rest are under various courts". In Sri Lanka it's important to produce effective ADR methods before such situation arrive.

2. ALTERNATIVE DISPUTE RESOLUTION METHODS

According to Fenn *et al*, (1998) success and general acceptance of these ADR methods had been so refreshing that the courts themselves are now encouraging to modifying their rules to allow ADR methods to be incorporated into their range of resolution options. Wimalachandra (2007) further mentioned numerous advantages of ADR like flexibility, confidentiality, time saving, cost savings, informality and low antagonism between the parties. Cheung (1999) demonstrated the relationship of ADR methods and level of cost and hostility escalations by stair step model as given in Figure 01. The rising steps in the model imitate the Increasing levels of cost and hostility associated with the various forms of ADR.

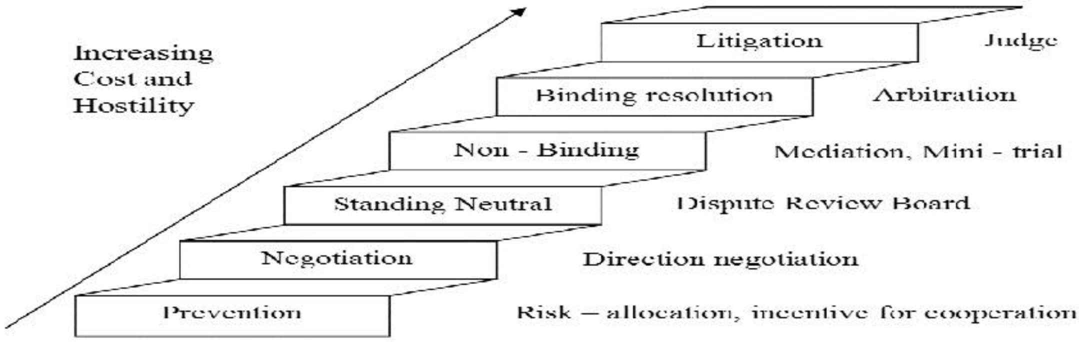

Figure 1: Stair Step Model for Dispute Resolution Process in Construction

Highway construction projects in Sri Lanka used ADR methods like Negotiation, Adjudication, DAB and Arbitration and rarely use Mediation, Ad-Hoc Adjudication, etc.

2.1. CRITICAL FACTORS AFFECTING TO EFFECTIVENESS OF ADR METHODS

ADR methods in dispute resolution are among recognised key input for success in highway Projects. In order to evaluate effectiveness of above mention ADR methods, factors affecting to effectiveness have to identify first. Previous researchers internationally (Cheung, 1999; Cheung *et al.,* 2002; She, 2011) and locally (Arsecularatne 2011, Gunasena 2010) have identified several factors and attributes which critically affect the ADR practices. Among above studies Cheung's (1999) article is considered as important because he identifies twelve critical attributes which are affecting ADR methods. Cheung (1999) in same article allocates those attributes into five different Critical factors. Cheung *et al*. (2002) in his late studies firmly identified ten factors that are used to test the performance and selection of dispute resolution methods namely cost, speed, outcome, enforceability, privacy and confidentiality, open and fairness, control, flexibility, creative remedies and relationships. She (2011); Gunasena (2010), etc. used these 10 factors to evaluate effectiveness of ADR methods. Researcher selected these 10 factors of Cheung to evaluate effectiveness since it's the latest, widest and most famous.

3. RESEARCH METHODOLOGY

Since study is done to evaluate how critical factors are affected to ADR from existing examples, most suitable approach for the research was qualitative approach and case study method.

- Identification of unit of analysis - Disputes arisen in highway project in Sri Lanka.
- Defining number of cases - three numbers of cases selected.
- Criteria for selection of cases - The cases were only selected from Expressway projects due to the fact they were the most notorious in generating disputes with highest impact. Every case was different to each other in many ways.
- Data Collection - Document review and semi-structured interviews.

4. RESEARCH FINDINGS

The case studies were extracted from two expressway construction projects which were using ADR methods. Cases were selected from vast pool of cases after preliminary study so these three cases are different to each other in many ways but carrying very significant value inside which worth a comprehensive analysis.

Table 1: Details of the Selected Cases

Case	***Case A***	***Case B***	***Case C***
Dispute	Additional Payment due to Legislation Changes to VAT on Bitumen	Payment for Environmental control & Protection	The Viaduct Foundations claims due to changed ground conditions
Claim amount (Rs.)	3 million	70 million	120 million
ADR	Negotiation, DAB	Negotiation, DAB	Negotiation, DAB
Settled by	DAB failed. Amicably settled Before Arbitration	DAB decision –Entitled, Claim Granted	DAB Decision No Entitlement, No additional Payment
Payments for DAB	525,000	906,500	900,000

4.1. PROCESS OF PRESENTING RESEARCH FINDINGS

Findings were present relating to sequence of questions asked from interviewees. As shown in interview transcript, every interviewee had to rate criticality of factors affecting to the whole construction industry first. For every case minimum four interviews conducted.

Table 2: Description of Interviews Distribution

Case	***Case A***	***Case B***	***Case C***
Total DAB Participants in hearings	8	9	12
DAB Members Interviewed	1	1	1
Members Interviewed from Contractors, Consultants, & Employers	3	3	4
Total Interviews Conducted	**4**	**4**	**5**

Table 2 represents the allocation of interviews for cases. Before moving onto cases, findings from data collection regarding the whole of construction sector are presented. Introduction for document analysis is presented afterwards, and finally followed by findings from cases.

4.2. *CRITICAL FACTORS AFFECTING TO EFFECTIVENESS OF ADR METHODS*

In the interviews, interviewees were asked to rate the criticality of factors affecting to effectiveness of overall ADR methods. These factors were derived from the literature based on studies of Cheung *et al.* (2002) ten factors and modified according to Sri Lankan context. For this study participant's idea about both overall ranking for factors and which were critical to selected case were recorded separately. Hence there are two separately rated tables for each case for each interviewee.

Overall criticality ranking table was commonly marked once by interviewee but criticality ranking of each case marked separately hence there are a total of four tables for three cases. This section presents ranking of criticality and analysis of the data presented using 'checklist matrix analysis' method.

4.3. *RATINGS FOR FACTORS AFFECTING TO EFFECTIVENESS OF ADR METHODS - OVERALL*

All the interviewees' ratings were obtained one time for below table which represents their view of criticality ranking in identified factors relating to the whole construction industry disputes.

Table 3: Ranking of Factors Overall

Factors	Total Mark	Rank
Cost	30	06
Openness, Neutrality & Fairness	36	02
Speed	40	01
Outcome	29	06
Privacy and Confidentiality	32	05
Enforceability	27	09
Preservation of Relationships	36	02
Flexibility	22	10
Creative Remedies	34	04
Degree of Control	29	06

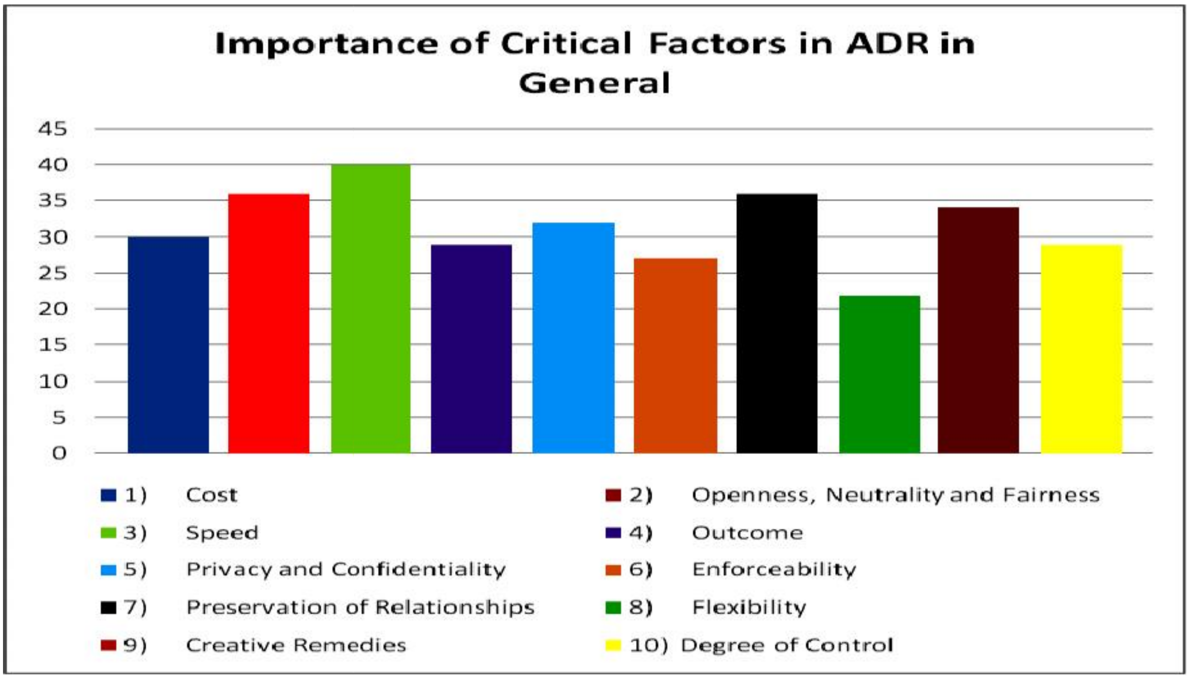

Figure 2: Rating for Critical Factors

4.4. CASE A IN BRIEF

Before the commencement of contract, sales of bitumen were subjected to value added tax (VAT) of 12% but afterwards the government removed VAT on bitumen. But price reduced after three months, with somewhat similar value for VAT removing. In the face of it, this shouldn't have affected the contractor because the project was excluded from VAT. But problem arises with regard to price fluctuation clause. Because of the drop of market price for bitumen, ICTAD indices which were used to calculate price fluctuation also reflected a fall. Due to that, the payment contractor received for bitumen was reduced. In other words VAT removal did not affect the cost of bitumen to contractor, but it lead to a reduction of contract price paid to the contractor. So changing of litigation resulting with additional cost to the contractor which was not redeemable.

Employer argued that contractor cannot prove changing of VAT resulted in fall of price. Also employer used a previously given Arbitration award related to exemption of VAT from diesel which was given in his favour. DAB decided price fall was a result of removing VAT from bitumen and most importantly relying on confidentiality argument and said they are not considering arbitration award because arbitration awards are confidential unless revised by the court. So DAB decided that the employer is not acting according to conditions so instructed to redeem the contractor for additional cost by paying it. Employer wasn't satisfied with this decision and issued notice of dissatisfaction and prepared to go to arbitration procedure. According to contract provisions both parties willingly and amicably settled before going to arbitration for a win-win situation.

Table 4: Ranking for Critical Factors in Case A

Factors	Total Mark	Rank
Cost	19	02
Openness, Neutrality & Fairness	15	04
Speed	13	07
Outcome	12	08
Privacy and Confidentiality	15	04
Enforceability	11	09
Preservation of Relationships	20	01
Flexibility	8	10
Creative Remedies	18	03
Degree of Control	14	06

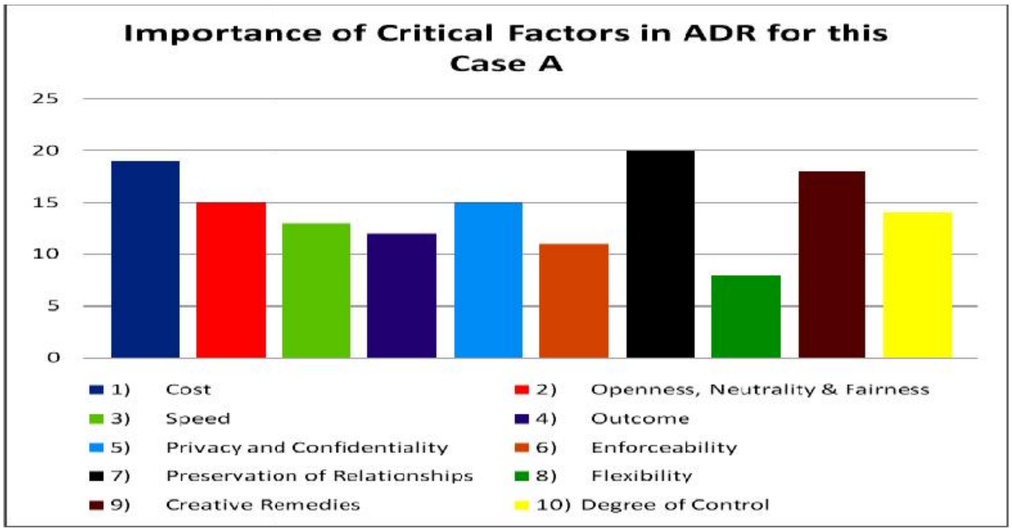

Figure 3: Ratings for Critical Factors Case A

4.5. *CASE B IN BRIEF*

Case B was occurred at a initial stage of the construction due to the difference in contention on the payment for Environmental Control and Protection which had to be carried out by the Contractor as specified in Sub section of the Specifications. The Contractor contended that the Cost of Environmental Control and Protection should be paid under Provisional Sum.

The Employer contended that Environmental Control, Protection and Monitoring were included in the scope of works in Contractor's Site Establishment and that the Contractor wasn't endued for payment for this activity under Provisional Sum. Additionally Employer thought in tendering, Provisional Sum was for any additional matters which can be popup at construction, security and maintain. But due to delays Engineer gave permission and instructions for test to be started which was recorded as unqualified approval by engineer's representative.

This dispute had effect to testing procedures and contractor withheld the second set of testing carrying out which included important details. Withheld testing was affected the critical path of the program and speedy decision was required in order to minimize risk for the work and environment. DAB decided the Contractor is entitled for payment under "Provisional Sum" for carrying out environmental control and protection required by the specifications, but confined to the scope in specifications with some adjustments done using actual cost occurred for expensive testing. This decision was somewhat creative remedy for both parties where, everyone's happily walk away with quick decision.

Table 5: Ranking for Critical Factors in Case B

Factors	Total Mark	Rank
Cost	4	10
Openness, Neutrality & Fairness	16	04
Speed	20	01
Outcome	14	06
Privacy and Confidentiality	13	07
Enforceability	16	04
Preservation of Relationships	20	01
Flexibility	10	09
Creative Remedies	19	03
Degree of Control	13	07

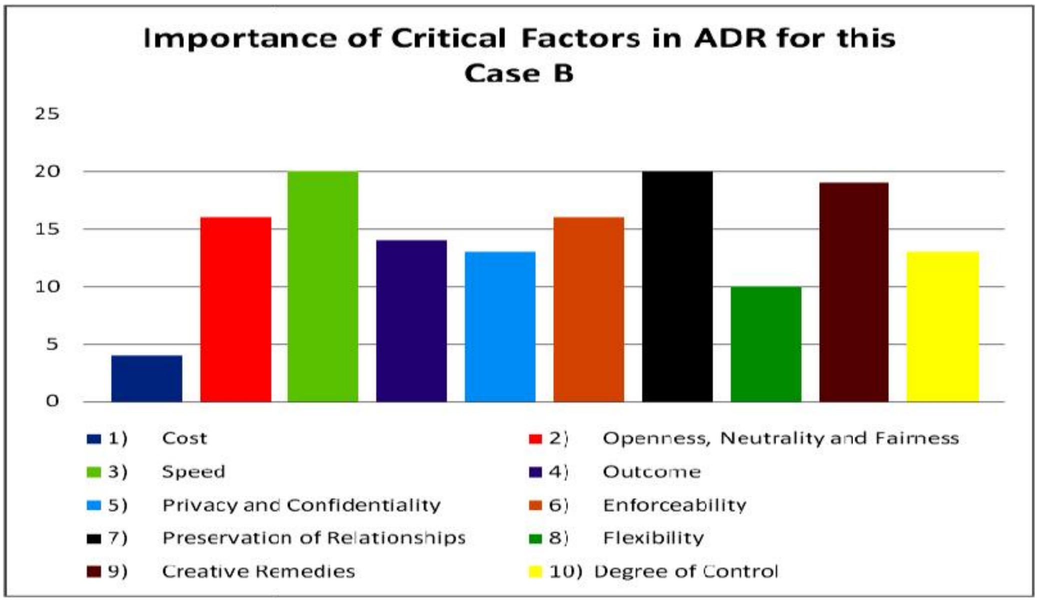

Figure 4: Ratings for Critical Factors in Case B

4.6. *CASE C IN BRIEF*

Dispute was occurred at latter stages of the construction due to contractor's belief to entitlement of additional payment and extension of time for re-design and additional works for bridge foundations due to change in ground condition. Contractor prepared the detail design based on the tender design based on such design approved by the engineer. The contractor stated that during the execution of work they encountered different site conditions at site. Due to this the contractor had to redesign the foundations. Contractor relied on to some sub clauses in condition of contract and data provide by employer, in addition, the claimant had cited "Unfair Contracts Terms Act No.26 of 1997.

The engineer stated that the contractor was responsible for the detail design prepared by them (for bridges) and also interrelation of the ground conditions since there was provisional sum for additional soil investigation. Employer relied on a document "Data provided by the Employer" and the "disclaimer" stipulated therein. So employer argued contractor cannot rely on initial document and had to prepare detail drawings with his findings from testing.

DAB decided there was sufficient time from submission of bid. In documents there was uncertainty stated in the date together with provision to carry out additional soil investigation. So experienced contractor had foreseeable physical conditions and was completely responsible for the final design of structures which specified in the contract as detailed design is an obligation of the contractor. DAB also rejected Unfair Contracts Terms Act stating about significance of an extra contractual exemption clause. DAB rejected the contractor's claims but agreed to instruct to issue two variations for some additional work carried out by contractor.

Table 6: Ranking for Critical Factors in Case C

Factors	Total Mark	Rank
Cost	8	10
Openness, Neutrality & Fairness	22	01
Speed	18	05
Outcome	17	07
Privacy and Confidentiality	19	02
Enforceability	19	02
Preservation of Relationships	19	02
Flexibility	15	08
Creative Remedies	18	05
Degree of Control	15	08

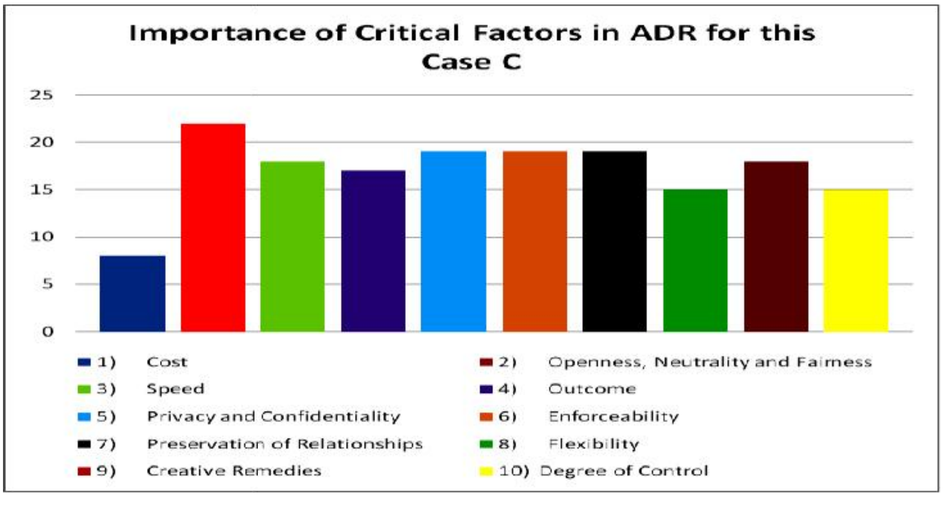

Figure 5: Ratings for Critical Factors in Case C

4.7. *WORD FREQUENCY RESULTS CONSIDERING ALL CASES*

Documents of cases were run through independent word frequency queries to get an idea about what words most frequency used. Techniques like "Stop word List" and customizing query were used to select results. Words with similar meanings and words related to similar factors added to primary value to get more accurate results. Using Excel functions list shortlisted to 10 factors and query result is shown below.

Table 7: Frequency of Critical Factors in All Documents

Word	Weighted Percentage (%)	Similar Words
Other	93.72	
Cost	2.38	cost, payments, cash, amount, sum, fee
Speed	1.41	speed, time, period, program
Creative	0.54	remedies, creative, negotiation
Control	0.47	control, degree
Relationships	0.35	relationships, connection, Preservation
Privacy	0.29	privacy , confidentiality
Outcome	0.26	outcome, satisfaction
Enforceability	0.21	enforceability, binding
Flexibility	0.20	flexibility, flexible
Fairness	0.17	fair, fairness

In above table, all ten factors obtain considerable weighted percentage. Considering these findings it's clear than in ADR methods these factors are used in ADR documents. Case study results establishes literature about 10 critical factors existence and their affect to effectiveness of ADR methods.

4.8. *FLUCTUATIONS IN RANKING OF CRITICAL FACTORS*

Considering all three cases there were many fluctuations in ranking among the factors about their criticality. Below Table 8 elaborates most eye-catching differences between cases regarding criticality

Table 8: Fluctuations in Ratings

Factor Affecting to ADR	Industry	Case A	Case B	Case C
Cost	6	2	10	10
Openness, Neutrality & Fairness	2	4	4	1
Speed	1	7	1	5
Outcome	7	8	6	7
Privacy & Confidentiality	5	4	7	2
Enforceability	9	9	4	2
Preservation of Relationships	2	1	1	2
Flexibility	10	10	9	8
Creative Remedies	4	3	3	5
Degree of Control	7	6	7	8

One thing is clear when you look at this table which is criticality ranking of the factors are changing from case to case significantly. One can not simply say this or that factor affects most to the success. So it is not fair to deal with every dispute in the same manner.

4.9. *EXAMPLE 01 - ANALYSING FLUCTUATIONS IN SPEED FACTOR*

Table reflects discrepancy in ranking for speed factor. She (2011), Gunasena (2010), etc. described speed is the most critical factor, highest rated. But cases A and C ratings show different story.

In Case A

Dispute had no direct effect to construction progress or program so it is not a critical event and it does not cause any disturbance to work or cash flow of contractor. Contractor already getting paid for fewer amount due to drop in ICTAD indices as described. Case was about additional payment due throughout the construction period and it is clear without this payment contractor can work according to contract. So speed of dispute resolution had less impact comparing to other factors.

In Case B

Speed of decision given (time taken for DAB) has much more importance because dispute was critical event and it cause disturbance to work. Contractor stopped carrying out testing procedures and some danger was there. Dispute did not affect cash flow but it stops the work so near maximum criticality was there.

In Case C

Contractor submitted claim after construction was finished and it had no direct effect to construction process ongoing at that time. As described current program did not affected much but considering financial value (120 million), contractor's cash flow and interest payment on demand, criticality of speed factor has to be more than case A but less than case B.

- Fluctuations in rating are due to impact to current program and cash-flow so criticality of factors is dependent on impact to construction program and cash-flow of the parties.

4.10. *EXAMPLE 02 - FLUCTUATIONS IN COST FACTOR*

Table reflects discrepancy in Rankings considering cost factors when comparing Cases A, B and C. Considering cases, case A obtained high rating than B and C. Accordingly claim in case A was the smallest as shown in Table 8 comparing to B and C cases. Additional cost (payments) for DAB was very high comparing to dispute (1/4 of claim amount) value. In case A, DAB paid for additional 2 hearings, meeting and daily fee for studying dispute pulse document charges which sums up near at half a million. But B and C cases cost for DAB were higher but it's percentage-wise less percentage of claim, respectively 1.41% and 0.8%. So lesser rating for B and C cases was justified comparing to Case A.

- It's safe to decide that low ratings for B and C were due to significance of dispute's monetary value when comparing to payments paid for ADR. So high ranking for A was due to less dispute value. Criticalities of factors are depending on disputes monetary value (claim amount).

4.11. *KEY ATTRIBUTES IMPACTED TO CRITICAL FACTORS*

As emerged from this Case study criticality of factors depend on some very key attributes related to each Case. Each case is Unique in Nature. According to these key attributes ranking for critical factors are changing from case to case significantly. Using findings from cross case analysis above, key attributes can be identified as below.

- Dispute's monetary value - amount of dispute / claim
- Construction Program - as build program to identify affect to critical path
- Cash-flow of the parties - disputes resulting cash block down
- project duration - long term or short term (time left for Completion)
- Importance of parties to each other - authority and future opportunities
- Availability of grounded arguments - validity entitlement to both parties

- Speedy solution requirement - parties requirement to get decision quickly
- Nature of Client - government, semi government or private, etc.

But some factors had no effect from these attributes. As an example Openness, Neutrality and Fairness factor which will not change its criticality across the cases. Fairness has to be there for every case similarly, without being affected by anything.

There are interconnections between ten critical factors affecting to the effectiveness of ADR methods. Changes in one factor rating can be affected to others positively or negatively. Person cannot isolate one factor and describe how critical it can be for final outcome. We have to consider all these factors and attributes as a whole and then it will give a crystal clear image why that factor got a higher ranking and why ADR methods are successful for particular case.

4.12. SUMMARY OF FINDINGS

Above findings leads to the conclusion that critical factors identified in literature review are affects to the effectiveness of ADR methods. But one cannot put a finger on speed, cost and say that factor has highest impact for success. Criticalities of the factors change from case to case significantly according to the attributes of the cases. So it is not fair to deal with every dispute in the same manner.

As emerged from this study criticality of factors are dependent on dispute's monetary value, construction program, cash-flow of the parties, nature of the project, importance of parties to each other, availability of grounded arguments and speedy solution requirement. Also analysis found that, critical factors are interconnected and can be affected to each other either positively or negatively. Participants stated that low value disputes had issue when going for contractual DAB methods regarding cost factor. So, they tend to be negotiated or neglect those disputes rather than complaining to DAB.

4.13. PROPOSED IMPLICATION TO THE HIGHWAY PROJECTS

The study showed that critical factors identified in literature were affecting to effectiveness of ADR methods. Criticalities of the factors are changing from case to case significantly according to attributes of the cases. So it is not fair to deal with every dispute in a same manner. But in whole construction industry including highway projects disputes are dealt with same manner. The study disclosed that some key attributes impacted to critical factors effectiveness. So according to those attributes, applicable ADR methods have to be varying to counter fluctuations described above. Considering findings of this study as the base, the below mechanisms are suggested as recommendations to improve effectiveness of ADR methods and this implication is directly applied to highway sector

- Divide disputes into ranges according to impact it causes to program and considering dispute's monetary value.

Considering effect to critical factors from two key attributes, namely monetary value and construction program, ADR methods have to be changed. Parties need quick and binding result in critical path event and cost is less significant considering high value dispute. First establish ranges in these two elements and calculate where the dispute stands in predetermined ranges. Each range has different ADR methods.

Table 9: ADR Methods for Different Ranges

Criticality	Dispute Amount	ADR method Suitable
Yes	High	DAB → Arbitration
Yes	Less	DAB → Arbitration
No	High	DAB → Arbitration
No	Less	Mediation ⟶ *Ad-Hoc* Adjudication

Example - Didnot go to DAB for less than a million, non-critical disputes

- Include Mediation ADR method to contract document for used only for low monetary value non critical path disputes. If Mediation fails to arrive at agreement, sole ad-hoc adjudication will commence rather than contractual DAB or Arbitration considering high cost.

Main recommendation in this study is a guideline for using Alternative Dispute Resolution Methods in Highway Construction shows using "Flow Chart" method. Guideline recommended for Expressway and Highway construction projects but can be successfully implemented in other areas too.

Proposed Guideline for using Alternative Dispute Resolution Methods in Highway Construction - Flow Chart

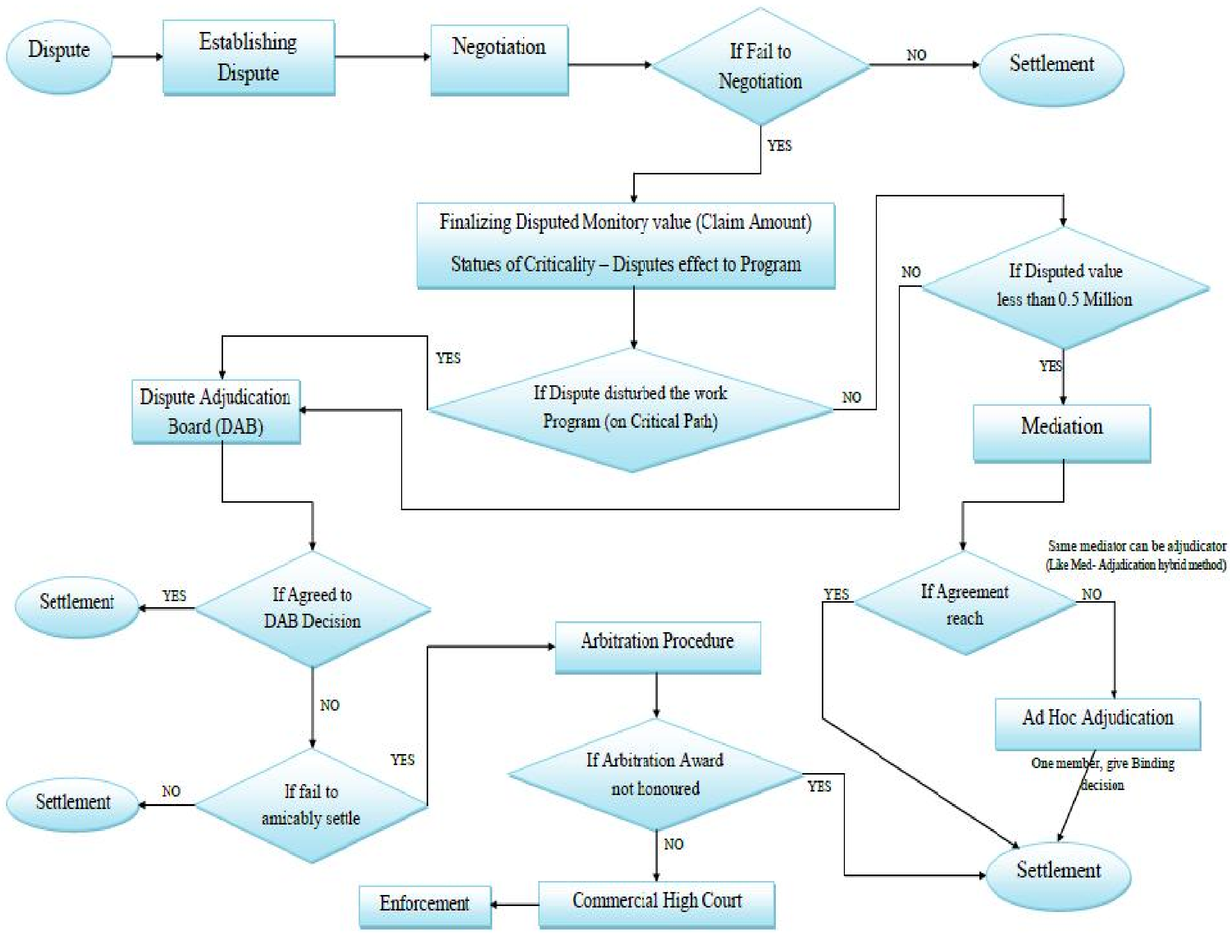

Figure 6: Proposed Guideline for using ADR Methods in Highway Construction

5. SUMMARY

This document indicates a new way of dealing disputes according to scenarios rather than following Contractual ADR procedures indicated in contract documents like FIDIC. It is not fair to deal with every dispute in a same manner because Criticalities of the factors are changing from case to case significantly according to attributes of the cases. So, best suited ADR method has to be determining after considering effect from key attributes to dispute.

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EMERGING COMPETENCIES WITHIN NATIONAL AND LOCAL GOVERNMENT FOR SOCIETAL RESILIENCE TO DISASTERS IN SRI LANKA

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ABSTRACT

Emerging competencies for societal resilience to disaster within the built environment domain of Sri Lanka were analysed in the aim of developing a professional doctoral (DProf) course through the CADRE (EU-FP7) project. Competencies were compiled following the amalgamation of both emerging market needs and skills within the built environment domain of Sri Lanka. In its investigation, qualitative and quantitative data collection was facilitated through a literature review. Data collection was conducted in respective to all stages of the construction cycle (i.e. Preparation, Design, Pre-construction, Construction, Use). The analysis was conducted using resilience themes for five thematic areas (i.e. social, technological, environmental, economic and institutional) in relation to each stage of the construction cycle.

Despite local and national government bodies affecting a central role in policy, planning and implementation of land use changes and construction, built environment professionals with specialised expertise was minimal. Parallels were drawn regarding the gaps within the private sector and local and national government, such as a critical need for skills development programmes to ensure a viable skilled labour force and job security. Finally, it is critical for national and local government to enforce existing certification systems and standards for skilled workers to ensure a safe, viable and competitive construction industry.

Keywords: *Professional Doctorate; Disaster Resilience; Built Environment.*

1. INTRODUCTION

Emerging competencies for societal resilience to disasters were explored, with a focus on the key stakeholder constituents national and local government in Sri Lanka. The compilation of competencies followed the amalgamation of emerging market needs and skills within the built environment for societal resilience to disasters. The literature review was explored through all thematic areas of Resilience I.e. Social, Technological, Environmental, Economic and Institutional. The aim of this paper is to provide guidance for the key stakeholders national and local government to facilitate built environment professionals in their continuing professional development through a professional doctorate (DProf) programme facilitated by the CADRE (EU-FP7) project. The knowledge exchange and training within all thematic areas of Resilience would ensure a holistic, multidisciplinary approach to disaster resilience construction, urban planning and other such activities to provide societal resilience to disasters.

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2. METHOD

The literature review was supplemented by qualitative, primary data collection of in-person interviews for each stakeholder group.

Altogether, 10 interviews were conducted with respondents from local and national government institutions. This includes 05 interviews with respondents from national level government organisations directly involved in disaster resilience in Built Environment (including 02 Divisional Secretariats) and 05 interviews with respondents from local government bodies (including both Pradeshiya Sabhas and local municipal councils). All of these local government bodies were selected from areas in the country that have been identified as being prone to disaster risks.

All of the respondents indicated that they play some role in all three phases (i.e. disaster mitigation/preparedness, relief/ response, recovery/ reconstruction) of the disaster management

3. THE CONTRIBUTION OF THEMATIC AREAS OF RESILIENCE TO SOCIETAL RESILIENCE

Oxfam (2005 cited Maguire and Hagan, 2007) states that in order to 'truly understand the social impacts of disasters, and to manage and prevent adverse consequences, we must understand the impacts of disasters on particular groups within communities'. Accordingly, developing a proper mechanism 'to identify the potential fracture points or social cleavages within a community' and the impacts of disasters on these groups is useful to facilitate the prediction of future breakdowns in social resilience in disasters, and to design preventative initiatives (Maguire and Hagan, 2007).

There is also no systematic means for obtaining valid and timely information that is required to address the myriad of human recovery needs before, during, or after a disaster (Acosta *et al.*, 2011). This is a key issue as in order to achieve significant improvements in social resilience all stages of a disaster cycle need to be considered in emergency management planning (Maguire and Hagan, 2007).

Carrying out 'vulnerability mapping', including local level assessment of structures, occupations, living patterns, cultural practices, etc., (National Disaster Management Authority, 2010) could act as a useful tool in allowing these human needs to be addressed, thereby increasing social resilience.

Differences in communities in terms of their socio-economic status, their degree of geographic isolation, or vulnerability to psychological trauma mean that different groups within the one society can be more or less resilient to a disaster (Maguire and Hagan, 2007). Vulnerable social groups, such as the elderly, children, or the economically disadvantaged, may be particularly susceptible to impacts of disasters as they have fewer resources available to cope. Hence, it is important to ensure that the needs of these vulnerable groups are addressed in designs during design approval.

As described, engaging local contractors and suppliers are an important means of restoring social resilience. The government could facilitate this by stating a preference to local contractors and suppliers during tender processes.

Promoting 'community-driven and locally managed processes' during construction can promote local decision making and ownership (FEMA, 2011).

It is understood that governments cannot prevent all disasters from occurring, or alternatively, 'shield people from all their consequences' (Osterholm, 2005 cited Maguire and Hagan, 2007). Hence, the priority of government should be on strengthening the resilience of communities and addressing this through research, policy and program development, as well as in crisis management and education initiatives (Maguire and Hagan, 2007).

Local governments also lead the community in preparing hazard mitigation and recovery plans, raising hazard awareness and educating the public of available tools and resources to enhance future resilience (FEMA, 2011).

Promoting food security is also an important aspect that can ensure the resilience of communities to hazards as disasters such as droughts, floods and cyclones can disrupt agriculture-based livelihoods (UNISDR, 2005).

Conducting multi-hazard mapping, including development of hazard maps at community levels and collating them for district and national levels, using technologies such as GIS-based community information systems (National Disaster Management Authority, 2010), can provide an accurate source of information on the resilient requirements to be addressed during design and construction phases. Such an activity could be complimented with ‘capacity mapping’, which would involve identifying capacities (including those of NGOs) from community level upwards.

It is also necessary to review and change the building regulations and codes so that they can be used to more efficiently facilitate improving the structural integrity of buildings and infrastructure (Mannakkara and Wilkinson, 2013).

The inadequate structural capacity of the Built Environment has been highlighted as a primary reason for extensive damage from natural disasters (Mannakkara and Wilkinson, 2013). The government has a key role to play in balancing the use of the land and ensuring that structures are designed and built taking into account the disaster risks for that local area through the proper implementation of Land use planning and building regulations. The majority of mitigation measures are adopted, codified and enforced at the local level. While there are national standards, it is often up to the local governments to adopt and enforce these (FEMA, 2011).

Non-structural mitigation is also a significant aspect of building safety, and can result in avoiding a large percentage of losses and casualties. This may include, inter alia, avoidance of heavy and hazardous building content, avoidance of storing or using hazardous materials in buildings, and avoidance of material with the potential of falling, dislodging, flying or floating that can cause injury and damage (National Disaster Management Authority, 2010).

Care should be taken not to let the obvious time pressures in the recovery process and expectations for fast results to result in hasty design and construction without due regard for building codes and resilience (Mannakkara and Wilkinson, 2013; Bosher and Dainty, 2011).

Special training needs to be provided to service providers, including Built Environment professionals, construction workers, local emergency response agencies and support volunteers on addressing technological resilience.

Having a database of skilled builders who are willing to participate in post-disaster reconstruction during the pre-disaster phase would also assist in guaranteeing construction quality (Mannakkara and Wilkinson, 2013) and in turn technological resilience.

Hence, the importance of regulative authorities conducting periodic inspections to ensure that constructions are being done according to the specified guidelines has been stressed (Mannakkara and Wilkinson, 2013). Without this, it is difficult to ensure proper implementation of building regulations increasing the technological resilience of structures.

Promoting the retrofitting and maintenance of Built Environment in ways which will reduce vulnerability to future disaster impacts (FEMA, 2011). It is particularly important that governments address this in relation to critical public facilities and physical infrastructures such as schools, clinics, hospitals, water and power plants, communications and transport lifelines, disaster warning and management centres, and culturally important lands and structures (UNISDR, 2005). The vulnerability of the existing Built Environment should be continuously assessed throughout the use stage (Witt *et al.*, 2014).

At the same time, ensuring the future safety of new houses and public buildings will require research, documentation and communication of appropriate materials and technologies for disaster-resistant construction.

Proper land use planning at national and local government levels is central to increasing environmental resilience. In Australia, land use planning and building codes (developed by taking hazard risks into account), have been identified as the ‘single most important mitigation measure in preventing future emergency losses’ in new developments (National Emergency Management Committee - Land Use Planning and Building Codes Task Force, 2012). Land use planning of the Built Environment, as noted by the National Emergency Management Committee - Land Use Planning and Building Codes Task Force (2012), is a ‘complex process that must consider the various interests of multiple stakeholders with respect to physical, social, environmental and economic constraints'. The planners and other involved professionals should be equipped with the necessary competencies for collecting and analysing large amounts of data in order to produce robust strategic plans and to competently assess development applications (National Emergency Management Committee - Land Use Planning and Building Codes Task Force, 2012).

The government has a key role to play in influencing land use planning, building codes and property resilience ratings through legislative and policy changes to increase the resilience of a nation's Built Environment.

As FEMA (2011) notes resilience, sustainability and mitigation need to be incorporated as part of the design for infrastructure systems and as part of the community's capital planning processes (FEMA, 2011). According to Mannakkara and Wilkinson (2013), the damage from the 2004 Indian Ocean Tsunami could be partly attributed to the lack of consideration of coastal risks in the design of structures.

Mannakkara and Wilkinson (2013) further suggest the introduction of monetary incentives to promote the adoption of risk reduction strategies, thereby encouraging the use of hazard resilient designs, materials and specifications.

Various indicators aimed at increasing environmental resilience can be incorporated into the tendering process as contractor/ supplier selection criteria. Use of Green Public Procurement (GPP) criteria, such as the criteria for construction projects developed by the European Commission, could also facilitate addressing environment resilience related issues during reconstruction (SCI-Network, 2007).

Schemes for providing training to building practitioners; conducting inspections; and not compromising quality for speed are some of the key areas highlighted in relation to increasing technological resilience during construct stage. National Disaster Management Authority (2010) emphasises that special skill training on disaster resistant technologies should be provided to construction workers.

Technological resilience during this stage could be adversely affected by poor regulative powers and the lack of strict enforcement building regulations/ codes leading to sub-standard structures. For example, Mannakkara and Wilkinson (2013) observe that during the time the Indian Ocean Tsunami struck, enforcement of building codes was mainly restricted to urban and suburban areas in Sri Lanka resulting in magnified damages to rural and coastal areas, where strict structural standards were lacking.

National and local government bodies need to carry out regular supervisions to ensure that the principles of sustainable and disaster-resistant communities have been adhered to throughout the construction phase through the protection of natural resources such as coastal barriers and zones, floodplains, wetlands and other natural resources critical to risk reduction (FEMA, 2011).

Awareness of end-users of Built Environment facilities, including house owners, families, students, teachers, decision makers, etc., on disaster resilience, should be increased prompting them to take local action to reduce risk (National Disaster Management Authority, 2010).

Although costs vary across nations and within regions in a single nation a number of authors have highlighted the need to a national standard for estimating recovery costs. Acosta et al. (2011) note that the lack of guidance on procedures for estimating the costs of recovery has led to inconsistent estimates being prepared which threaten the credibility of reimbursement of costs. They go on to highlight developing such a standard could benefit national and local governments, by providing them with a more accurate figure on associated costs, as well as NGOs, by ensuring that their appeals to donors are consistent and appropriate.

Extra costs incurred by adopting new technologies and materials to improve structural resilience have been noted to discourage compliance with new building codes (Mannakkara and Wilkinson, 2013). As mentioned, introducing monetary and other types of incentives for construction stakeholders to incorporate disaster resilience could be addressed.

Where the upfront budget for construction work is restricted, it is useful to promote the setting of minimum standards together with higher aspirational targets in relation to incorporating disaster resilience (SCI-Network, 2007).

During pre-construction areas of potential financial challenges need to be identified (FEMA, 2011). In instances, where these costs can go beyond the capabilities of local governments, necessary funding should be arranged from the national government and/or other sources (e.g. NGOs) (IFAS, 1998). Focus should also be given to promoting financial risk-sharing mechanisms (e.g. Insuring against disasters) as well as developing and promoting alternative and innovative financial instruments for addressing disaster risk (UNISDR, 2005).

Mannakkara and Wilkinson (2013) further suggest the following strategies that governments can undertake to help increase economic resilience: i.e. taking the responsibility for funding the extra cost required for improvements not covered by insurance; restricting construction on high-risk lands requiring improvements which are too costly and time-consuming; introduction of “Buy-back” or “Land-swap” schemes for those lands on which construction costs cannot be covered by insurance or government funding (here the high-risk lands are either bought by the government, or exchanged, allowing occupants to settle into lower risk lands).

Promotion of indigenous technologies during construction with appropriate adaptation and promotion of local materials and skills, and low-tech, low-cost technologies is important in increasing economic resilience (National Disaster Management Authority, 2010).

Promoting diversified income options for populations in high-risk areas is important to reduce the vulnerability of these community groups to hazards. Care should also be taken to ensure that their income and assets are not undermined by development policy and processes increasing their vulnerability to disasters (UNISDR, 2005).

Ensuring that disaster risk reduction is a national and a local priority is necessary to provide the strong institutional basis needed for addressing disaster resilience (UNISDR, 2005). The 2009-2011 mid-term review of progress against the Hyogo Framework for Action has highlighted weak capacity in many local governments, which in turn affects their ability to accurately account for disaster risk in investment and development decisions (Hall *et al.,* 2013). Competencies should be developed particularly in relation to identifying hazards and assessing risks and vulnerabilities (FEMA, 2011).

National platforms should also facilitate coordination across sectors, including by maintaining a broad-based dialogue at national and regional levels for promoting awareness among the relevant sectors (UNISDR, 2005). At national government level, steps should also be taken to avoid duplications of effort, lack of alignment between systems and legislation, lack of common standards, lack of clarity about various roles and responsibilities of different agencies involved as well as lack of leadership, teamwork, political will and commitment (National Emergency Management Committee - Land Use Planning and Building Codes Task Force, 2012; Malalgoda *et al.,* 2014). Herein, UNISDR (2005) suggests the importance of ‘national integrated disaster risk reduction mechanisms’, such as multi-sectoral national platforms that lay out the responsibilities at the national through to the local levels to facilitate coordination across sectors. This is also important to overcome the complexities and long durations taken to resolve issues due to the involvement of the large number of organisations (Malalgoda *et al.,* 2013).

At the same time, Hall *et al.,* (2013) maintain that a clear demarcation of responsibilities is needed at national, provincial and local government levels, whilst establishing strong linkages between local and national government levels with national policies being aligned with local needs. The latter is important since some researchers have found that certain information at the national level was misinterpreted at the local level (Karunasena and Rameezdeen, 2010).

Flexibility (for example in staffing and management structures) is needed at organisations at all levels of government to facilitate the application of laws, regulations and policies in the context of disasters, so that the government’s adaptability to govern in unforeseen incidents is enhanced (FEMA, 2011).

Malalgoda et al. (2014) highlight that amending policies so as to provide municipal councils with more authority and power to engage in resilience building. The authors go on to stress the importance of ‘raising awareness of council officials on disaster risks and resilient practices’, engaging council officers in national level decision processes that affect their local areas and establishing proper communication channels to exchange decisions and information related to resilience. The national government should also ensure that the necessary resources to address disaster risk reduction are allocated to the local governments (Hall *et al.,* 2013).

It is also important to develop and strengthen partnerships with other stakeholders such as universities, professional associations, the private sector and NGOs to facilitate recovery capacity-building activities and expansion of resources available for planning and decision making (FEMA, 2011).

A strong legal framework and consistent regulations are needed to ensure the enforcement of building codes and regulations aimed at increasing building resilience. Witt *et al.* (2014) stress that 'regular review (and tightening) of urban planning policies and building codes and the continual re-assessment of design guidance and the vulnerability of existing assets' are necessary to ensure Built Environment resilience in the increasingly hazard prone and dynamic future.

Functional and effective intergovernmental relations (FEMA, 2011) are necessary at this stage to influence the efficiency pre-construction stage activities. Transparency in the tender process is also important to minimise corruption or wrongdoing.

Public–Private Partnerships can be promoted to better engage the private sector in resilient construction activities (UNISDR, 2005).

As discussed, greater emphasis needs to be placed on establishing and implementing monitoring and accountability instruments to ensure enforcement of available laws and regulations.

Capturing after-action recommendations and lessons learned during this stage can help all government levels to evolve, adapt and develop new skills and capacities to address the changing landscapes (FEMA, 2011). UNISDR (2005) also highlight that this phase should be used to 'develop capacities that reduce disaster risk in the long term, including through the sharing of expertise, knowledge and lessons learned'.

4. DISCUSSION

National and local government have a crucial role in the process of planning, designing and approval of housing and infrastructure making a significant contribution to making the Built Environment more resilient. In this respect, it holds a central position in all three phases (i.e. disaster mitigation/ preparedness, relief/ response, recovery/ reconstruction) of the disaster cycle.

The literature review highlighted that Government has a key role to play in developing hazard maps, carrying out risk assessments and influencing land use planning, building codes and property resilience ratings through legislative and policy changes to increase the resilience of a nation's Built Environment. However, to accurately account for disaster risk in investment and development decisions competencies need to be developed particularly in relation to identifying hazards and assessing risks and vulnerabilities.

The research found that at present the national and local governments lacked the resources (in terms of technical assistance, finance, equipment and human resources) needed to identify high-risk zones, buildings and other structures, assess risks and carry out resilient designs.

Most of the activities such as identifying risk locations, conducting awareness programmes, preparing construction estimates, overseeing construction process to ensure compliance with guidelines, etc. were mainly carried out by Technical Officers (TOs). The involvement of Built Environment professionals in these activities was not at a satisfactory level. Respondents highlighted that whilst there was only a limited number of TOs available to carry out all these activities, their knowledge and skill level was also not up to the standard that may be expected from Built Environment professionals with specific expertise in these areas. More training and education for current employees was highlighted by national and local government respondents as a vital need to close this competency gap. Not being able to match the lucrative wages offered by the private sector to Built Environment professionals was seen as one of the main impediments to retaining them as permanent staff and hence, most of the government departments resort to retaining them on contract on an 'as-needed' basis. Some of the respondents also highlighted that Built Environment professionals showed a lack of awareness of local contexts (e.g. local climate, lifestyles, geographical location, etc.) and did not give proper attention to selecting materials suitable to a specific location and climate and identifying the needs of local communities.

Being a developing country, there was also consensus that the funds allocated to disaster management were insufficient compared to the associated expenses. The use of public-private partnerships is one suggestion highlighted in literature to engage the private sector in sharing some of these costs. Political interferences from higher levels was also an issue in allocating the available funds.

In relation to reconstruction, national and local government respondents noted that they were involved in all stages of the property life-cycle except the physical construction stage. Requiring TO's report and NBRO recommendations in granting permission for construction projects, site visits by TOs during construction to ensure compliance to aforementioned, providing guidance on resilient designs, conducting awareness programmes, providing funds for rebuilding under the supervision of TOs and conducting risk assessments are some of the actions carried out by national and local government bodies in order to facilitate Built Environment resilience. Respondents also highlighted that more attention should be given to ensuring construction quality, with a professional institute with relevant expertise in the field assessing each construction.

Funds provided for victims not being sufficient to address resilience in design and construction, lack of knowledge on the concept of disaster resilience, lack of technical advisors, not using sufficient risk reduction methods in planning and design of disaster reconstruction were some of the challenges government bodies have experienced in practically implementing disaster resilience. For instance, some of the respondents noted that despite NBRO recommendations being needed to provide building approval, some of the recommendations given by them could not be practically addressed within the budgets available to owners. Respondents also noted that better coordination with private sector institutes could be used to overcome some of the resource requirements.

5. CONCLUSION

Local and national governments have a key role to play in developing hazard maps, carrying out risk assessments and influencing land use planning, building codes and property resilience ratings through legislative and policy changes to increase the resilience of a nation's Built Environment.

The involvement of Built Environment professionals in these activities was minimal with most of the activities such as identifying risk locations, conducting awareness programmes, preparing construction estimates, overseeing construction process to ensure compliance with guidelines, etc. being carried out by Technical Officers (TOs).

More education and awareness should be given to Built Environment professionals, on considering local contexts (e.g. local climate, lifestyles, geographical location, etc.) in designs, selecting materials suitable to a specific location and climate, and identifying the needs of local communities.

Enforcement laws and regulations should be strengthened. At the same time, laws should be revised and updated to meet the present demands in relation to resilience.

There is lack of funds available for disaster management as well as lack of transparency in allocating funds to victims

Funds provided for victims not being sufficient to address resilience in design and construction, lack of knowledge on the concept of disaster resilience, lack of technical advisors, not using sufficient risk reduction methods in planning and design of disaster reconstruction were some of the challenges government bodies have experienced in practically implementing disaster resilience.

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ENERGY FROM WASTE: A SOLUTION FOR THE GARBAGE CRISIS AT MEETHOTAMULLA, KOLONNAWA, SRI LANKA

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ABSTRACT

Municipal Solid Waste (MSW) generation and management is a continually growing problem at global level, and is becoming more complicated day by day. Sri Lanka as a developing country also confronts the issue of increasing solid waste. Its major conventional solid waste management practice of open dumping is being challenged at present due to its negative impacts on environment and public health. Therefore, there is a necessity to look at this problem from a new perspective. Being identified the Energy from Waste (EfW) technologies as one of the best solutions to solve MSW problem, this paper aims at assessing the viability of setting up an EfW facility to get rid of Meethotamulla, Kolonnawa Garbage Mountain which has become a pressing issue today. The data gathered from secondary sources such as government publications, journal articles, newspaper articles, and other published reports intensifies this analysis. Based on the analysis, it is identified that mass combustion is the best possible technology to treat about 1300 tons of waste per day in order to make the Meethotamulla garbage site hazard free zone by 2040 and to generate 14MW of electricity per day as a by-product of waste combustion. And eventually, the PESTE analysis identifies the opportunities and threats that can be affected when implementing such a capital intensive facility.

Keywords: *Energy from Waste; Municipal Solid Waste; Meethotamulla Garbage Dump; Sri Lanka.*

1. INTRODUCTION

Current global Municipal Solid Waste (MSW) generation rates are expected to be increased steadily, challenging the environmental and public health management at global level. A recent estimation done by the World Bank (2012) reveals that world cities generate about 1.3 billion tonnes of solid waste per year at present, and estimates that this volume will be increased to 2.2 billion tonnes by 2025. The main causes to accelerate the generation rate of MSW are made known as increase of population, changes in life styles, rapid economic growth and rapid urbanization (Minghua *et al.*, 2009 cited in a Guerrero, Maas and Hogland, 2013).

Waste generation is unavoidable. The main issue associated with MSW in low-middle income countries, is inefficient collection and disposal which contributes to natural disasters such as flooding, erosion, air and water pollution and public health issues (The World Bank, 2012). Therefore, most of the countries have now begun to search for long term solutions to dispose of their solid waste in a proper and safe manner. With that, the interest for the concept of recovering Energy from Waste (EfW) has increased all over the world as a long term solution for waste management. In this concept, the waste is considered no more a waste but, as a renewable energy source (Rogoff and Screve, 2011).

Sri Lanka as a middle income country also confronts the issue of managing the increasing solid waste. The most common method of disposing waste still remains as open dumping (Bandara, 2011). Though it is a pressing issue impacted on the environment and public health, particularly in the most urbanized areas such as Colombo, Dehiwala-Mt Lavinia and Kandy, more than 95% of final waste are disposed in open dumps.

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When taking all districts of Sri Lanka into consideration, this is most grave in Colombo district where about 1500 tons of solid waste are collected and disposed in open dumps per day (Bandara, 2011 and Perera, 2003). Almost all these dumpsites are located in environmentally sensitive areas and in the vicinity of residential, commercial or institutional establishments. None of them have designed to minimize or control pollutants released from the decomposition of waste. Therefore, the high moisture content in the MSW have led to excessive leachate generation and produce methane about 72kg/t, causing numerous problems to the environment and public (Gunawardana *et al.* 2009 and Basnayake *et al*. ,2007). Further, exposing these dump sites to waste scavengers and insects such as mosquitoes, flies, etc., the surrounding residents face many health related issues, nuisance, air and water pollution (Gunawardana *et al.* 2009).

Though this issue has been curtailed to some extent by means of land filling, anaerobic digestion, composting and 3R concept, still the most common method of solid waste management remains to be open dumped in a more or less uncontrolled manner (Basnayake and Visvanathan, 2013 and Bandara, 2011). Therefore, the existing disposal sites in Colombo area have now become unmanageable with increased quantities of collected waste at present (Basnayake and Visvanathan, 2013).

Among approximately 58 garbage dumping sites in Colombo area, it was evidently identified that an immediate solution needs to be taken to treat Meethotamulla Garbage Mountain as it is almost filled to its capacity and more complains on various health hazards and frequent disasters such as flooding and explosions are being received by Kolonnawa Urban Council. It has turned out to be a common sight nowadays to see frequent protests organised by Kolonnawa general public against this dumping site. In view of that, this paper intends to identify the viability of implementing an EfW facility as a long term solution for waste management.

Accordingly, a desk study is presented in this paper. The data gathered from books, reports, paper articles, journal articles and other published documents on waste management in Sri Lanka as well as global and EfW technologies synthesises in order to identify the existing condition of the Meethotamulla garbage dump site, quantify the existing waste and the waste anticipated to be dumped at Meethotamulla garbage dump site, select an appropriate EfW technology and estimate the plant. Finally, the PESTE analysis identifies the external environmental impacts on implementing an EfW facility to treat this garbage dump.

2. FEASIBILITY STUDY

2.1. INTRODUCTION TO MEETHOTAMULA GARBAGE DUMP SITE

Figure 1: Meethotamulla Garbage Dump Site
Source: http://www.sundaytimes.lk/140706/news/authorities-promises-stink-as-much-as-garbage-mountain-105967.html

The Meethotamulla garbage dump site is located in Dahampura Grama Niladhari Division of Kolonnawa Divisional Secretariat Division in Colombo District of Western Province. The geological co-ordinates are: 6 0 56/ 6.4// N and 790 53/ 13.9//E. This has been existence for over 20 years and as shown in Figure 1, it spreads over 18-acre where 4700 families in eight villages live clustered around it. In addition to the residential places, three schools and few religious places are situated around it.

More than 50% of waste generated around Colombo and its suburbs are dumped by nearly 200 lorries in this site daily (Karunarathne, 2015). Though its capacity has almost exceeded, still the garbage is dumped there due to the lack of land filling sites. As a result, the residents of the surrounding area has become the worst victims of various environmental and health hazards. Residents have launched number of protests to draw the attention of relevant authorities to find a long term solution for the issues created by this garbage dumpsite.

Despite promises, none of the authorities have taken any action over the years to remove garbage from this site (Karunarathne, 2015). An interview conducted by Karunarathne (2015) with surrounding residents of this site reveals the following dreadful issues for which they seek immediate solutions.

- Haphazard dumping without a proper segregation process
- Unbearable stench which now has become part of their lives
- Breathing toxic air emitted from the waste
- Cracked houses as a result of the weight of the disposal and gas emissions from the rotting refuse
- Uncontrolled surface emissions of LFG into the air which contains carbon dioxide, methane, volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and odorous compounds that can adversely affect public health and the environment
- Crows and other birds flying around the garbage dump seeking food
- No clean water due to the contamination of ground water with waste leachates
- Most of the houses close to the canal often get flooded even after a brief shower
- 60% children in this area suffer from skin related diseases, respiratory problems and viral diseases
- The area is a breeding spot for rats, crows, cockroaches and other types of insects and reptiles

2.2. ANALYSIS OF WASTE STREAM

The initial sizing of an EfW plant is mainly depend on the volume of waste, its composition and energy content. Therefore, the main objective of this waste stream analysis is to estimate both the volume and composition of MSW that is currently being disposed and expected to be disposed in Meethotamulla garbage dump site in future.

It is to note that this analysis was carried out based on the data gathered through secondary researches due to the absence of a proper record keeping system on waste disposal.

2.2.1. QUANTIFYING THE WASTE VOLUME

As it is identified in section 2.1, the age of the dump site is about 22 years for 2015, dump area is about 18 acres and height of the mountain is about 250 feet. Accordingly, it is estimated that the existing waste volume of this site is averagely 4,900,500 tonnes.

With the population growth in urban areas, Basnayake and Visvanathan (2013) estimates that the annual growth rate of waste generation in Sri Lanka as 1.2%. Further, the same authors reveal that about half (750 tonnes out of 1500 tonnes) of municipal waste generated from Colombo area are disposed in Meethotamulla garbage dump site daily. Based on this information, the expected waste quantity to be dumped at this site for next 25 years was calculated and is shown as in Figure 2.

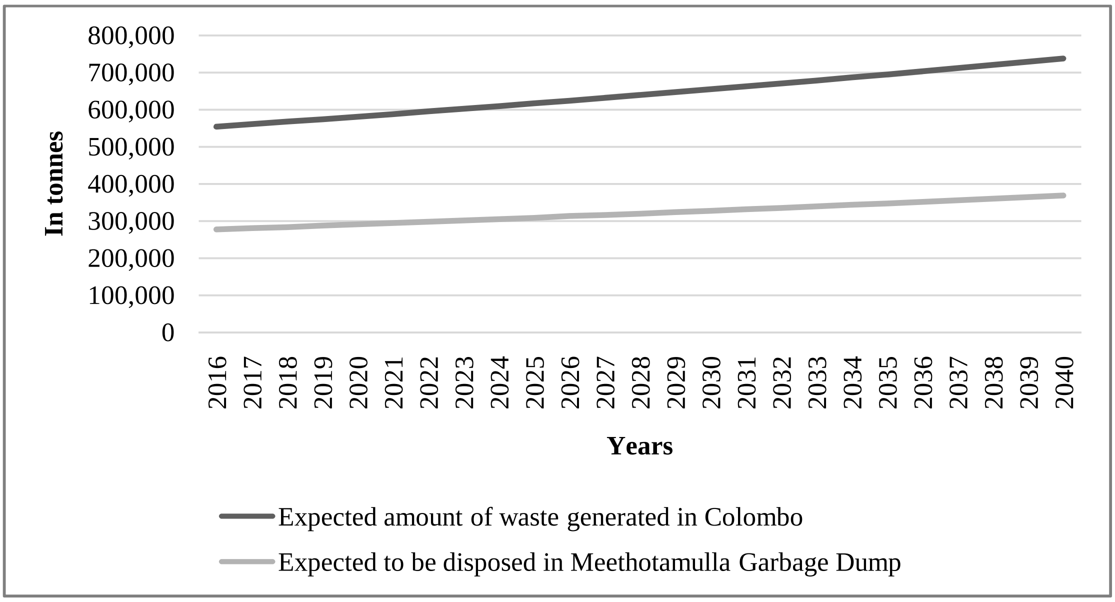

Figure 2: Expected Amount of Waste to be Generated in Colombo Area and Disposed in Meethoatmulla Garbage Dump

2.2.2. QUANTIFYING THE WASTE VOLUME

A study done by Waste Management Authority - Western Province in 2010 provides a detail analysis of composition of waste generated from Colombo municipal area. According to that, 75% of total waste is biodegradable while other 25% distributes among plastic, rubber, glass, metal, e-waste and clinical waste.

The average moisture content of the MSW has been revealed as 40-45% (Waste Management Authority-Western Province, 2010) and as a result, Asian Productivity Organisation (2007) mentions that the calorific value is between 600 kcal/kg and 1200 kcal/kg in this waste. Therefore, it is considered 900kcal/kg as the average calorific value of the waste dispose in Meethotamulla garbage dump.

2.3. SELECTION OF APPROPRIATE EFW TECHNOLOGY

Reduction of the existing volume of waste mounted in Meethotamulla and simultaneously discontinuing dumping in this site mainly depends on the selection of an appropriate EfW technology. Accordingly, Table 1 summarises the results of the extensive analysis carried out in order to select the appropriate EfW technology for this particular case. Eventually it is selected “mass burning” over other EfW technologies as the most appropriate technology.

Table 1: Justifying the Selected Technology

Technology	Justification
Anaerobic Digestion Anaerobic digestion allows microorganisms to work on the feedstock available in a low temperature plant in order to recover carbon dioxide and methane that can be combusted to generate electricity, heat or bio fuel (Renewable Energy Association, 2011)	This technology is best suited for the treatment of wet organic waste such as, food waste, high moisture agricultural biomass and animal wastes including manure and domestic sewage (Renewable Energy Association, 2011). Therefore, it cannot be used as a MSW treatment method as it leaves all other waste materials except wet organic components which still requires disposal. Further, the waste dump in this particular site are not segregated, it may require additional strategies and resources to get sorted only the wet organics.

<table>
<tr>
<td>Gasification and Pyrolysis

The waste transforms into energy without burning. Instead, the waste is heated to produce “syngas” which can be used to recover energy as steam, heat, electricity or bio fuel by creating a chemical reaction (Gasification Technologies Council, 2013).</td>
<td colspan="2">Gasification and pyrolysis are suitable for substantial reduction in the total quantity of MSW after an extensive pre-treatment process.

They are attractive alternatives for combustion.

However, when comparing with combustion technology, thermal energy production in these systems is significantly low due to the reduction of the temperature of the residual heat in the steam (Murphy and McKeogh, 2004).

Further, it’s a more complex and an emerging technology with high capital and operating cost compared to the combustion (Belgiorno et al, 2003).

In general, there is a very limited track record of commercial scale pyrolysis plant accepting municipal derived wastes in the world due to the problems related to tarring. The deposition of tars cause blockages and other operational challenges associated with plant failures and inefficiencies (DEFRA,2013)

Therefore, Sri Lanka as a country which suffers from lack of institutional capacities and financial support for solid waste management projects (Vidanaarachchi et al, 2005), this technology would not be the best option.</td>
</tr>
<tr>
<td rowspan="2">Combustion

Combustion is the most dominant EfW technology which uses widely due to its simplicity and relatively low capital cost (Themelis, 2003). It is functioned in an Energy from Waste (EfW) plant, in which the waste is burned at 1000 ^{0}C and recover steam, heat or electricity as energy.

The most common methods used to combust solid waste are mass burning, modular combustion, fluidized bed and refuse derived fuel (RDF). Among them, the two most widely used and technically proven technologies are mass-burning, and modular combustion. Fluidized-bed and refuse-derived-fuel combustion technologies have been used to a lesser extent (United Nations Environment Programme, 1996).During the last 30 years of period, the development of EfW facilities have increased significantly and there are about1300 combusting EfW facilities worldwide (Rogoff and Screve, 2011).</td>
<td>RDF Burn</td>
<td>In this method, all waste is sent through a pre-treatment process prior the combustion. It is removed all non-combustibles such as metals, glass, rock, concrete, and sheet rock and hazardous materials. With this minimal sorting, it has the capability of getting a high average calorific values and achieving higher energy content. The ash production and the GHG emission is lower than in mass burn mode (EnviroPower Renewable Inc, 2013). Further, an extra income can be earned by selling sorted recyclable and non-combustible materials.

Although RDF processing gives the above advantages, its complexity has increased the operating and maintenance costs and reduced the reliability of RDF production facilities around the world (UNEP, 1996). UNEP (1996) further mentions that capital costs per ton of RDF combustion are higher than mass burning. Therefore, this technology is also set aside for the same reason of disqualifying gasification and pyrolysis technologies.</td>
</tr>
<tr>
<td>Mass Burning</td>
<td>Mass burning is the predominant and simplest method of combusting waste to generate energy (Hasselriis and Mahoney, 2013). This is one of the best technologies to reduce the volume of waste too. In this technology, all types of MSW are burnt as received, after the removal of hazardous and non-combustible materials such as metal and glass. Therefore, it requires less labor power for sorting, so that it is cost effective (EnviroPower Renewable Inc, 2013). When comparing with gasification and RDF technologies, mass burning is a simple process with affordable capital and operation cost. Though it has a high impact to the atmosphere through emission of greenhouse gases, it can be reduced by using an extensive flue treatment system. Further, it is identified, mass burning process generates high volume of ash (Hasselriis and Mahoney, 2013). However, they can be used in making eco bricks or in concrete mixtures.

Thus, in consideration of simplicity, affordable capital and operation cost and disposition of by-products, mass burning would be the suitable technology for handling waste in Meethotamulla garbage dump.</td>
</tr>
</table>

2.4. *PLANT CAPACITY AND ITS POWER GENERATION CAPACITY*

It is to note that the estimation of plant capacity is based on the plant life time of 25 years. It is assumed that the first four years (2016-2019) of the project life cycle will be taken for the preparation and implementation and then the facility will be operated from the 05th year for 21 years ahead (2020-2040).

Considering both existing and expected waste as calculated in section 5.2.3, it is assessed that there is a waste volume of 4,900,500 tons already in the dump site and expected to be dumped during the 2016-2019 period of facility preparation as 1,127,226 tons. Accordingly, there is a total amount of 6,027,726 tons. Among them, it is assumed only 65% of waste can be used for the EfW process, while 30% is set aside as almost composted in the dump it self and remaining 5% is put aside as non-combustible materials.

The expected waste quantity to be dumped during plant operation period (2020-2040) is estimated as 6,894,029. It is assumed that only 90% can be used for the EfW process, while 10% is set aside as non-combustible materials.

Based on above data and assumptions, the amount of waste that can be combusted daily from year 2020 is calculated as follows.

Waste from Meethotamulla	= (4,900,500 + 1,127,226) *0.65/ (21*365)	(Eq: 01)
Garbage Dump	= approximately 510 tons/day	

Waste from daily collection	= 6,894,029 * 0.9/ (21*365)	(Eq: 02)
(From 2020)	= Approximately 800 tons/day	

Accordingly, the facility has to be designed to process average 510 tons per day from exiting volume in Meethotamulla garbage dump and 800 tons per day from daily collection from Colombo area from 2020. Eventually, it requires to treat averagely 1300 tons of waste per day. Thus, the plant capacity is estimated as 1300tons/day

With the identification of daily combustible solid waste quantity and net calorific value, net power generation capacity of the plant is estimated as 14MW as in Eq: 03.

Total combustible solid waste quantity (W)	= 1300 tons/day	(Eq: 03)
Net calorific Value (NCV)	= 900kcal/kg	
Energy Recovery Potential (kWh)	= W x NCV x (4.184 x 1000 /3600)	
	= 1,359,800 kWh	
Power Generation Potential	= 1,359,800 /24	
	= 56,658 kW	

When producing electrical power only, World Bank mentions that (1999) it is possible to recover up to 35% of the available energy in the waste as power. Therefore, it was considered the conversion efficiency of waste collected from Colombo as 25%.

Thus, total net power generation per day of operation is estimated as 14 MW

3. PESTE ANALYSIS

With the identification of appropriate EfW technology, plant capacity and its net power generation capacity, PESTE (Political, Economic, Social, Technological, Legal and Environment) analysis identifies the opportunities and threats that can be considered prior making strategic decisions on implementing an EfW facility for this particular case.

3.1. *POLITICAL*

- Sri Lanka is a developing country which still has an unstable political condition and less political commitment on developing public infrastructure projects.
- There is no provision for energy recovery from waste in existing national waste management strategy, other than avoidance, reduction, reuse, recycling, and final disposal. Therefore, it may take considerable time to convince the advantages of this kind of a project to Sri Lanka.
- Though, the National Energy Policy 2006 has identified municipal solid waste as a renewable energy source and a Feed in Tariff has been introduced to be effected from year 2012, there is no an incentive or subsidy scheme to encourage investors to invest in EfW facilities.

3.2. *ECONOMIC*

- This is a capital intensive project.
- Generally, waste incineration experts mention that it is required to have an incinerator that burns at least 1000 tonnes of garbage each day to have an economically viable operation (Alternative Energy news, 2006). In view of that, this proposed plant possibly will make an economically viable operation by burning 1200 tonnes every day.
- This kind of a project will contribute to the local economy by creating both direct and in-direct employment opportunities in the form of officers, operators, technicians, labourers, and drivers.
- The main income source of this plant is selling electricity to the national grid. If it operates without major failures throughout its lifetime, it would be a profitable investment.
- Selling scrap metal and bottom ash will also create a considerable income from the project.

3.3. *SOCIAL*

- The proposed project will help to make the Meethotamulla garbage dump site as hazard free zone by 2040.
- It will cause to improve the local sanitisation by eliminating harmful fauna such as mosquitoes, flies, rats, cockroaches and other disease-causing vectors.
- No more bad odours will generate from the decomposition of organic waste in the dump.
- Further, the negative impacts such as frequent disasters (floods and explosions), ground water contamination with leachate, emission of toxic gases to the atmosphere and spoiling of the quality of soil due to leaching of salts and heavy metals will be nullified.
- The project will be a real example to increase the awareness on EfW facilities, so it will cause to widen the EfW plants throughout the country as a long term waste management strategy.
- In general, it is unavoidable the oppositions raised from the public and environmental organisations regarding this kind of an infrastructure project in Sri Lanka. Therefore, necessary actions have to be planned at the initial stage to face them.

3.4. *TECHNICAL*

- Generating energy from waste combustion is not a proven technology in Sri Lanka yet.
- Therefore, the project will lead to share and transfer the technical knowledge and the technology between Sri Lanka and other countries from where the equipment are imported.

3.5. LEGAL

- Compliance with all statutory requirements is highly essential prior setting up the project.
- However, the approval process possibly will take considerable time due to the poor coordination among relevant government agencies such as Central Environmental Authority, Sustainable Energy Authority Sri Lanka, Ministry of Mahaweli Development and Environment and Ceylon Electricity Board.

3.6. ENVIRONMENTAL

- This is an eco-friendly project which generates electricity using a clean energy source.
- It will reduce the amount of garbage piled in the Meethotamulla dump site and avoid methane emissions from the site.
- This will further help in reducing the future need of open landfill sites and decreasing the disasters and health hazards associated with them.
- However, it requires an effective air emission control system to avoid emitting harmful pollutants to the air generated through waste combustion.

4. SUMMARY

The aim of this paper was assessing the viability of setting up and EfW facility to get rid of Meethotamulla, Kolonnawa Garbage Mountain which has become a pressing issue. After a comprehensive analysis of several EfW technologies, it was identified “mass combustion technology” as the best possible option to reduce the waste heaped in Meethotamulla garbage dump. Based on the waste stream analysis, it expects to treat about 1300 tons of waste per day in order to make that garbage site hazard free zone by 2040 and it is anticipated to generate 14MW of electricity per day as a by-product of waste combustion. The PESTE analysis carried out on political, economic, social, technological, legal and environmental aspects identified that this project has a considerable capacity to contribute to local economy by managing solid waste to a certain extent, generating electricity from clean energy source and creating more job opportunities for the locals.

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ESTABLISHMENT OF THE MOST COMMON GROUND ON WHICH LOCAL ARBITRAL AWARDS BECOME UNENFORCEABLE IN SRI LANKA

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ABSTRACT

The parties select more adversarial arbitration process over other alternative dispute resolution methods mainly due to the enforceability of the arbitral award. If the arbitral award becomes unenforceable due to any reason, the selection of arbitral process is useless. In this scenario, aresearch was conducted specially to find out the most common ground on which local arbitral awards become unenforceable in Sri Lanka and to explore the reasons to occur the unenforceability under that most common ground with the expectation that this improved knowledge would assist to minimize the unenforceability of local arbitral awards.

The research was conducted under the quantitative research approach. A cross-sectional, retrospective and non-experimental study design was adopted. The local arbitration cases registered at the High Court-Colombo during 2009-2012 for the setting aside or for the enforcement of the awards and the courts had completed the proceedings were selected as the convenient sample. The sample contained 910 cases.

The data collection process was a two tiered process. In the first tier, a cross sectional survey was carried out at the High Court-Colombo to find out arbitral awards become unenforceable due to setting aside or refusal of the enforcement by the High Court. If the judgment of the High Court was appealed to the Supreme Court the judgment of the Supreme Court was also considered. Through the first tier of data collection, it was found that non adherence to the enforcement procedure is the most common ground on which local arbitral awards become unenforceable in Sri Lanka.

During the second tier of data collection, semi structured interviews were conducted with the parties who failed to enforce the arbitral award due to non adherence to enforcement procedure, those parties were mainly financial institutions and contained 16 organizations. Through the interviews it was found that performance defects of the legal counsel and the performance defects of the officer in charge of the case are the main reasons for the unenforceability of arbitral awards under the most common ground. Therefore it is recommended to establish proper reporting and monitoring systems within the organizations dealing with arbitration.

***Keywords**: Arbitration; Setting Aside; Enforcement; Unenforceability.*

1. INTRODUCTION

According to Arbitration Act No.11 of 1995 of Sri Lanka, there are two broad reasons which make local arbitral awards unenforceable in Sri Lanka. The first is the setting aside of arbitral awards by local courts under section 32 of the Arbitration Act. The second is the refusal to enforce the arbitral award by the local courts. The courts may refuse enforcement on non-adherence of the parties to the procedure laid down in section 31 or section 40 of the Act.

This paper presents the findings of a research conducted to establish the most common ground which leads to the unenforceability of local arbitral awards in Sri Lanka and to find out the reasons to occur the most common ground leading to unenforceability.

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2. BACKGROUND

Mustill and Boyed (1989) described that misconduct of arbitrators, error on the face of the award, excess of jurisdiction by arbitrators, patent defects in the award, misunderstandings of one of the parties which prevented that party to present his case effectively, mistakes by arbitrators and fresh evidence which was not available at the hearing stage, leads to remit the award or to set aside the award by courts. The Court has the discretion to decide whether the setting aside of the award or the remitting is most appropriate remedy and to decide which part of the award to set aside or to remit. The court has to consider all the circumstances of the case, when exercising this discretion. A serious error or miscarriage of justice, in most of the cases will lead to setting aside of the award.

When considering the arbitration law in Sri Lanka, the grounds for invalidity or setting aside of an arbitral award are stated in section 32 of Arbitration Act No. 11 of 1995, and correspond generally to the provisions of the New York Convention 1958 (Amerasinghe, 2011). Kanag-Isvaran (2011) pointed out that as per Section 32 of the Act, an arbitration award made in Sri Lanka may be set aside by the High Court only on very specific, limited grounds.

Section 31 of Arbitration Act 1995 enacts that an application for recognition and enforcement of an arbitral award to be made to the appropriate High Court within 1 year of the expiry of 14 days period from the making of the award (Amerasinghe, 2011). In addition, s.31 of Arbitration Act No.11 of 1995, requires that the application to enforce the award to be accompanied by the original of the award or duly certified copy of the award and original of the arbitration agreement or duly certified copy of such agreement. If a document or part of a document above mentioned is written in a language other than the official language of the court or other than in English, a certified translation of the relevant document or such part to be submitted along with the application.

Further s.40 of the Arbitration Act No.11 of 1995 provides that every application to the High Court under the provisions of the Act is to be by way of petition and affidavit and all the parties to the arbitration other than petitioner should be named as respondents and shall be given the notice of the application. Therefore if the applicant does not adhere to the above described procedures required for the enforcement, the courts have the discretion to refuse the enforcement of the arbitral award.

Recognition and enforcement are essential elements in arbitration. If the wining party is not able to enforce the award, the whole process of arbitration is pointless (Nacimiento and Bamashov, 2010). Nacimiento and Barmashov (2010) further added that the parties will only recognize arbitration as a viable alternative to litigation, only if the arbitral award can be enforced with the equivalent effects as a state court's judgment.

In any of the events of setting aside or refusal to enforce the arbitral award, the effort given on the arbitral process will be in vain. Therefore it is important to identify the most common ground which leads to setting aside or refusal to enforce the arbitral awards in Sri Lanka. After identifying this most common ground it can be searched for the reasons to occur this most common ground.

By identifying the reasons for the most common ground leading to unenforceability of arbitral awards in Sri Lanka, it would be easy to find ways to minimize such adverse effects on arbitral awards. It would facilitate to save the value of resources spent on arbitral process and to uphold the arbitration practice in Sri Lanka.

3. AIM AND OBJECTIVES

The aim of the study was focused to establish the status of enforcement of local arbitral awards in Sri Lanka. To achieve above aim, following objectives were set.

1. Determine the most common ground which leads to setting aside or refusal of enforcement of the local arbitral awards by local courts, where the arbitral proceeding were conducted under the purview of Arbitration Act No.11 of 1995.

2. Find out the reasons to occur above most common ground which leads to setting aside or refusal enforcement of local arbitral awards.

4. RESEARCH METHODOLOGY

A preliminary investigation revealed that it is difficult to find out old arbitration case records at the High Court. Further it was found that enforcement and setting aside proceedings of arbitral awards at the High Court and Supreme Court take a considerable time. Therefore considering the access to data and finalization of the law suit on arbitral awards, it was decided to select a convenient sample. The convenient sample of the study was selected as arbitral awards based on arbitral proceedings commenced in Sri Lanka after the appointed date of the Arbitration Act No. 11 of 1995 and falling within the purview of the Arbitration Act and the arbitration cases registered at the High Court Colombo during 2009-2012 for the setting aside or for the enforcement of the arbitral awards and such arbitration cases were finalized by the courts. The sample contains 910 arbitration cases. To achieve the objectives, quantitative research approach with a retrospective, cross-sectional, non-experimental study design was adopted.

In addition, to achieve the second objective, semi structured interviews were conducted with the parties who failed to get the arbitral award enforced due to non-adherence to enforcement procedure. Interviewed parties were mainly financial institutions and banks and contained 16 organizations.

5. DATA COLLECTION AND ANALYSIS

5.1. AN OVERVIEW OF THE DATA COLLECTION

Table 1 gives a summary of completed arbitration cases by the High Court on local arbitral awards.

Table 1: Summary of Completed Cases by High Court on Local Arbitral Awards

Year	Completed cases on local arbitral awards	Applications for setting aside	Awards set aside	Applications for enforcement	Awards been refused to enforce	Awards become unenforceable and percentage of unenforceability	
2009	204	1	0	203	4	4	1.96%
2010	405	4	1	401	3	4	0.99%
2011	196	3	2	193	6	8	4.08%
2012	105	0	0	105	14	14	13.33%
Total	**910**	**8**	**3**	**902**	**27**	**30**	**3.30%**

As indicated in Table 1, 30 numbers of arbitral awards become unenforceable from 910 arbitral awards, either due to setting aside or refusal to enforce by the High Court. The percentage of unenforceability is very low in 2009 and 2010 with 1.96% and 0.99% respectively. The percentage is moderate in 2011 and recorded as 4.08%. However when considering the year 2012 the rejection rate is high and recorded as 13.33%. The overall result indicate that the percentage of unenforceable award as 3.30%.

5.2. ANALYSIS OF ARBITRAL CASES BASED ON INDUSTRY

It is important to analyze the composition of the sample and how awards become unenforceable with respect to the relevant industry. Table 2 shows that 95.93% cases from the sample are belonging to financial and insurance industry. The contribution from construction industry is 1.87%. When considering the percentage of unenforceable awards, only 3.09% of awards become unenforceable in financial and insurance industry. However the percentage is considerably high for the construction industry, which is recorded as 11.76%.

Table 2: Categorization of Arbitration Cases Based on Industry

Industry	Total cases from 2009 to 2012	Percentage contribution of the industry	Awards become unenforceable	Percentage of unenforceable awards
Financial and insurance	873	95.93%	27	3.09%
Construction	17	1.87%	2	11.76%
Whole sale and retail	4	0.44%	0	0%
Real estate activities	5	0.55%	0	0%
Electricity, gas, steam and air conditioning supply	4	0.44%	0	0%
Transportation and storage	2	0.22%	1	50%
Manufacturing	1	0.11%	0	0%
Other	4	0.44%	0	0%

5.3. ANALYSIS OF ARBITRATION CASES BASED ON THE GROUND FOR REJECTION

One of main objectives of this study is to find out the most common ground on which local arbitral awards become unenforceable. Table 3 provides a categorization of arbitral cases based on the ground for rejection of the arbitral awards.

Table 3: Grounds Leading to Unenforceability of Arbitral Awards

Ground for setting aside or refusal to enforcement	Total for the category
Non adherence to enforcement procedure	17
Violation of due process	3
Excess of authority	1
Irregular constitution of the arbitral tribunal or irregularity of arbitral procedure	1
Award conflicts with the Public Policy	8

As per Table 3, it is clear that “non-adherence to enforcement procedure” is the most common ground which leads to unenforceability of local arbitral awards. From 30 numbers of unenforceable awards, the above ground is responsible for 17 awards to become unenforceable. The result given in Table 3 is graphically presented in Figure 1.

A close look at Figure 1 shows that 57% of unenforceable arbitral awards are belonging to non-adherence to enforcement procedure while public policy grounds lie next corresponding to 27% of unenforceable awards. Therefore the former is more than twice the size of latter. Violation of due process constitutes 10% of unenforceable awards while other two grounds constitute only 6%.

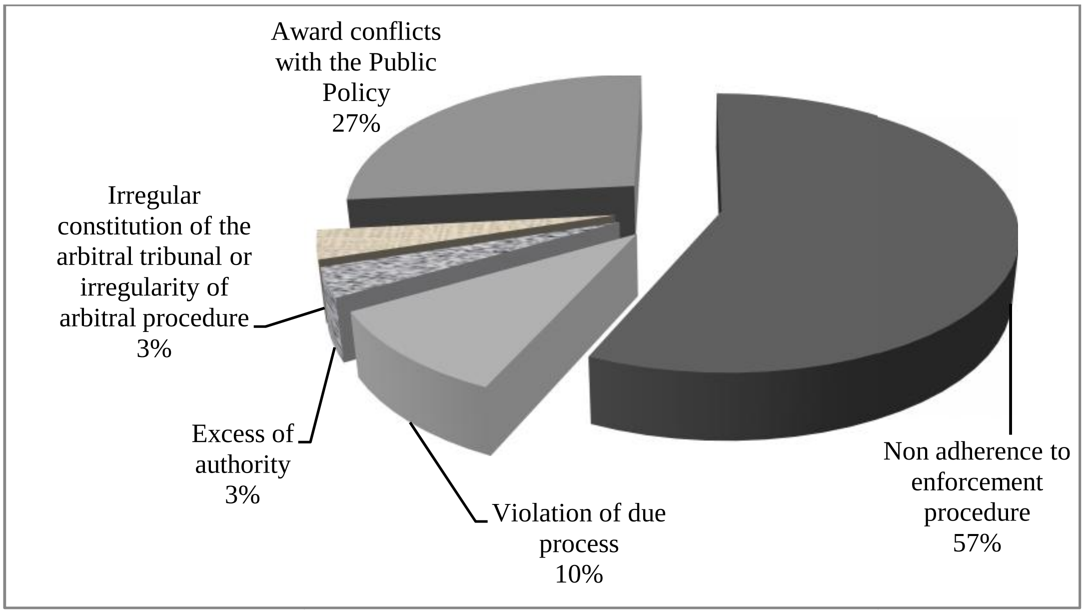

Figure 1: Grounds for Setting Aside or Refusal Recognition and Enforcement

The primary grounds to refuse the enforcement under non adherence to enforcement procedure are given in Table 4. This categorization is corresponding to the Arbitration Act. Figure 2 graphically presents the results of Table 4.

Table 4: Categories of the Default in Enforcement Process which Lead to Refusal of Enforcement

Category of the default	Number of cases
Not adhering legal principles or court procedures outside Arbitration Act	1
Not submitting arbitration agreement as required	6
Not submitting arbitral award as required	1
Not submitting a formal affidavit	1
Delay in application for enforcement	8

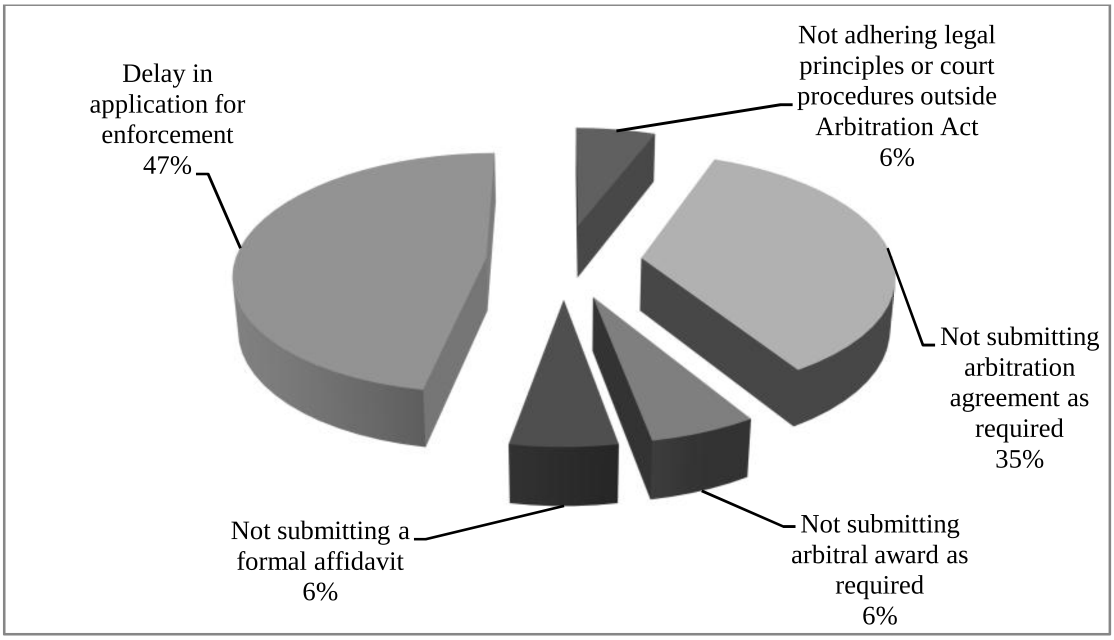

Figure 2: Refusal of Enforcement due to Non-adherence to Enforcement Procedure

5.4. *Finding Out the Reasons to Occur the Most Common Ground Leading to Unenforceability*

During the second tier of data collection, the data collection process was aimed to find out the reasons for the most common ground leading to the unenforceability of arbitral awards. Table 5 summarizes the results of the interviews carried out. Figure 3 gives a graphical representation of the contribution of the reasons which leads to non-adherence to enforcement procedure.

Table 5: Result of the Interviews

Reasons for non-adherence	Numbers of cases
Performance defects of legal counsel	9
Not understanding the requirements of s.31of the Arbitration Act	1
Failure of the company strategy on the award	1
Performance defects of the officer in charge of the case	3
Relevant officers are not knowing the actual reason	2

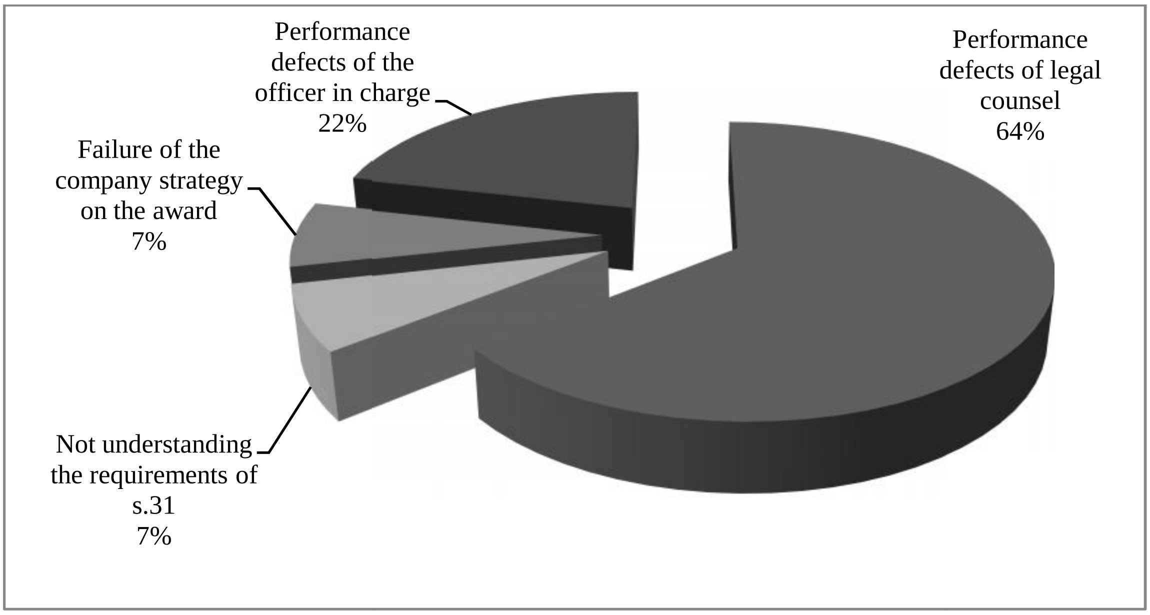

Figure 3: Reasons for Non-adherence to Enforcement Procedure

Figure 3 indicates that 64% of arbitral awards belonging to “non-adherence to enforcement procedure” become unenforceable due to the performance defects of the legal counsel. Performance defects of the relevant officer in charge (to follow up the case) are responsible for 22% of arbitral awards to become unenforceable in the category. Another 7% of arbitral awards become unenforceable due to failure of the company strategy on the arbitral award. Lack of understanding of the requirements of section 31 of the Act is responsible for 7% of arbitral awards to become unenforceable under this category.

Further as per Table 1 and Table 3, from 30 unenforceable arbitral awards, other than 3 arbitral awards been set aside and 17 arbitral awards become unenforceable under non-adherence to enforcement procedure, there are another 10 unenforceable arbitral awards. Those 10 arbitral awards become unenforceable due to refusal of enforcement under section 34 of the Arbitration Act. Further in the total sample of 910 cases only 8 cases are registered under section 32 and from those 8 cases only in the 3 cases above mentioned the arbitral awards have been set aside. Therefore it can be concluded that though there are ground for setting aside of arbitral awards, the parties involved in arbitral process do not obtain the precise usage of the provisions in section 32 of the Act for challenging arbitral awards. A close scrutiny of the data collection revealed that all the 10 cases where the arbitral awards were not challenged under section 32 are from financial and insurance industry and the lessee or the borrower had not utilized their rights.

However in a recent case Hatton National Bank vs. Sella Hennadige Chandrasiri *(*2015), the Supreme Court of Sri Lanka set aside the High Court judgment on the arbitration case HC/ARB/388/2011 whereby the High Court refused to enforce an arbitral award on the grounds mentioned in section 34 of the Act. In the Supreme Court judgment, it was held that section 34 of the Arbitration Act is for foreign arbitral awards and cannot be applied to local arbitral awards. This makes more pressure on the parties involving in arbitral process to exercise their right under section 32 of the Arbitration Act more vigilantly and promptly.

6. CONCLUSIONS AND RECOMMENDATIONS

Non-adherence to enforcement procedure is the most common ground which leads to the unenforceability of local arbitral awards in Sri Lanka. Performance defects of the legal counsel and officer in charge of the case are the main reasons for the non-adherence to enforcement procedure. These two reasons are responsible for 86% of the unenforceability within the non-adherence to enforcement procedure. Therefore it is important to establish proper reporting and monitoring systems within the organizations dealing with arbitration to follow up arbitral cases properly.

Borrowers and lessees of financial industry do not properly utilize the provisions in section 32 of the Arbitration Act, when the awards are having grounds for setting aside. As the Arbitration Act does not provide any other opportunity to prevent enforcement of unfair local arbitral awards, it is very important to utilize section 32 for setting aside. Therefore an awareness programme is to be carried out aiming the relevant strata of the society to improve their knowledge on the impact of arbitration agreement they sign when they obtain financial facilities and to improve their knowledge on the repercussion they would face if they do not utilize the provisions in Arbitration Act for their good. This is very important to uphold the arbitration practice in Sri Lanka as the financial and insurance industry constitutes around 95% of the arbitration cases referred to the courts.

During the interviews with finance companies and banks, most of them expressed that enforcement proceedings at courts become cumbersome and very time consuming. Due to these reasons one bank and one finance company have removed the arbitration clause from their loan and leasing agreements. This difficulty in enforcement process is a considerable drawback in the arbitration sphere in Sri Lanka. Therefore it is highly recommended that the government should take some steps to smoothen and speedup the enforcement proceedings of arbitral awards in the courts.

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FACTORS AFFECTING THE INDOOR ENVIRONMENTAL QUALITY IN SRI LANKA: GREEN VS. CONVENTIONAL HOTEL BUILDINGS

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ABSTRACT

The hotel building sector is now using sustainable design and construction practices thereby helping to prevent environmental pollution. Green building practices are capable of promoting a healthy and comfortable indoor environment for hotel occupants (including guests and staff). Some criticism has been made by occupants of green buildings on the accuracy of the certification process and the performance of LEED certified buildings. Therefore, this study is aimed at identifying the key factors affecting the Indoor Environmental Quality (IEQ) of green buildings compared to that of conventional hotel buildings by evaluating building performance. Firstly, a literature survey was conducted to identify the importance of IEQ in green buildings and the methods of evaluating IEQ performance. Subsequently, key and sub factors relating to IEQ performance identified from the literature review were validated through expert interviews. A questionnaire survey and semi structured interviews were used as data collection techniques by making use of two green buildings and two conventional buildings. The data was analysed using Mann-Whitney U-test and "Nvivo 10" software. The analysis revealed that green hotels provide an overall IEQ performance that is higher than that of conventional hotels. However, factors such as lighting, acoustics and the degree of personal control that occupants have on the indoor environment were comparatively less satisfactory in green hotels. The paper also discussed the reasons for the low satisfaction of IEQ in respect of these factors. Finally this study confirms that the hotel industry needs to consider a climate responsive design to ensure a better IEQ and pay attention to post occupancy evaluation throughout the life cycle of a building.

Keywords: *Green buildings; Indoor Environmental Quality (IEQ); Occupants' Satisfaction; Sustainability.*

1. INTRODUCTION

IEQ refers to the quality of a building's indoor environment in relation to the health and wellbeing of those who occupy the space within it (Mallawaarachchi *et al*., 2012). Indoor air quality, thermal comfort, acoustics, day light and lighting quality are the factors that determine the indoor building performance in the building sector (Parkin, 2000). Industrial, commercial, residential and hospitality sectors are responsible for polluting the environment as they satisfy the occupants and end users of their buildings to reap economic and financial benefits (Tzschentke *et al*., 2004). These industries are adopting green building practices to generate a healthy environment for the occupants of their buildings, increase the quality of indoor environment and improve social, economic and environmental sustainability for the benefit of both present and future generations (Walker *et al*., 2007). The hotel industry plays a vital role in the economy and sustainability and is gradually becoming an issue with business and guest interests (Chan and Chan, 2004). The comfort of the guests and their willingness to return are factors that have a significant impact on the success of the hotel sector and the have to adopt green design and construction practices to save energy, water, and other resources thereby helping to prevent the pollution of the environment at increasing costs, and with economic, social and environmental responsibility (Schor, 2008).

The hotel industry being an environmentally responsible industry, the evaluation of its building performance is essential to identify how their services and buildings assist to achieve the business goals and occupants' needs (Fischer, 2009). According to Mallawaarachchi et al. (2012), most of the industries

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use several assessment tools and techniques. Among them, the U.S. Green Building Council's LEED rating system act is leading green certificate rating systems. LEED certification has progressively contributed to decreasing IEQ and increasing energy savings during the year 2009 through new construction practices. According to Krik (2005), the reduction of credits in the IEQ category can increase to ensure resource conservation, which could be a reason for a conflict between guest comfort and green building practices in hotels. Therefore occupants of green certified buildings has low satisfaction and comfort (McLennan, 2004; Boecker *et al.*, 2009). IEQ experts state that to create healthy spaces in LEED certified green buildings, industries need to look forward to appropriate and applicable green practices. It is derived that there is necessary to improve green building practices that can be implemented throughout a building life cycle to minimise environmental impact, increase social and economic benefits and enhance guest satisfaction and comfort (Cassidy, 2003).

In both developed and developing countries, the previous studies have majorly examined on office, university and factory buildings, and there has been almost no studies on the user satisfaction of other buildings. In Sri Lanka, a previous research has focused on "IEQ evaluation in green certified office and factory buildings" (Samaranayake and De Silva, 2010) to identify the key factors that affect the indoor environmental quality of green buildings and appropriate and suitable green building practices that will facilitate the highest LEED rating while providing a comfortable and a healthy environment for the occupants in the hospitality sector. Considering the statistics on hotel sector in Sri Lanka, the economic indicators expect a growth of 22.3% (Central Bank of Sri Lanka, 2013). Maintaining guest satisfaction and creating a healthy work place are major considerations of the hotel buildings. Nowadays, a majority of hotel buildings in Sri Lanka have been able to attain the LEED certification (Green buildings) which governs the standards of the facilities, especially the higher environmental responsibility. Still, a proper comparison between Green hotel buildings and conventional hotel buildings for maintaining better indoor environmental quality has not been done. Hence, this research study focuses on identifying the key factors that affect the indoor environmental quality of green hotel buildings compared to conventional hotel buildings through the evaluation of building performance. Further, identifying the key factors implies the importance and the impact on the quality of indoor environment of hospitality green buildings. In order to achieve the aim, the following objectives were formulated.

- To identify evaluation methods of IEQ performance of hotel buildings in Sri Lanka
- To identify significant key and sub indicators relating to IEQ performance in green and conventional hotel buildings in Sri Lanka
- To evaluate the current performance of IEQ in relation to the identified significant indicators in green and conventional hotel buildings
- To propose strategies to enhance IEQ of green hotel buildings in Sri Lanka

2. THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Buildings have a huge effect on climate change, generation of waste, indoor and outdoor environmental pollution (Zimmermann *et al.*, 2005). According to Douglas (1996), the term 'Sustainable Development' can be explained as a mode of improving the quality of life and allowing people to live in a healthy environment under enhanced social, economic and environmental conditions. Green building is a new trend in the construction industry (Kubba, 2012). According to USGBC (2009), the key features of green buildings are sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and operation and maintenance. A green building has to have high efficiency in the use of energy, water and materials, and a reduced impact on the health of its occupants and its environment throughout its life-cycle.

2.1. INDOOR ENVIRONMENTAL QUALITY

The concept of IEQ is a major factor of concern for ensuring "sustainability" (Catalina and Iordache, 2011). Increased positive health effect is a priority in the design of buildings as people spend on average, 90% of their time indoors. The effect of indoor air on people is hundred times more than that of outdoor air. Air, thermal, lighting and acoustic qualities significantly affect IEQ (Mahbob *et al.*, 2011). A good IEQ performance will enhance work place conditions and this in turn will reduce complaints from end users (Catalina and Iordache, 2011). Apart from physical and environmental factors, performance factors such as office layout, amount of space, privacy, office furniture and furnishings, cleaning and maintenance, access and ability of having personal control over indoor air quality have a greater influence on IEQ performance (Lombardi, 2011). In any type of building overall occupancy satisfaction is quite important, as otherwise there can be building sick syndrome, absenteeism and high turnover and low occupants comfort (Lai and Yik, 2009). Thus, buildings have a responsibility to facilitate better indoor environmental quality for their occupants and therefore the maintenance and evaluation of IEQ factors over a life cycle of building has become very necessary.

2.2. IEQ EVALUATION METHOD

Preiser (1995) has stated that for the evaluation of environmental performance of buildings, several environmental methodologies and methods are presently in place. Potbhare *et al.,* (2009) have stated that Sri Lanka has adapted to the sustainable building culture and green building rating systems for the built environment are recognized as a standard for sustainable building design and construction practices. The primary goal of LEED is to support green building practices in order to deliver environmentally responsible healthy environments for building occupants. According to Amarathunga and Barldry (1998), there are objective and subjective measurement evaluation techniques. Among those, Post Occupancy Evaluation (POE) is the appropriate technique to evaluate occupant's satisfaction and comfort. POE is a measurement of building performance throughout the life cycle of a building from its initial to end phase". Marans (1984) has stated that POE is a formal evaluation of a building by its occupants after it has been completed, in order to identify areas that do not meet users' requirements.

2.3. AN OVERVIEW OF HOTEL SECTOR

The hotel industry is playing a key role in the economic development of Sri Lanka (Bocker *et al.,* 2009). The main goal of hotel buildings is the improvement of the guest's satisfaction which will lead to the productivity of the workers. Most of the guests and customers arrive from foreign countries and there are guidelines regarding the provision of health, safety and welfare of the workers. As a result of this, most of the hotels in Sri Lanka have good ventilation systems and the IEQ is regularly monitored by health and environmental officers of the Government (Saheed, 2005). However, issues relating to IEQ performance can be seen in large and luxury hotel buildings as a result of improper lighting, acoustic, thermal factors and IAQ (Birt and Newsham, 2009). Some of the visitors have complained about IEQ related issues. Dustiness of the indoor environment is still there. Dust is normally generated by fabrics and there is a probability of dust being inside the hotel due to the low number of exhaust fans used (Samaranayake and De Silva, 2010).

2.4. IMPORTANCE OF IDENTIFICATION OF IEQ EVALUATION FOR HOTEL BUILDINGS

Several sectors are seeking to be environmentally responsible due to both economic and financial requirements, and to satisfy their own personal ethics they tend to introduce green building practices (Tzschentike *et al.,* 2004). The hotel industry plays a major role in the economy of the country and issues of sustainability in the hotel industry are becoming increasingly relevant to business and consumer interests (Chan and Qian, 2009). Guest satisfaction, intention to return, and the likelihood to recommend hotels are important factors for the success of the hotel industry. Hoteliers are increasingly motivated towards adopting green design and construction and investments in environmental technology can have a direct positive impact on guest experience and occupancy (Schor, 2008). Consequently to meet the requirements pertaining to the targeted tourist arrivals, hotel buildings are expected to increase their green features and capacity to achieve this targeted number of tourist arrivals. Hotel buildings can increase their potential by creating guest comfort and a stable indoor environment. Thus, the evaluation of IEQ performance of hotel buildings is very important (Levin, 1995). Considering the outcome of previous studies, some proponents argue that a green building will enhance indoor environmental quality and improve occupants' productivity to a higher degree compared to conventional buildings. On the contrary, some researchers have found that in green buildings air quality is very satisfactory while other three indicators are same and that there is a low satisfaction level compared to conventional buildings due to the use of sustainable practices and products as well as poor rating of some of the green building IEQ variables. When past research is reviewed, mixed questions such as whether green buildings provide a comfortable, satisfying and productive work environment to their users arise. The following hypotheses in respect of green building performance, relative to conventional buildings was therefore developed.

H0: The occupants' satisfaction with IEQ performance in the LEED certified hotels is similar to that of non-LEED certified hotels.

3. METHODOLOGY

In order to attain the aim of identifying the key factors that affect the indoor environmental quality of green buildings compared to conventional buildings through the evaluation of building performance, the case study approach was followed. Initially, a preliminary interviews series were carried out to analyse and identify the main and sub indicators relating to IEQ performance of hotel buildings. Subsequently, a detailed survey was conducted through a questionnaire survey to identify the satisfaction and comfort level of guests and staff occupying a set of selected green buildings and conventional buildings in Sri Lanka. Interviews with key professionals were carried out to identify the problems and complaints regarding IEQ performance in buildings.

3.1. SELECTION OF CASE STUDIES

Table 1 presents the details of selected cases.

Table 1: An Overview of Different Categories of Buildings

Description	**Green Building (Part I)**	**Conventional Building (Part I)**	**Green Building (Part II)**	**Conventional Building (Part II)**
	CASE A1	CASE A2	CASE B1	CASE B2
Type of building	Hotel	Hotel	Hotel	Hotel
Duration	6 Years	5 years	5 years	8 years
Number of stories	5 stories	11 stories	5 stories	6 stories
Floor area	40,300 m^2	36,025 m^2	100,000 m^2	90,000 m^2
Star rating	Gold	-	Silver	-

In order to measure users' satisfaction with respect to the indoor environmental performance of each type of buildings, a survey was developed based on the expert interviews and literature review survey. The POE tool was used for measuring occupants' opinions and satisfaction with the IEQ performance of buildings. Building users across the two types of buildings were asked to rate their satisfaction levels for each indicator on a 5-point Likert scale (1 being very dissatisfied to 5 being very satisfied). Participants were selected randomly from each pair of buildings (green and conventional) for the paper based survey and to identify the complaints and causes, interviews were conducted with six key professional working in two green certified hotels.

3.2. QUESTIONNAIRE SURVEY

Mann Whitney U test was used to identify the difference between the occupants satisfaction with IEQs of the two buildings. The IEQ performance of the two types of buildings was compared using median and average median of factors. To determine whether the null hypothesis can be rejected or not, the decision rule was applied. This contributed to the hypothesis that occupants' satisfaction related to green buildings (x) is equal to that of non-green buildings (y). This assumption will be confirmed, at a 95% confidence level, for the null hypothesis (H0) or its rejection (H1):

H0: x = y if p-value is greater than 0.05 in which case the occupants' satisfaction with IEQ is similar for both hotels.

H1: x ≠ y if p-value is less than 0.05 in which case the occupants' satisfaction with IEQ is different for the two hotels

3.3. SEMI-STRUCTURED INTERVIEWS

The semi-structured interview was expected to compare the questionnaire survey results of occupants. A cross case analysis was carried out separately for green hotels in order to compare complaints about the IEQ factors. The factors identified under each theme were structured and supported by 'NVivo 10' computer software.

4. RESEARCH FINDINGS AND ANALYSIS

4.1. SIGNIFICANT KEY AND SUB INDICATORS RELATED TO IEQ IN GREEN AND CONVENTIONAL BUILDINGS

Respondents identified eight (8) indicators in addition to the IEQ indicators identified from the literature review and removed six (6) of them while, combining four (4) of them to make in to two (2) and modifying another two (2). In addition, the indicator 'odour' was dropped as the respondents were of the view that it was covered under the indicator 'smell'. Further, 'relative air velocity' was modified as 'air movement'. The 'day lighting factors' that came under the key indicator 'lighting' were removed by the respondents and 'glare' that also came under' lighting; was divided into two as 'natural light glare' and 'artificial light glare'. At the expert interviews, blinds/shutters that are effective in blocking natural light were added as a sub factor. 'Surface temperature' and 'thermal resistance of clothing' that were grouped under the key factor 'thermal comfort' were dropped. The sub factors 'overhearing private conservation' and 'equipment and mechanical noise' were modified as 'background noise'. The respondents also wanted to revise 'outdoor traffic noise' as 'noise from outside'. In addition 'person control' was added as a factor which could influence the IEQ performance and 'view to outside', 'provision of ventilation', 'cleaning and maintenance', 'sufficient and comfortable furnishing' and 'sleeping quality' were considered as important key factors of IEQ in the green buildings of the hotel sector.

According to the findings of the expert survey, there are forty five (45) IEQ sub indicators. Most of the IEQ experts agreed that the post occupancy evaluation method has a higher preference in evaluating occupants' satisfaction of IEQ performance of green hotel buildings.

Table 2: Evaluation of the Current Performance of IEQ in Green and Conventional Buildings

Evaluation Methods	A	B	C	D	E	F	G	H	I	J
Physical Measurement	×	√	×	×	√	√	×	×	×	×
Post Occupancy Evaluation	√	√	√	√	√	√	√	√	√	√

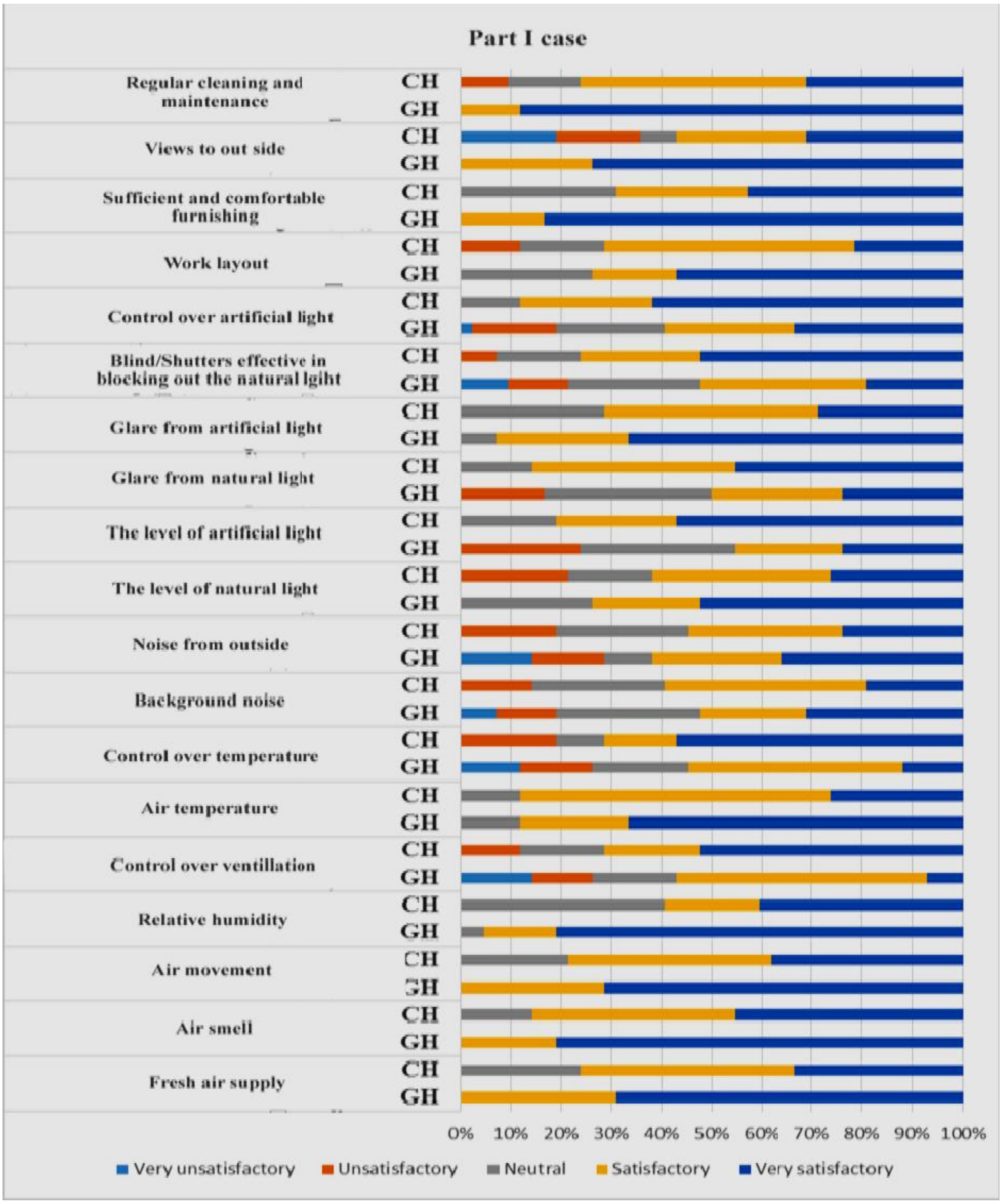

Figure 1: Distribution of Occupant's Satisfaction on Identified IEQ Factors Relating to Buildings: Part I

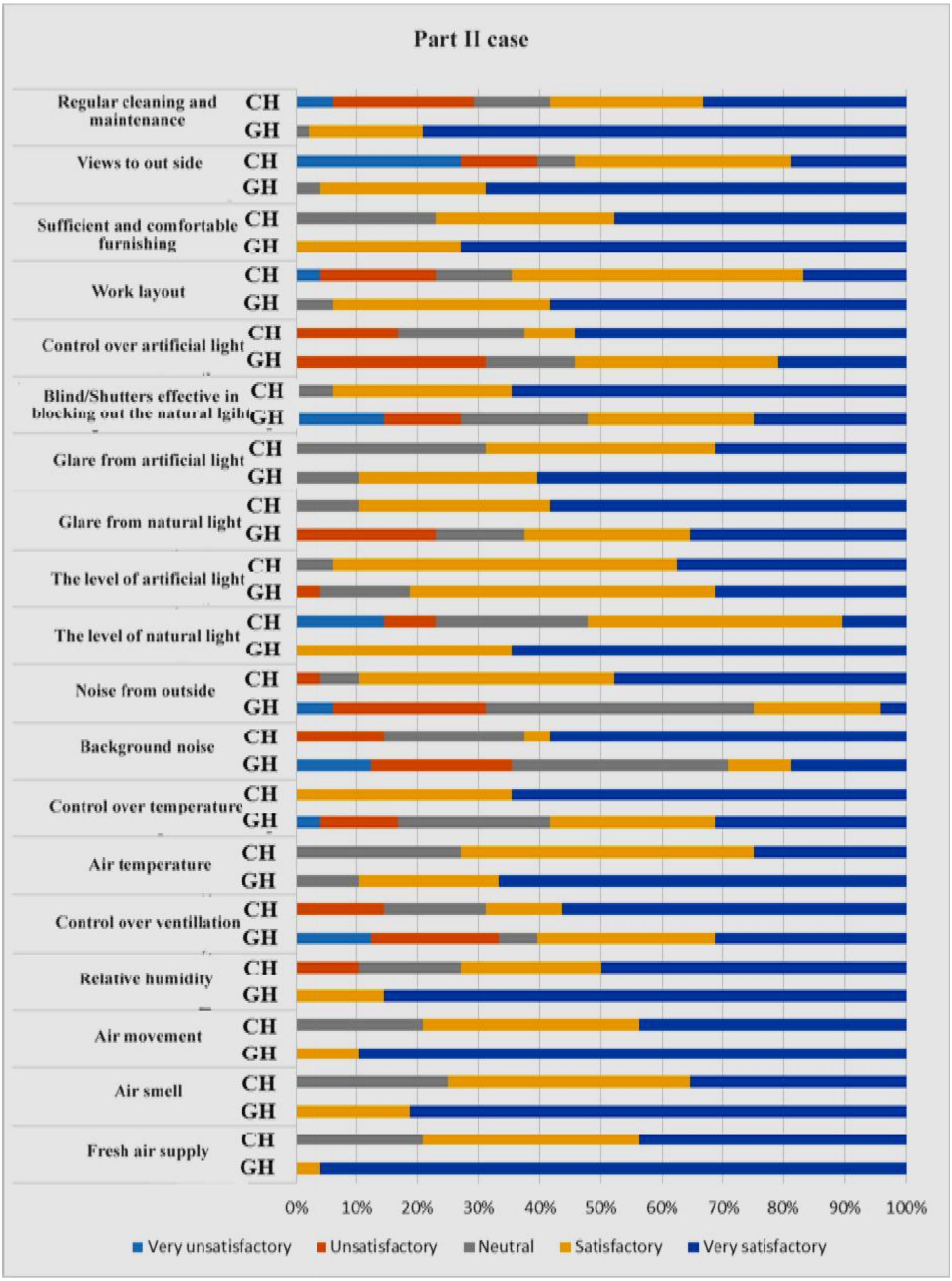

Figure 2: Distribution of Occupant's Satisfaction on Identified IEQ Factors Relating to Buildings: Part II

Figures 1 and 2 indicate the distribution of occupant's satisfaction on identified IEQ factors relating to buildings coming under Part I and Part II categories. The average median scores of the air quality, thermal comfort, work layout, sufficient and comfortable furnishing, view to outside and regular cleaning and maintenance have positive signs in both green and conventional hotels, which means that on average these factors are satisfactory in both types of buildings. However the median of each factor is higher for green hotels. The key professionals working in green buildings indicated that green buildings specifically exhibited lower air pollution and higher air filtration, avoided the use of volatile organic compounds for cleaning purposes and maintained preventive maintenance schedules. BMS had been installed to control CO_2 and RH levels and the main key feature of LEED certified hotel buildings is the implementation of IAQ management, temperature recording and low admission of heat through walls from outside, windows and electronic light appliances due to good thermal design. Therefore the null hypothesis is rejected and the alternative is accepted which means that green hotels have higher levels of IAQ than conventional hotels.

On the other hand in both the green and conventional hotels, the average median scores of the acoustic quality, lighting quality and the ability to have personal control on the indoor environment have positive signs, which means that on average these factors are satisfactory for both groups. However the median of each factor is slightly lower for green hotels than for conventional hotels. Also 50% of the representatives of the management of both buildings when interviewed stated that there was too much darkness, lack of artificial light and reflections on the computer screens caused by lower levels of ambient electric lighting, façade glass and ineffective blocking of natural light by blinds/ shutters and requested more daylight. Eighty three percent (83%) of the respondents of both buildings stated that there is a lack of privacy for conversations, excessive echoing of voices or other sounds making occupants to complain, because of the low partitions that allow day light and opening of windows to allow natural ventilation. Therefore the null hypothesis is rejected and the alternative is accepted which means that green hotels have lower levels of IAQ than conventional hotels.

Table 3: Identification of Occupant's Satisfaction of Well-Being

		Part I			Part II		
		Never	**Occasionally**	**Often**	**Never**	**Occasionally**	**Often**
Common cold/ running nose	GH	75%	25%	00%	82%	18%	00%
	CH	60%	28%	00%	72%	28%	00%
Headache	GH	53%	47%	00%	83%	17%	00%
	CH	36%	64%	00%	64%	36%	00%
Influenza	GH	76%	24%	00%	76%	24%	00%
	CH	78%	14%	00%	86%	14%	00%
Difficulty in concentrating	GH	69%	25%	04%	25%	69%	04%
	CH	62%	38%	00%	38%	62%	00%
Fatigue	GH	64%	24%	04%	62%	38%	00%
	CH	27%	77%	00%	23%	77%	00%
Nausea	GH	76%	18%	00%	76%	18%	00%
	CH	80%	20%	00%	65%	35%	00%
Itchiness/ eye irritation	GH	84%	16%	00%	53%	35%	00%
	CH	82%	18%	00%	60%	40%	00%
Dry throat/coughs	GH	82%	18%	00%	82%	18%	00%
	CH	76%	20%	00%	76%	24%	00%

According to Table 3 with regard to occupant's satisfaction of well-being in the Part I and Part II categories of buildings, headache, influenza, nausea, eye irritation, common cold, dry throats/cough, sick building syndromes are at satisfactory levels in both types. However occupants stated that due to high level of back ground and outside noise there is occasional health issues. This implied that the occupants of green hotels were concerned about perceived healthiness. Also the management of the green buildings have not received any complaints regarding headache, influenza, nausea, eye irritation, common cold and flaking/itchiness. This implied that occupants of green hotels' had a high perception of healthiness.

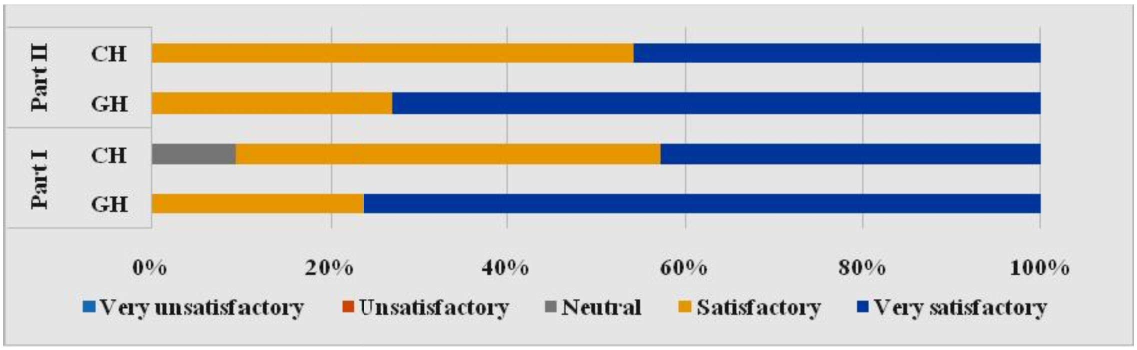

Figure 3: Comparison of Part I and Part II: Distribution of Occupant's Satisfaction on Identified IEQ Factors Relating to Buildings

This statement was validated by the questionnaire survey that provided the average median of overall satisfaction of IEQ in Part I (GH=5, CH=4) and Part II (GH=5, CH=4) buildings. Green buildings exhibited higher levels of overall satisfaction of IEQ. Even though the occupants of green hotels have a slightly lower level related to acoustic quality and lighting quality when compared to conventional hotels it will not affect the overall satisfaction of IEQ in the hotels. On other hand, the occupants are highly satisfied with fresh ventilation and temperature, aesthetic appearance, size of workspace, and access to the view of outside. Occupants of green buildings were less likely to prefer a change in thermal conditions, and took fewer actions to improve their thermal comfort. Green building occupants had higher ratings of satisfaction with access to the view of outside. The result of this study suggest that, on the whole, both green and conventional hotels deliver an indoor environment that was acceptable to most people (with the exception of acoustic quality), although however the indoor environments in green hotels were of higher quality.

5. DISCUSSION

H0: The occupant's satisfaction with IEQ performance in the LEED certified hotels is similar to non-certified hotel buildings.

H1: The occupant's satisfaction with IEQ performance in the LEED certified hotels is higher than that in Non-LEED certified buildings. Furthermore it was found that even though the building met the recommended standards, occupants occasionally complained about noise and lighting quality.

Both the green and the conventional buildings provide an environmental quality which can be accepted by most of the occupants according to the research. It is apparent that certain factors are not much satisfactory. The differences between green and conventional buildings could be identified here with the help of the factors that have been used in the research. Comparatively the IEQ in green hotels was higher. However this does not mean that there is no necessity to enhance green buildings further. Certain factors of IEQ were superior in green buildings. This may indicate that there is no necessity for a simple cause-and-effect while considering the results of the individual design credits and the post occupancy performance. As mentioned earlier, acoustics and lighting should be ensured at the design stage. It is recommended that an acoustics and lighting credit be created to counter balance design choices affected by other credits. There are acoustic credits in some green rating systems, and suggestions for a LEED credit. However, these existing and proposed credits do not place specific emphasis on reducing the spread of acoustics related issues.

6. SUMMARY

The aim of the research was to identify by evaluating building performance the key factors that affect the indoor environmental quality of green buildings as compared to conventional buildings. Air quality, thermal, lighting and acoustic qualities, external view, provision of ventilation, cleaning and maintenance and furnishings were identified as these key factors. Furthermore the ability to have personal control on the indoor environment and blinds/shutters effective in blocking natural light were identified as key and sub factors affecting the IEQ in buildings. Overall satisfaction, job satisfaction and wellbeing of staff were high. As far as environment/ physical factors were concerned, air quality and thermal comfort were at a high level, and performance factors such as the view of outside, cleaning and maintenance, work layout were also at a high level. In LEED certification, air quality and air quality management and maintenance are the factors that are mostly considered. In green hotels there is good ventilation, glass walls are made available to enable viewing outside and, more space is provided for occupants to work and live. On the contrary in green hotels when compared to conventional buildings, lighting quality is at an average level and acoustics are at a very low level which according to the key professionals are some of the causes and problems of dissatisfaction related to IEQ factors in green buildings. Complaints made by those who were dissatisfied with lighting point to problems with day lighting and electric lighting levels which could be due to inadequate provision of controls over lighting. Complaints made by those who were dissatisfied with the acoustic quality in their work places point to problems with sound privacy, and distracting noise arising from people's conversations and telephone ringing. According to the occupants and experts who were interviewed, there are certain design decisions and operational practices that are generally known to affect IEQ which are commonly used in green buildings. These strategies include improving ventilation, removing indoor pollutants, using green material, giving occupants personal control over operable windows, air-conditioning, or under floor air distribution systems, employing daylight, and reducing ambient light levels by using task lighting.

It is recommended that a modification to these credits that enhance the importance of a particular reduction be justified. In order to do that, the joint design process has to be as important as specific and creditable actions, suggesting that a credit be developed that improves such action. Perhaps this credit could reward documented interdisciplinary design team meetings, or record of all implemented measures intended to enhance the building performance, credit-eligible or not, or a particular mechanism that facilitates on-going accomplishment review and continuous improvements. Hence, the Hotel Buildings can achieve a green rating with very few specific IEQ credits.

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FRAMEWORK FOR MITIGATING CONTRACTUAL DISPUTES IN THE SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Dispute is defined as "any contract question or controversy that must be settled beyond the jobsite management". Most of the construction disputes related to the contractual matters. The aim of the research was to develop a framework as a strategy that could mitigate to the occurrences of contractual disputes in Sri Lankan construction industry. Literature synthesis aimed at adapt the nature of contractual disputes by establishing critical attributes of contractual disputes, causes of contractual disputes, strategies used to avoid contractual disputes, Alternative Dispute Resolution methods and attributes in ADR methods. The five Semi-structured interviews and thirty five detailed questionnaire surveys were aimed at detailed studying of practical situation in Sri Lankan contractual disputes, identifying the areas, causes, effects, avoidance strategies of contractual disputes and attribute in Alternative Dispute Resolution methods and behaviour of the attributes in ADR methods. The research findings revealed major areas of contractual disputes named as general causes, contractor and owner related causes. Major causes of contractual disputes are ambiguities in contract documents, delays in work progress, design errors and major effects identified as cost overruns, project delays and damage business relationships. Contract documentation, proper coordination between contract documents and proper contract administration are the major contractual dispute avoidance strategies. Furthermore, major attributes in ADR methods are identified as duration of the proceeding, obtaining fairness decision and binding of the decision. Further research findings are revealed that arbitration require highest duration of the proceeding, mediation provide the more fair decision and arbitration decision is more binding and enforceable.

Keywords: *Sri Lankan Construction Industry; Contractual Dispute Avoidance; Contractual Dispute Resolution.*

1. INTRODUCTION

Construction project is defined as the process which having a certain time period from start to finish of inter-related activities and involves no of parties, who must work in unison within temporally time period (Jayalath, 2010). Within last two decades nature of the construction projects become more complex. The complex, lengthy and relational construction a process virtually ensured disputes (Jaffar *et al*., 2011).

As explained by Jaffar *et al*. (2011), "a dispute is defined as an argument about an issue concerning project operations, usually resulting from a debate over differences in two or more parties' understanding of situation". Causes of disputes in a different section like standard of workmanship, applications for extensions of time not being granted, contractor delay and subsequent deduction of liquidated and ascertained damages and sometimes the meaning of contractual terms (Adriaanse, 2007). Most of the construction disputes arise related to the contractual matters including variation, improper management and administration, lack of available information, quality of technical specification and unrealistic client expectations and tenacity in the construction industry (Jaffar *et al*., 2011).

2. NATURE OF THE DISPUTES IN THE CONSTRUCTION PROJECTS

Construction industry has higher uncertainty and involves more unknowns and due to that high possibility to rise contractual disputes (Kumaraswamy, 1997). According to Armes (2011), manufactured products

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are fully designed and build models before begin the production and performance are tested and established the durability and buildability. Construction project have less possibility to fully design before commencement the contract. Disputes are always costly to the projects (Armes, 2011). As average 50% of the legal costs borne by the construction industry are related to the contractual disputes. Disputes waste time and money, deflect energy away from construction projects. The resources that could have been spent on the dispute resolutions can be invested in the same project to better performance of clients and users. Importantly contracts may be viewed as the compulsory evil for the project to minimize the contractual dispute (Grunwald, 2001).

2.1. CONSTRUCTION CONTRACTS

Construction contracts can be defined as legally binding written agreement signed by the contracting parties. Contract defines the obligations, responsibilities of each and every party and relationship among contracting parties in a particular project (Broome and Hayes, 1997). Standard forms of contacts are always used by the construction stakeholders to communicate the procedures to be adopted in executing the project including regulate their contractual obligations and expectations during the execution of the projects. There are number of independent professional organizations developed internationally recognized standard forms of contract such as FIDIC, SBD, ACE, NEC and JCT and these are used in different contractual arrangements such as design and build, traditional procurement method and turnkey (Rameezdeen and Rajapakse, 2007).

2.2. CAUSES OF CONTRACTUAL DISPUTES

Contextual point of view that disputes may arise due to misunderstanding, disagreement, poor relationships or escalated conflicts between parties. Most of the disputes arise due to errors and omissions in the contract documents (Gukert and King, 2002). The contract documents prepare using the standard documents that is produced is considered to be poor and in many instances erroneous due to inadequate adjustments and those lead to a delay work progress, and claim for loss and expense by the contractor, scope changes and a claim for loss of productivity (Davis *et al*., 2008). The other major cause to arise disputes is interpretation errors in conditions of contracts and misunderstanding of construction contracts (Chong and Zin, 2012). When contract parties enter in to contract, both parties undertaken the risk and they are well aware of the risk. Additions, alterations, omissions or changes in the nature of the work lead to the excessive contract variations. Most change orders are happen at the request of the client and are generally in the form of design changes (Zeitoun and Oberlander, 1991). Poor contract administration and progress delays by the main contractor have been identified as important causes to arise disputes (Ayudhya, 2011). In addition to that Waldron (2006) explained extension of time (EOT) claims, late issuing of incomplete substantial information, variations to scope, contract interpretations are also cause to the arise disputes. Thus Mitkus and Mitkus (2014) revealed poor management, inadequate design, unrealistic tendering, unrealistic client expectations and inadequate contract drafting also are the causes of disputes.

2.3. EFFECTS OF CONTRACTUAL DISPUTES

When a dispute arises during the execution of the project, it can affect to fulfill objectives and the business relationships between the contract parties to the project (Fernandezsolis, 2008). If the constructions disputes are not properly manage, those are cause to the project delays, increase project costs, undermine team spirit and damage business relationships (Cheung and Suen, 2002). According to the Cheung *et al*., (2000) disputes need resolve through dispute resolution methods. Lengthy duration of the dispute resolution process, suspension of works due to contractor or client faults affect to project delays (Cheung, 1999). He further stated huge cost required as professional fees for dispute resolution, locations for dispute resolution process, administration charges, prepare submissions and other legal costs. Further Armes (2011), he revealed through findings of the research, prevention cost is lower than remedies to the disputes. Therefore final solution is use avoidance strategies at early stage of the projects to avoid disputes.

2.4. *CONTRACTUAL DISPUTE AVOIDANCE STRATEGIES*

Clearly hindsight only the solution to mitigate contractual disputes is used dispute avoidance strategies betterment for the anticipated problems during the construction (Armes, 2011). The dispute avoidance techniques create the team work and harmony, by that prevents arising disputes (Cheung, 1999). However contract administrators and project participants need to identify the contractual dispute avoidance strategies to success the project (Kumaraswamy, 1997). Some forms of contract includes provision to formalize risk register which can be help to decision making in the event a problem arises (Armes, 2011). Risk register identify the risks associated with the project, then set out how those risks might be managed and identify the time and cost associated to managing those risks (Blismas *et al*., 2008). According to the CRCCI (2009), the dispute avoidance check list can be used to elimination or minimisation of causes of disputes and avoid the risk of disputes and wasted effort at the beginning of the projects.

American Arbitration Association [AAA] (2009) explained most of the disputes arise due to ambiguities in contract documents and then proper contract documentation use as important dispute avoidance strategy. Armes (2011) explained contract administrators can use good programme which is regularly updated can help to administrate the construction process and always avoid the disputes. Different forms of procurement methods allocate risk in different ways. The selection of appropriate procurement method which is most satisfactory for the work to be undertaken and by considering the aspirations of the Employer and the likely aspirations of the Contractor, some disputes can be avoided. Dispute Adjudication Board (DAB) or Dispute Resolution Board (DRB) is a full time standing board normally has a duty to monitor the project in ways that enable the warning signs of possible disputes to be recognized (Armes, 2011). The On-Site Neutral is selected at the commencement of the project by the contract parties to facilitate timely resolutions and to minimize the arisen of disputes during the execution period of the project (AAA, 2007). On-Site Neutrals assists in identifying on-site problems which deal with the day to day activities of the projects by contract parties and advice risk assignment and risk management strategies.

2.5. *ALTERNATIVE DISPUTE RESOLUTION (ADR) METHODS*

Alternative Dispute Resolution (ADR) is general term circumscribe various techniques for resolving disputes outside of court system (Teo and Aibinu, 2007). This statement was supported by Hedemann (1991) stating that the ADR includes dispute resolution processes and techniques that act as alternatives for disputant parties to come to settlement apart from litigation.

Negotiation is the first and informal method to resolve disputes and does not involve third party in the process of resolution (Marzouk and Moamen, 2009). In negotiation disputant parties attempt to communicate the grievance and negotiate for a settlement. The most disputes are resolve by this process due to the disputant's preference (Cheung *et al*., 2000). The mediation procedure starts normally negotiation process becomes unsuccessful or otherwise with the mutual agreement of disputant parties before conduct negotiation (Cheung and Yiu, 2007). Mediation is a process in which a neutral person facilitates communication between the disputant parties and, without deciding the final decision or imposing on the parties enables them to understand and to reach a mutually agreeable resolution to their dispute (Marzouk and Moamen, 2009). Turker (2005) have recommended referring to the adjudicator for decision which cannot be resolved first by the disputant parties by themselves. The neutral third party called as adjudicator refer the dispute and resolve by the adjudicator. Adjudicator decision is binding on the parties (Newman, 1999). Arbitration process involves a neutral and independent third party or parties appointed by disputant parties to hear the disputes with evidences and arguments present by the parties involved in dispute. The decision given by the arbitrators called as arbitral award and decision is binding (White, 2008).

2.6. *CRITICAL ATTRIBUTES IN ADR METHODS*

Alternative Dispute Resolution is a contractual dispute resolution mechanisms and selection of appropriate method depends on the agreement level between the contract parties (Bekele, 2005). The key is to understand the proper application and relevant benefits of each ADR method understand the attributes of the dispute resolution. The ADR methods characteristics are duration of the process, involvement of neutral, confidentiality of the process, binding or non-bonding of the decision, confidentiality of the process, enforceability of the decision, cost of the process, preservation of business relationship and higher degree of control by parties differ from method to method (Goldberg *et al*., 1999). Similar to above findings Cheung and Suen (2002) identified critical attributes are cost, time duration, degree of control by the parties, flexibility, confidentiality, voluntariness, enforceability, binding decision and privacy. Cheung (1999) supports those attributes by presenting summarized five main attributes identified from thirteen attributes named settlement agreement, benefits, nature of the proceedings, outcome of the process and process of proceedings.

3. Research Methodology

The research initiated with a literature synthesis to mitigate contractual disputes in the construction industry. It was discussed in detail the survey approach which was selected as research approach of this research. The reason was nature of the particular topic of the research set as “what is the framework to mitigate contractual disputes in Sri Lankan construction industry”. Semi-structured interviews were conducted as the preliminary study and questionnaire survey were conducted as detailed survey. Semi-structured interviews conducted to gather details of practical situations of the contractual disputes in the industry and content analysis were used to analyses data. Questionnaire survey was used to rank the details gathered from interviews and literature survey. Questionnaire was MCQ type and data recorded using likert scale. One tailed t-test, RII and mean rating were used to analyses data collected through the questionnaire survey.

4. Research Findings

Data was collected through questionnaire survey conducted among contract administrators practicing in Sri Lanka and semi-structured interviews were conducted among practitioners having expertise with Dispute resolution. Presented data was analyzed from various perspectives to understand the inter relationships between variables and underlying truths to demonstrate a clear understanding on the research findings.

4.1. Characteristic of the Survey Sample

The profile of the respondents of the questionnaire survey are classified according to the type of organization they are attached to, their working experience, working sector respectively in Figures 1, 2, and 3 for further analysis to be interpreted.

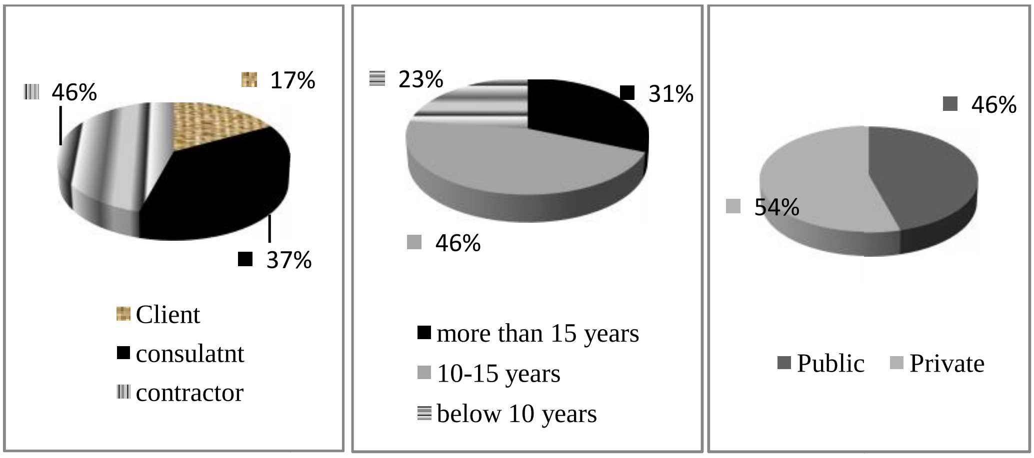

Figure 1: Respondent Profile Based on Type of Organization, Based on Experience and Based on Working Sector

4.2. *RESULTS OF ONE TAIL T-TEST*

Areas, causes and effects of contractual disputes, dispute avoidance strategies and attributes in alternative dispute resolution methods were analyzed using statistical tool t-test. In order to identify the significance a one tailed t-test was carried out with the following hypothesis. Hypothesis involves the phrase “greater than”, and with a specific direction of values distribution, one tailed t-test was used. To the t-test, Null hypothesis; H0 :$u \leq uo$ against the Alternative hypothesis; H1 : $u>uo$, where *uo,* is the neutral point in likert scale. In the analysis of all the data sets *uo* was fixed at 3 because, by definition, Likert scale distribute from 1 to 5 and given in the rating scale 3 is neutral.

Since this is one-tailed t-test, factors which have obtained more than critical t-value 1.6955 (from the table of critical t-values) and less than 0.05 significance level and degree of freedom (df) of 34 from t-value table. Thus in the analysis factors, if the observed t value is greater than the critical t-value are considered as very significant, then the null hypothesis is rejected and alternative hypothesis is accepted. This can also be proven by maintaining a lower significance (*p*-value) than 0.05. Results of the test on questionnaire survey are tabulated as follows. Data collected from interview are incorporated into the research findings.

Table 1: Areas of Contractual Disputes

Areas of contractual disputes	Mean Rating	Std. Dev.	t-Value	Significance	Rank
General Causes	3.914	1.422	3.80	0.000	1
Contractor Related Causes	3.657	1.305	2.98	0.003	2
Owner Related Causes	3.629	1.308	2.84	0.004	3
Consultant Related Causes	3.514	1.358	2.24	0.016	4
Third party Related Causes	3.457	1.559	1.73	0.046	5

Table 2: Causes of Contractual Disputes

Causes of contractual disputes	Mean Rating	Std. Dev.	t-Value	Significance	Rank
Ambiguities in Contract Document	4.343	1.083	7.33	0.000	1
Delays in Work Progress	4.000	1.111	5.32	0.000	2
Design Errors and Omissions	4.057	1.187	5.27	0.000	3
Change of Scope	3.914	1.147	4.72	0.000	4
Inadequate Contract Drafting	3.857	1.141	4.44	0.000	5
Improper Administration	3.771	1.114	4.10	0.000	6
Subcontractor problems	3.800	1.208	3.92	0.000	7
Any Rejected Claim	3.686	1.051	3.86	0.000	8
Excessive contract variations	3.829	1.294	3.79	0.000	9
Different Interpretations in conditions of contract	3.771	1.262	3.62	0.000	10
Claim validity Absence of Notice requirements	3.457	0.817	3.31	0.001	11
Payment Delays	3.629	1.165	3.19	0.002	12
Late Giving of Possession	3.600	1.143	3.11	0.002	13
Inadequate or Incomplete Specification	3.543	1.197	2.68	0.006	14
Availability of Information	3.514	1.147	2.65	0.006	15
Entitlement and Quantification of EOT	3.371	1.003	2.19	0.018	16
Adverse Weather	3.400	1.090	2.17	0.019	17

Causes of contractual disputes	Mean Rating	Std. Dev.	t-Value	Significance	Rank
Entitlement for Price Escalation	3.343	0.968	2.09	0.022	18
Quantification of Liquidated Damages	3.314	0.932	1.99	0.027	19
Market Inflation	3.343	1.027	1.97	0.028	20
Risk Allocation	3.314	0.993	1.87	0.035	21
Time for issuing Taking Over Certificate	3.371	1.239	1.76	0.042	22
Changing Government Codes	3.286	0.987	1.71	0.048	23
Determine Defect Liability Period	2.943	1.027	-0.33	0.628	24
Technical inadequacy of the Contractor	2.771	1.262	-1.07	0.854	25
Contractor’s Financial failure	2.600	0.736	-3.22	0.999	26

Table 3: Effectsof Contractual Disputes

Effects of contractual disputes	Mean Rating	Std. Dev.	T Value	Significance	Rank
Cost Overruns	3.914	1.269	4.26	0.000	1
Project Delays	3.829	1.294	3.79	0.000	2
Costly Dispute Resolution Methods	3.514	0.818	3.72	0.000	3
Damage Business Relationship	3.371	1.165	1.89	0.034	4
Cancellation of contracts	3.343	1.162	1.75	0.045	5
Reduce the Performance of the project	2.457	1.12	-2.87	0.996	6

Table 4: Contractual Dispute Avoidance Strategies

Contractual dispute avoidance strategies	Mean Rating	Std. Dev.	T Value	Significance	Rank
Proper Contract Documentation	4.257	0.95	7.83	0.000	1
Proper Coordination Between contract documents	4.143	1.004	6.73	0.000	2
Proper Contract Administration	4.057	1.187	5.27	0.000	3
Select most appropriate procurement method	3.857	0.974	5.20	0.000	4
Early Notification and Resolution of dispute	3.771	1.060	4.31	0.000	5
Negotiation in an event of Differentiate in matter	3.629	1.262	2.95	0.003	6
Equitable Sharing of Risks	3.400	1.193	1.98	0.028	7

Table 5: Attributes in Alternative Dispute Resolution Methods

Variable	Mean Rating	Std. Dev.	T Value	Significance	Rank
Duration of the proceeding	4.143	0.912	7.41	0.000	1
Obtaining fairness decision	3.857	0.974	5.20	0.000	2
Binding and enforceability of the decision	3.743	0.919	4.78	0.000	3
Confidentiality of the process	3.686	0.900	4.51	0.000	4
Cost for the process	3.571	1.008	3.35	0.001	5

4.3. *RESULTS OF RELATIVE IMPORTANT INDEX AND MEAN RATING*

Questionnaire survey was indicated the five attributes in the Alternative Dispute Resolution methods and respondents were asked to rank those attributes in separately considering the significance to the negotiation, mediation, adjudication and arbitration process, considering the five attributes in Alternative Dispute Resolution methods.

Table 6: Behaviour of Attributes in Alternative Dispute Resolution Methods

Duration of the Proceeding	Obtaining Fairness Decision	Binding and Enforceability of the Decision	Confidentiality of the Process	Cost for the Process	Rank
Arbitration	Mediation	Arbitration	Negotiation	Arbitration	1
Negotiation	Negotiation	Adjudication	Mediation	Adjudication	2
Mediation	Adjudication	Mediation	Adjudication	Mediation	3
Adjudication	Arbitration	Negotiation	Arbitration	Negotiation	4

4.4. *FRAMEWORK TO MITIGATE CONTRACTUAL DISPUTES IN SRI LANKAN CONSTRUCTION INDUSTRY*

In accordance with the literature findings, it was identified six stages to mitigate the contractual disputes in construction industry. Those are establish context, identify potential contractual disputes, analyse potential contractual disputes, evaluate potential contractual disputes, threat the causes of contractual disputes, contractual dispute resolution using informal resolution methods or dispute resolution using formal resolution methods. According to the research findings most critical causes of disputes, effects, dispute avoidance strategies and resolution methods were identified.

4.4.1. *ESTABLISH THE CONTEXT*

This is the first and basic step of the dispute mitigation process. In this step external project environment (Areas of third party related causes), internal project environment (Areas of general causes, Areas of owner related causes, Areas of consultant related causes, Areas of contractor related causes) and the dispute mitigation strategies (proper contract documentation, proper contract administration, proper coordination between the contract document, negotiation in an event of differentiate in matter, early notification and resolution of issues, select most appropriate procurement method and equitable sharing risks) needs to be clearly identified at very beginning of the project. This is the foundation step for other six steps and this step implement to achieve following key drivers of the project.

- Clearly and equally share the risks of the project
- Enhance the problem solving before escalate to dispute
- Implement the keep business relationships
- Complete the project on time with estimated budget

Establishing the context weaknesses and strength of the project can be identified. Then set up the mitigation strategies at early stage of the project.

4.4.2. *IDENTIFY POTENTIAL CONTRACTUAL DISPUTES*

This is the second step of the dispute mitigation framework. This categorize into three sub steps.

I. Method of identify potential disputes

As identified in the literature findings (CRCCI, 2009) it can be used dispute avoidance checklists, risk registers and expert opinions such as contract administrators and project managers to identify the potential disputes exist within the project.

II. Identify the areas of potential contractual disputes
III. Identify the causes of potential contractual disputes

4.4.3. *ANALYSE POTENTIAL CONTRACTUAL DISPUTES*

This is the third step of the dispute mitigation framework. Under this step analyze the effect of potential contractual disputes accordance with the identified findings.

4.4.4. *EVALUATE POTENTIAL CONTRACTUAL DISPUTES*

This is the fourth step of the dispute mitigation framework. This categorize into two sub steps.

I. Compare potential contractual disputes identified and evaluate with criteria

In accordance with the research questionnaire survey findings areas of potential contractual disputes, causes of potential contractual disputes, effects of potential contractual disputes should be compare and evaluated using the criteria which are based on the rankings of the particular contractual disputes.

II. Set priorities

In accordance with the research questionnaire survey findings areas of potential contractual disputes, causes of potential contractual disputes, effects of potential contractual disputes should be prioritized based on the rankings of the particular contractual disputes.

4.4.5. *TREAT THE CAUSES OF CONTRACTUAL DISPUTES*

This is the fifth step of the dispute mitigation framework. In this step need to prepare plans how to treat the root and proximate cause of contractual disputes and existence dispute avoidance strategies need to take place accordance with their significance identified in the research findings.

4.4.6. *CONTRACTUAL DISPUTE RESOLUTION*

This is the sixth and last step of the dispute mitigation framework. If the potential contractual disputes are could not mitigate then needs to resolve the disputes using dispute resolution methods. This categorize into two sub steps.

I. Identify the factors affect to the selection of Alternative Dispute Resolution methods
II. Selection of Alternative Dispute Resolution methods according to the attributes of the ADR methods.

While conducting the above steps project participants need to be communicate, consult, monitor and review the progress of the process to success the contractual dispute mitigation process.

5. CONCLUSIONS

Disputes have become an inherent feature of the construction industry. Most of the disputes arise due to contractual matters in the construction industry. However in Sri Lanka, there have not been conducted dispute avoidance and settlement procedure together and this study anticipates to fills that research gap. As a recommendation before project commencement contractual dispute mitigation needs to be implemented and throughout the project duration hole the process continuously needs to be process.

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GAPS IN PUBLIC PROCUREMENT PROCESS IN SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Procurement Process is back bone of the country to achieve the economic development. Accordingly, since 2006, government of Sri Lanka has made significant efforts toward to reform and develop the Public Procurement Process (Public PP) in construction industry with the assistance of the Ministry of Finance and Planning (MOFP), the Construction Industry Development Authority (CIDA), foreign funding agencies, and relevant institutions and practitioners. Current regime is in process of formulating a sustainable framework to the Public PP not only to the construction industry but also to the entire industries.

Thus aim of this paper is to carryout comprehensive diagnosis to identify the gaps in Public PP in Sri Lankan construction industry and propose remedial measures to bridge the gaps in order to facilitate the government endeavour. Paper is based on secondary data and opinions of experts. The gaps are identified as absence of procurement strategy and legislative framework, lack of integration with governance, unavailability of procurement regulatory body, and Incapable Capacity Development.

Further paper presents the remedial measures and provides recommendations to bridge the gaps that will enable to the GOSL to initiate the Sustainable Public Procurement Process (SPPP) to the construction industry. Findings revealed that establishment of procurement strategy and legislative framework, integration with governance, establishment of procurement regulatory body, and capacity development as the remedies in line with the short term, medium term, and long term measures to initiate and implement contemporary version of Public PP to the Sri Lankan Construction industry.

Keywords: *Public Procurement Process; Construction Industry; Sustainable Public Procurement Process; Gaps; Remedies.*

1. INTRODUCTION

Public Procurement Process (Public PP) identified as integral part to achieve the sustainable development (World Bank, 2012). The activities of the Public PP identified as continues processes from planning and risk assessment, selection of source, evaluation of alternative solutions, contract award, payment, and management of a contract up to the end of defect liability period (Murray, 2009; World Bank, 2010; Zheng *et al*., 2008). However, late delivery, cost overrun, low efficiency and poor quality have been discovered as widespread challenges in existing construction projects of developing or developed countries as a result of gaps and deficiency of the activities of the Public PP (Weisheng *et al*., 2013). Absence of procurement strategy and legislative framework, lack of integration with governance, absence of procurement regulatory body, and incapable capacity development are the main gaps in Sri Lankan context for these challenges (World Bank and Asian Development Bank, 2012). To bridge these gaps governments of Sri Lanka is searching for innovative solutions that can help construction projects in a more efficient way to achieve the value for money thus truly deliver value to society (World Bank and Asian Development Bank, 2012; Brammer and Walker, 2011).

Accordingly, in order to bridge the gaps, contemporary version of the existing procurement process is identified as cost effective alternative solution that link with requirement of external environment as per the global needs and which identified as sustainable procurement. Hence, Sustainable Public Procurement

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Process (SPPP) is in line with the triple bottom line indicators of economic, environmental and social to achieve the present global needs and uplift the economy and living standards of the country (Brammer and Walker, 2011; World Bank, 2012). However, government of Sri Lankan still try to initiate preliminary actions to bridge the gaps of the Public PP by formulating Legal and Regulatory Framework, enhancing capacity of Institutional Framework and Management, and establishing Electronic Government Procurement (e-GP) System to the Sri Lanka not only to the construction industry but also to the entire industries in the country through the 19th amendment of the constitution of Sri Lanka.

Thus, aim of this paper is to identify the gaps in Public PP in Sri Lankan construction industry and propose remedial measures to bridge the gaps through the literature and opinions of the experts in the field of procurement. Five numbers of procurement experts having more than 15 years of experience of the funding agencies, government ministries, and private institutions were interviewed. Consequently, scope of this paper includes Public PP in Sri Lankan construction industry, prevailing gaps of the existing Public PP in Sri Lankan Construction industry, remedies to the gaps of the Public PP in Sri Lankan Construction industry, and conclusion and way forward.

2. PUBLIC PROCUREMENT PROCESS OF CONSTRUCTION INDUSTRY IN SRI LANKA

The reigning political party has taken major steps to regularise the procurement process of the country in line with the 19th amendment to the constitution. This involved several inter related initiatives to enhance the procurement process of the country by increase the transparency and accountability of the Public PP, improve its effectiveness and efficiency in the delivery of projects, strengthen ability to incorporate public participation in policymaking, and reduce opportunities for corruption in Public PP. Accordingly Public PP in the country has been shown transition features since 2015 (CIDA, 2015a).

The government investment for major projects through the Public PP in the field of infrastructure has directly contributed to economic growth in Sri Lanka. In the early period of 1948-77, there was insufficient investment in infrastructure. During 1956-77, it was the public sector that undertook most of the investments. A number of state owned enterprises established proper procurement process to produce manufactured goods, including steel, mining, and chemicals. Hence, the incentives for private investment were limited, and public investment was restricted by resource constraints. However, in Sri Lanka overall investment rate was only 6.2% (Central Bank of Sri Lanka, 2014) of Gross Domestic Product (GDP) during the period from 2009 to 2010. Following the liberalization of the economy in 1977, investment was raised from 14.4% of GDP in 1977 to 33.8% in 1980, with an average of 27.6% during 1978-84 and in 2010 to 2012 the average of 30%. This was due to the ambitious of Public PP accompanying with reform after the 30 years of war (Central Bank of Sri Lanka, 2012; Central Bank of Sri Lanka, 2014; World Bank, 2010).

Further statistical figures of the Central Bank of Sri Lanka (2015) revealed that total expenditure of the government increased by 7.6% to Sri Lankan Rupees (Rs.) 1,796 billion in 2014 from Rs.1,669 billion in 2013. Furthermore, real gross domestic production (GDP) grew by 7.4% in 2014, in comparison to the growth of 7.2% in 2013. Moreover, Public Procurement expenditure is approximately 10 % of the GDP. Specially the construction sectoral growth, 20.2% of the GDP in 2014. Hence, Public PP in construction industry of the country will be an integral part in order to achieve desired aim of the economy. Therefore, enhancement and improvement of the activities of Public PP in Sri Lankan construction industry will be directly benefitted to the nation in order to achieve the economic development of the country.

Central Bank of Sri Lanka (2014) found that the Public PP in construction sector was the main driver of economic growth in Sri Lanka. Further author mentioned that it makes the most significant contribution, reflecting the massive public investment programmes and several private sector projects. Furthermore, it was identified that Public PP of construction industry in Sri Lanka hold major share of the Gross Domestic Products (GDP) as developing country. Moreover, noted that interest of the stakeholders has grown to moderate the existing process. Hence, contemporary version of the Public PP of the construction industry should be substantiated and will have to be met by both the public and private sectors requirement to optimum alignment with the vision of the medium term development plan of the country in line with the global needs (Central Bank of Sri Lanka, 2014). Accordingly, improvement of existing

Public PP in line with the global needs and requirements has positive impacts on the sustainable development of the country.

Administrative process of the Public PP of the country is implemented under the three authority levels: (i) Central Government, (ii) Provincial Councils, and (iii) Local Government in order to ensure effective public expenditure. Hence, effective and efficient improvement of activities of the Public PP positively affected to uplift the economy of the country (Central Bank of Sri Lanka, 2012). Elaborating in this regard further emphasised that government is major client and regulator in the construction procurement in Sri Lanka (CIDA, 2015b).

Therefore, the Public PP in construction industry should give equal weightage not only to the dimensions of time, cost and quality but also to the dimensions of social, environmental and economic when acquisition of goods, works and services with consideration of value for money in line with the requirements of the stakeholders and the global needs (Mohan, 2010). Accordingly, establishment of Legislative and Regulatory Framework, enhancement of capacity of Institutional Framework and Management, and establishing Electronic Government Procurement (e-GP) System will facilitate to bridge the existing gaps (World Bank and Asian Development Bank, 2012).

Accordingly, Institute for Construction Training and Development (ICTAD) was restructured and established as Construction Industry Development Authority (CIDA) as the prime institution to facilitate to the activities in construction industry in Sri Lanka. Further, Chamber of Construction Industry (CCI) Sri Lanka and Institute of Engineer's in Sri Lanka (IESL) play assistance role in order to facilitate to streamline the procurement activities in construction industry (CIDA, 2015a).

Towards that vision, the government development policy framework expressed that procurement process in national and provincial should be upgraded inter alia with formulate Legal and Regulatory Framework, enhancing capacity of Institutional Framework and Management, and establishing Electronic Government Procurement (e-GP) System (World Bank and Asian Development Bank, 2012).

3. PREVAILING GAPS OF THE "PUBLIC PP" IN SRI LANKAN CONSTRUCTION INDUSTRY

Many authors have identified gaps in the Public PP in deferent ways. The key areas of identification not limited only for the construction industry but also valid to the entire industries of the country. However, in this paper findings mainly focus to the Sri Lankan construction industry.

3.1. ABSENCE OF PROCUREMENT STRATEGY AND LEGISLATIVE FRAMEWORK TO THE CONSTRUCTION INDUSTRY

The country does not have the well-defined national public procurement strategy to measure the performance of the questions of what, when, how procure in terms of economy and efficiency. Further the absence of mechanism to identify the staff professionalization and capacity development needs. Furthermore, policy and regulatory framework not available to monitor and evaluate the performance other than the general accounts and audit aspects. Moreover, some important provisions of the government Procurement Guidelines are not enforced in the absence of a procurement act or law of the country. Accordingly, lesson learnt through the previous activities in construction sector will not be practised (World Bank and Asian Development Bank, 2012). However, developed countries clearly articulated the government's vision and long-term objectives for the implementation of national activities in sound, transparent and efficient manner. The existence procurement strategy not contributes to a sound Public PP to the construction industry and also to a more positive image to the foreign investors to invest in the country (Ey *et al*., 2014; Eriksson and Westerberg, 2011). Thus, absence of national and public procurement strategy for the country is identified main gaps in the industry. Further, the Public PP in Sri Lankan construction industry is not regulated by a law. Accordingly, Legal and Regulatory Framework in line with the global standards shall be enacted.

3.2. *LACK OF INTEGRATION WITH GOVERNANCE*

In global context, Governance will be a crucial part of the Sustainable Development Goals of the country. However, there are also different ways of integrating key aspects of governance into the construction industry. Good governance (the processes of decision-making and their institutional foundations), effective governance (the capacity of countries to pursue sustainable development), and equitable governance (distributive outcomes). These three different aspects have a number of inter connections between each other and require separate political efforts to achieve the outcome (Foresti *et al*., 2014; Sustainable Development Solutions Network, 2014). Accordingly, when consider the Sri Lankan context it was revealed that the integration of procurement reform actions were not being conducted between relevant public and private institutions. Activities for reform the industry had been conducted in ad-hoc manner including planning, budgeting, implementation, delegation, approval, monitoring and evaluation of activities in construction projects (CIDA, 2015a). However, good governance refers broadly to a set of qualitative characteristics relating to processes of rulemaking and their institutional foundations in construction industry. The good governance encapsulates values such as enhanced participation, transparency, accountability, and public access to information. It also helps to combat corruption and secure both basic human rights and the rule of law (Foresti *et al.*, 2014). Accordingly, activities of the construction industry and relevant institutions in national and provincial level shall be interlinked to formulate the broad agenda of the good governance in construction industry.

3.3. *UNAVAILABILITY OF PROCUREMENT REGULATORY BODY*

National Procurement Agency (2006a, 2006b); World Bank and Asian Development Bank (2012) noted that Ministry of Finance and planning (MOFP) is conducting prime role of the country regulating procurement actions. The CIDA, CCI, IESL facilitate to the MOFP to formulate the procurement regulations in construction industry. However, the country doesn’t have regulatory framework between the MOFP, CIDA, CCI, and IESL effective and sustainable reform of construction industry except issuing supplements to the procurement guidelines and manuals with some procurement activities in the Public PP, develop Standard Bidding Documents (SBDs) and technical specifications, and conduct training programmes and workshops for the activities in construction industry (CIDA, 2015b; World Bank and Asian Development Bank, 2012). Hence, initiate and develop the sustainable network between regulatory bodies in construction industry in line with the good governance agenda is one of the prevailing gap.

3.4. *INCAPABLE CAPACITY DEVELOPMENT*

Available human resources with up to date knowledge of current trends in procurement in construction industry and support from the top management also identified as major gaps to implementation of activities of the Public PP in line with global needs requires reforms in the areas of policies and investments in technology, research, education and information. Further functions of the public procurement process not yet professionalize and officers involved in the activities of the procurement process does not fulfilled the requirement of procurement professionals in construction industry (World Bank, 2010; Biller and Nabi, 2013). Further, need assessments and formulating the capacity building strategies in construction industry are not identified by the any of the government institutions other than the ad-hoc trainings of the Sri Lanka Institute for Development Administration (SLIDA), Ministry of Public Administration (MPA), Academy of Financial Services (AFS), CIDA, CCI, and IESL. Accordingly the funding agencies have taken actions to analysis the existing Public PP in Sri Lanka in order to upgrade and enhance the process in line with global needs. Thus the actions are revealed by the government and funding agencies to bridge the existing gaps of Public PP in Sri Lankan construction industry (World Bank and Asian Development Bank, 2012; Biller and Nabi, 2013).

E-Government Policy approved by the cabinet of ministers in Sri Lanka by 2009 in order to facilitate to upgrade the infrastructure capacity of information technology to improve the efficiency and effectiveness of Public PP. However, Lee *et al*. (2007) pointed out that valid Information Technology act and Law should be in acted in advance to implement the procurement activities of of e-procurement. Accordingly, implementation of e-Government procurement actions are limited to publish the invitation for bid (IFB) on the website in addition to the paper advertisement published in national newspapers (World Bank and Asian Development Bank, 2012).

Thus literature revealed that number of gaps of the Public PP in construction industry as obstacles to deliver the desired outcome of the stakeholders in compatible with the global needs and requirements. Moreover it was identified that the interest to upgrade the Public PP in construction industry has been increased by the stakeholders in line with the 19th amendments of the constitution of Sri Lanka. Further, the funding agencies has given consent to provide financial assistance to upgrade the existing procurement system together with the capacity development of the industry.

4. Remedies to the Gaps of the "Public PP" in Sri Lankan Construction Industry

4.1. Establishment of Procurement Strategy and Legislative Framework to the Construction Industry

Establishment of a national public procurement strategy for procurement reform in construction industry that sets out the goals of social environment and economic those to be achieved in line with the national strategy is vital requirement of the sustainable development of the economy. Hence, it is imperative to formulate clearly defined national and provincial procurement strategy on public procurement in construction industry. The procurement strategy shall clearly articulates the government's vision and long term objectives for the implementation of a sound, transparent and efficient public procurement system in construction industry. However, in accordance with the 19th amendments of the constitution initial actions are being taken to formulate the strategy which contributes to a sound procurement system and also to a more positive country business image toward foreign funding agencies and investors. Accordingly, implementation of initial actions are identified as remedies to establish the national procurement strategy (CIDA, 2015b; World Bank and Asian Development Bank, 2012).

The enactment and implementation of procurement law for the construction industry is the remedy on establishment of legislative framework as described by the World Bank and Asian Development Bank, 2012. Review the existing bidding documents in construction industry and extend the procedure for construction dispute in line with the enhancement of procurement law and build-up relationship between the relevant institution and authorities are the key remedies to formulate the legislative framework for construction industry (CIDA, 2015b).

4.2. Integration with Governance

Good governance, effective governance, and equitable governance were identified major elements of the developing path of the economy (Raymond, 2008). Further Raymond (2008) and World Bank and Asian Development Bank (2012) explored that internal and external arrangement shall be made to address the gaps of the existing Public PP to achieve the desired outcome. Accordingly, actions are being identified by the government of Sri Lanka to integrate the governance under the 19th amendments to the constitution as remedy the existing gaps of the procurement process in construction industry (CIDA, 2015b). Hence, better integration of procurement reform of the institutions in line with the broader governance reform agenda that shall link with the external environment of public administration, civil service reforms, and audit is identified as possible remedies to bridge the gaps. Further, actions for integrate the activities of the individual institutions on procurement planning, budgeting, delegation, and approval mechanisms in line with broad objectives of the institution also identify remedies for the prevailing gaps (Raymond, 2008; Williams *et al.*, 2007; World Bank, 2012).

4.3. Establishment of Procurement Regulatory Body

Since 2008, the procurement regulatory body has not been existed in the country from the date of dissolved the National Procurement Agency (NPA). Further World Bank and Asian Development Bank (2012) noted that Procurement Department of the Ministry of Finance and Planning (MOFP) need to be strengthen in terms of both status and capacity, in order to effectively perform as a regulatory body. Biller and Nabi (2013) highlighted that establishment of regulatory body will facilitate to provide advice to the institutions in construction industry, to make improvement to the legislative and regulatory framework, to monitor and review the public procurement performance, to provide information and reports to the relevant parties, and to provide support on training and capacity development of procuring entities. Accordingly, the actions are being explored to established independent authorised body by the government of Sri Lanka under the purview of national procurement commission as a remedy in collaboration with the foreign funding agencies (CIDA, 2015b; World Bank and Asian Development Bank, 2012).

4.4. CAPACITY DEVELOPMENT IN LINE WITH NATIONAL PROCUREMENT STRATEGY

CIDA (2014) revealed that lack of sufficient human resources and organizational capacity in construction industry for ensuring the efficient and effective implementation of the rules, regulations, and procedures of the procurement process shall be addressed through sustainable capacity building programmes. Moreover World Bank and Asian Development Bank (2012) noted that strengthening the government institutions for initiate and implement capacity building programmes on construction industry policy and public procurement regulatory function facilitate to formulate the public procurement development agenda in line with the construction industry policy. CIDA (2015b) noted that establishment of independent national commissions will stream line future activities of capacity development as a remedy to the existing gaps of the procurement process in construction industry. Accordingly national strategy on capacity development in the field of procurement is formulated by the government of Sri Lanka with the coordination of MOFP, MPA, SLIDA, AFS, CIDA, CCI, and IESL.

4.5. CAPACITY DEVELOPMENT IN INFORMATION TECHNOLOGY AND INTRODUCTION OF E-GOVERNMENT PROCUREMENT

Brammer and Walker (2011) highlighted that e-government procurement used by the countries as successful tool to bridge the existing gaps of the procurement process and it will facilitate to take initiatives towards the sustainable public procurement process (SPPP) in construction industry. E-government procurement process to be considered by the government of Sri Lanka to implement with the assistance of the foreign funding agency with the approval of the cabinet of ministers on e-government policy in 2009 (World Bank and Asian Development Bank, 2012).

Hence literature revealed gaps and remedial measures to the Public PP in construction industry under the key elements to identify the initiatives to take appropriate actions to bridge the gaps in order to facilitate to formulate the SPPP to the Sri Lankan construction industry. Moreover, it was identified that the interest to upgrade the Public PP in construction industry has been increased by the stakeholders in line with the 19th amendment of the constitution of Sri Lanka and concept of sustainable development as per the global needs and requirements. Hence, findings of the literature revealed that implementation actions of formulation of SPPP shall be done through the short term, medium term, and long term measures by bridging the gaps of the existing Public PP towards the development objectives of the country with the assistance of the funding agencies.

5. DISCUSSION

As a result of the findings through the opinions of the experts justify and reconfirm the significant gaps of the existing Public PP in the Sri Lankan construction industry in line with the 19th amendments to the constitution of Sri Lanka. Though, the findings through the literature confirmed by the experts to bridge the gaps through the short, medium, and long term measures.

The experts in the construction industry pointed out that the construction industry is an open system, hence, which is very sensitive to change with the needs and requirements of the stakeholders; further, its characterisation throughout the world is determined by the operating external environment, which consists of subsystems such as economic, political, financial, legal and technological. Further, emphasised that this has leaded the industry to be in a challenging state in addressing the gaps of the subsystems in an efficient and effective manner to achieve the target of contemporary version of the Public PP.

Thus, the practitioners pointed out that the construction industry in Sri Lanka is striving to tackle current improvements of the 19th amendments of the constitution of Sri Lanka through the innovative ways of construction, efficient resource utilization and better organisation of projects to bridge the identified gaps through the explored remedies of the literature.

Consequently, the findings through the literature and opinions of the experts confirmed that; the Public PP in the Sri Lankan construction industry also subject to changes resulting in adopting many newly innovated procurement systems through the short, medium, and long term measures that could be used to meet contemporary requirements. Further, the experts explained that the governments should take the full range of economic, social and environmental costs and benefits of public procurement into account for the sustainable improvement of the economy. Sustainability means the capacity to maintain the entity, outcome, or process over the period of time. The concept of sustainability came to public attention after the 1972 based on the report of “Limits of Growth” that issued by the international think tank Club of Rome. The SPPP is contemporary version of the existing Public PP and affected to potential saving of costs of the procured goods, works and services (CIDA, 2015b; Brammer and Walker, 2011; World Bank and Asian Development Bank, 2012). However, the experts argued that enactment of sustainable national procurement strategy to the country and change the attitude of the officers and stakeholders will be critical tasks to establish the SPPP.

Moreover, findings revealed that well regulated Public PP has direct impact to expedite the sustainable development of the country since the Public PP contribute to the budget of the developing nations is often large (about 20% of the GDP). This will be expanded and visible in terms of short, medium, and long term measures as shown in Figure 1.

According to the findings through the literature and opinions of the experts following recommendations are offered to implement the short term, medium term, and long term measures in order to initiate the activities of the contemporary version of Public PP to the Sri Lankan Construction industry as shows in Figure 1.

Establishment of regulatory and legislative framework shall be initiated through the preparation of national procurement strategy and update the procurement guidelines and manuals, bidding documents, rules and regulations in line with sustainable elements as short and medium term measures in line with Figure 1. Further as highlighted in Figure 1 introduce and implementation of sustainable public procurement act also identified as long term measure in accordance with the point of views of the experts,

Integration with Governance shall be done by introducing the initial activities of the good governance, effective governance, and equitable governance to the construction industry as short term. Further as medium term measures integrate the internal and external strengths to implement the activities of the good governance, effective governance, and equitable governance to the construction industry. Furthermore, as long term measure establish the institution to sustainable reform the procurement process of the country in line with the broader governance reform agenda that link with the perspectives of external environment of public administration, civil service reforms, and audit in line with the identification of Figure 1.

Establishment of Procurement Regulatory Body shall be implemented by initiating preliminary actions to establish the independent authorised division or department under the Ministry of Finance and Planning to inspect, monitor, and control the procurement activities of the construction industry in national and provincial levels under the purview of national procurement commission as short and medium term measures in line with Figure 1. Moreover, Figure 1 shows as long term measure to carry out an in-depth review and analysis on entire institutions involved in activities of procurement and establish sustainable integration between the institutions and authorities. Further establishment of empowered independent authorised national body as main pillar to initiate and implement the SPPP to the country.

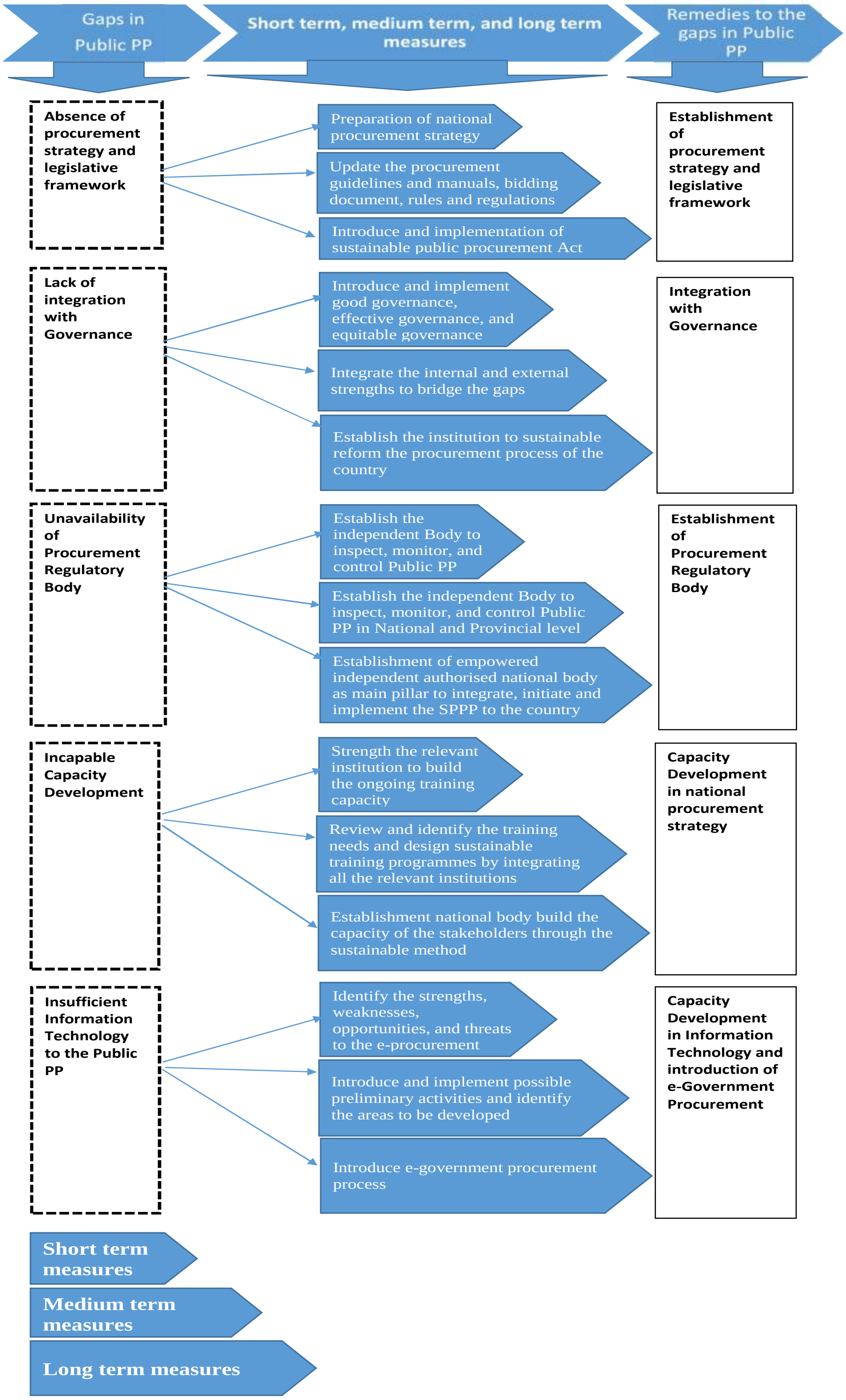

Figure 1: Short, Medium and Long Term Measures to Reach the Contemporary Version of Public PP

Capacity development in line with national procurement strategy shall be executed by strengthening the institutions of MOFP, MPA, SLIDA, AFS, CIDA, CCI, and IESL to provide regular capacity building programmes to cater the demand of the industry and identify the training needs through the diagnosis review of the existing Public PP to avoid the repetitions and minimise the waste of government funds as highlighted in Figure I under the short term measures. Further as long term measure to establish national body to build the capacity of the stakeholders in the field of procurement, and finally.

Introduction of e-government procurement shall be commenced by conducting the diagnosis review to identify the strengths, weaknesses, opportunities, and threats towards introduce and implement the e-procurement process to the construction industry as short term as shows in Figure 1. Further as medium term measures introduce and implement possible preliminary activities on e-government procurement process and identify the areas and infrastructure to be developed to implement entire framework of e-government procurement process. Furthermore, Figure 1 indicates that introduce e-government procurement process to the construction industry as long term measure as per the opinions of the experts.

6. CONCLUSION AND IMPLEMENTATION

The aim of this paper is to identify the gaps in Public PP in Sri Lankan construction industry and propose remedial measures to bridge the gaps. The objective of the paper is to discuss critically on prevailing gaps with special attention to the areas on policy and practices, and government of Sri Lanka's (GOSL) ongoing efforts for the future development of Public PP in line with the identified remedial measures towards the desired achievements of the 19th amendments of the constitution of Sri Lanka in order to fulfil the requirement of the stakeholders of the Public PP in Sri Lankan construction industry in line with the global needs.

As mentioned, Figure 1 findings revealed that how to address the identified gaps through the short term (within 03 years), medium term (within 05 years), and long term measures (more than 05 years) to implement the contemporary version of Public PP to the Sri Lankan Construction industry. Hence through the literature and the opinions of the experts in the field of procurement identified the feasibility of adopting those measures to the Sri Lankan construction industry. Further, measures to bridge the gaps were explored through the in-depth analysis in line with the identified data.

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IMPLEMENTATION OF BUILDING INFORMATION MODELLING WITHIN CONSTRUCTION SMES

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ABSTRACT

Building Information Modelling (BIM) is promoted as a requisite to improve construction project performance. In the UK, the Government has set the construction industry targets to attain with timescales, such as achieving the BIM Level 2 for all government projects by the year 2016. In terms of the UK construction sector, over 86% of employees work within small and medium sized enterprises (SME), and are responsible for 75% of the turnover. However, BIM implementation within the SME sector is considerably low. As such, SMEs may be left behind in the BIM journey, thereby hindering the policy level targets.

This research was aimed at identifying the key barriers to the implementation of BIM within the construction SMEs in the UK. The data were collected through a literature review, questionnaire survey and four semi-structured interviews.

The findings reveal lack of investment and commitment to resource to skill development in relation to BIM, and the absence of incentives within the government procurement processes as significant among the several barriers to the implementation of BIM within the UK construction SMEs. Despite the UK government's intention that at least 25% of all central government contracts should be awarded to SME businesses by 2015, many construction SME firms are finding it difficult to win public sector work. Therefore, the research findings highlight implications for both policy and practice. For the macro level policy makers, the non-consideration of the diversity and the market dynamics the construction industry may lead to unrealistic policy level targets being developed. For the construction industry and its firms, it is high time to reflect on their current practices and the level of commitment to resource skill development and continuous improvement.

Keywords: *BIM; SMEs; Barriers; Construction Industry; United Kingdom.*

1. INTRODUCTION

The construction industry contributes in average of £100 billion per annum to the UK economy, which represents 7% of GDP (Rhodes, 2015). With the industry being such important and complex (engaging number of stakeholders with different influence and interest), it is important that new methods are constantly developed to respond to the increasing complexity of the construction industry (Bryde *et al.*, 2013). The latest technology introduced to the construction industry is Building Information Modelling (BIM) which has a significant potential to bring positive impacts to the effective delivery of project goals (Poirier *et al*., 2015). BIM provides a robust platform to share and reuse project information, which highly benefit in through-life project management. There are variety of definitions for BIM, however this study adopted BIM as "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design project and data in digital format throughout the building's life-cycle" (Bryde *et al*., 2013, p. 971) as it is closely focused on construction context.

Although BIM is new to the construction industry, its concept has been around since 1970's, dominantly in the manufacturing and engineering sector (Cain, 2003). Construction is always blamed for poor

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performance (Latham, 1994; Egan, 1998). However, it has high potentials to improve as manufacturing and production industries, where there is a clear system in place that visualises the production flow, in which everything is scheduled in advance with all work carried out to an agreed time table, resulting in reduced waste (Bossom 1934 cited by Cain 2003). The report 'Construction 2025' (HM Government, 2013) emphasises the desperate need to restructure the industry through adopting modern methods to its products and processes to make the industry more smart, competitive and efficient. As a result, the UK government has now mandated for a fully collaborative 3D BIM as a minimum by 2016 to be used in all government procured projects.

However, as an industry it is lacking knowledge and experience of how the adoption of BIM can be helped to fulfil the visions of Construction Strategy 2025 (NBS, 2015). Lack of knowledge and understanding on BIM is identified as a key barrier, making it incredibly hard for organisations to get on board; in particular small and medium sized enterprises (SMEs) (Open BIM Network, 2012). SMEs contribute over 99% of the 3.7 million trading businesses in the UK, accounting for two thirds of the construction industry. 52% of these employees are employed by organisations of less than 115 employees and 96% are thought to have less than 8 employees (Federation of Master Builders, 2013; HM Government, 2013). Many researchers and practitioners are still unclear 'why' BIM should be adopted and 'what' are the factors that influence BIM implementation, resulting in its acceptance and use remaining a central concern (Azhar, 2011). Current statistics show the limited implementation of BIM within the construction SMEs UK. This paper aims to identify the significant barriers for implementing BIM within construction SMEs.

2. ADOPTED RESEARCH METHODS

Several methods were adopted to collect data for this study. A literature review was conducted to identify the principles and practices of BIM and further to understand its current application within construction context. An online questionnaire was designed through 'survey monkey' software and distributed among 100 construction industry professionals whose industry experience varies from less than 5 years to over 30 years. The respondents were from different disciplines (architecture, quantity surveying, construction management and engineering disciplines) who workin large to small construction organisations. The response rate to this online questionnaire is 31%. Survey data were analysed through descriptive statistics. In addition, four semi-structured interviews were undertaken among two quantity surveyors, one construction manager and a facilities manager who have already adopted BIM within their practices.

3. BUILDING INFORMATION MODELLING

Building Information Modelling has given number of definitions in the current literature. Eastman *et al.* (2011) explain it as "a novel approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format" (Eastman *et al*, 2011). With reference to Smith and Tardif (2009), BIM is an enabling technology with the potential for improving communication, quality of information available for decision making, improving the quality of services delivered, reducing cycle time, and reducing cost at every stage in the life cycle of a building. Having identified the holistic nature of BIM, Bryde *et al.* (2013) explain that not only is it a useful software for geometric modelling of a buildings performance, but also it assists in the management of construction projects with potential to improve collaboration between stakeholders. On average, 70% of the life-cycle cost of a building is established through the decisions made during the design phase (Sebastian, 2010). BIM therefore enables knowledge integration from various project participants who would traditionally work in different phases of the building process to interact and regularly update a central model of the building, therefore producing beneficial project outcomes.

The aim of adopting BIM within the UK construction industry is to maximise client value by increasing benefits with little or no extra cost, by contributing to achieve the goals set out in the Construction Strategy 2025. This relies on integrated design which has also been an important subject in the Construction industry in the UK for the past few decades. The success of BIM rests on the ability of the supply chain changing the processes and culture, work collaboratively to produce such information rich models (RICS, 2014). Having studied the available definitions for BIM, it is clear that there are some uncertainties as to whether BIM is a new way of working or whether it is highly reliant on merely the software. However, International BIM implementation guide (2014) states “BIM, when combined with issues pertaining to people, processes and organisations, has the potential to significantly impact the industry” (RICS, 2014, p.5). In fact, this confirms that BIM ensures both a new ways of working and also its associated software, so when in practice it is important that both considerations are taken into account in order to gain maximum benefits.

3.1. APPLICATION OF BIM IN MANUFACTURING AND SERVICES INDUSTRIES

BIM has been used for ages in manufacturing, production and services industries. For example, the visual-based product development process, ‘Oobeya’ (which is a Japanese word for ‘big room’) developed by the Toyota Motor Company in 1990’s to manage information and on the spot decision making (Patrick, Mustapha and Howard, 2012). The tool significantly helped to shorten the product and process development time by managing information, co-ordinate and accelerate cost improvements, monitor progress and bring decisions forward much earlier in the lifecycle (QV System, 2012). This is all done by creating more communication between the people in the different divisions (Frank, 2009). Similar to BIM it manages the entire projects workings of a system through lifecycle.

Similarly, Rolls Royce (car and aero-engine manufacturing company, UK) also introduced ‘Optimised Systems and Solutions’ (OSyS) mechanism to reduce risk, increase asset availability and improve revenue for their customers, which has been so successful in recent past. For example the system (OSyS) predicts when operationally critical equipment may require out of schedule inspection or maintenance (Rolls Royce, 2010). It also enables proactive resolution of potential issues, improving asset availability and reliability with much better visibility of quality data through a central database which will result in overall savings (Rolls Royce, 2010). Moreover, the OSyS solution is enabled the company to generate and update business plans, achieve growth in the services with 20% fewer staff and 80% reduction in queries. It also provides an opportunity to make informed business decisions to achieve other operational savings (Patrick *et al*., 2012).

3.2. BIM IN CONSTRUCTION INDUSTRY

Being the principal client in the construction industry, the UK Government holds over 40% of the construction output. Therefore, it is important that the Government commit themselves to finding a way to galvanise the industry by exploring modern methods, which will improve the industry performance. In this regards, the Royal Institute of British Architects’ (RIBA) attempted to integrate BIM in their Plan of Work 2013. It provides a shared framework for organisations and management of building projects which has been widely used as both a process map and a management tool, reflecting the robust principles in best practice guidance. The RIBA recognises “assembling of right project teams “as one of the most important considerations of any BIM adopted project, which clearly reflects who does what, when and how (Sinclair, 2013). As BIM creates a robust platform for projects to commence as early as possible, this requires a greater degree of clarity to ensure that roles are clearly understood.

BIM enables three-dimensional (3D) models to be created, taking the industry from the drawing board to the computer and ultimately into the digital age (NBS, 2015). BIM levels change emphasis of a project, having all information contained in a single, continuously updated database with the model being the primary tool for documentation (Bryde *et al*., 2013). With the government recognising that the process of moving the construction industry from “independent working” to “collaborative working” involves a lot of dedication and guidance, with clear defined milestones (NBS, 2015). As previously noted, BIM is not only a new technology for the construction industry, but also a new way of working that will change the way in which the stakeholders engage in their role. BIM maturity levels considers stakeholders’ contribution throughout the project lifecycle.

Literature argues if BIM is managed correctly, it can become a key enabler of the integrated process, giving unique opportunities for reducing time and cost whilst increasing value. BIM can contribute to effective decision making at the early design and preconstruction stage, involving all parties of the supply chain. The integration of the different parties contributes to reduce both costs and time as errors are able to be identified during the early stages. It also enables three-dimensional models to be created, providing opportunity for variety of benefits throughout the project lifecycle (Azhar *et al*., 2009). This takes the guess work out of design intent and enables better collaboration which in result improves buildability and innovation (RICS, 2014). On the other hand, early visualisation of the model allows the team to enhance the quality of the project by displaying any weaknesses (Build Offsite, 2013). The project team is able to virtually see how all the systems integrate; architectural, structural, mechanical and electrical. It gives the design team the ability to eliminate duplications of design and a lot of the risks by the detection of clashes; enabling for corrections to be made easily with automatic low level correction through the use of the parametric relationships between objects before construction physically takes place on site (Build Offsite, 2013). The building information model acts as a single source of data. Data from the model can be easily extracted and manipulated. For example being cost estimates which can be done off exact quantity take-offs. This will therefore generate accurate cost estimates of a project before construction stage enabling for fewer overruns (Jayasena and Weddikkara, 2012; NBS, 2015).

3.2.1. BIM IN CONSTRUCTION SMES

Small and Medium Scale Enterprises (SMEs) account for two thirds of the UK construction industry, contributing 99.9% of the UK's trading businesses, with 52% of all employees employed by firms of less than 115 people, 96% are thought to have less than 8 employees (Federation of Master Builders, 2013: HM Government, 2013). Although SMEs dominate the industry in terms of both output and employment, BIM is still not a welcoming practice within the construction SMEs. Many barriers have been identified potentially preventing SMEs from growth, hindering their contribution to the development of sustainability (Open BIM Network, 2012). It can be argued that the desire to raise standards of delivering projects in a much shorter time scale at a higher standard has been at the expense of SMEs (Local Government Task Force, 2007).

Literature explains that the lack of access to funds and modern technology, market conditions and the government regulations as key barriers to the adoption of BIM with in construction SMEs (Miller, 2009). Pickford (2015) highlights that the main challenge for SMEs is not actually spending money on software, it is about them investing their time to truly understand what BIM means to them so that they can have a better understanding of what BIM can do for them. In addition to the results from a pilot survey of one of SMEs concludes that "SMEs engaged in small-scale projects, can adopt relatively simple working methods with basic BIM for direct tangible impacts, without having to radically change their ICT systems or putting their business organisations at stake" (Rizal, 2010, p. 105). Moreover the same study recommends that in order for SMEs to benefit from BIM they need to first establish a sustainable strategy to manage the processes, by optimising the benefits of integrated design and engineering and encourage clients to adopt an integrated procurement method that facilitates a transparent and high-performance collaboration.

SMEs are ideally suited to adopting BIM as they can make decisions and adapt to client/project/industry needs much quicker as they have less employees to catch up on, especially if they have learnt how to use BIM before it really matters on a live project. This could be done by trailing BIM alongside a current project in order to learn without the risks (Pickford, 2015). The National Building Specifications (NBS, 2015) states that they intend to ensure that their programme is well understood and can be adopted by all (irrespective of company size) without barriers. Key to this is the creation of regional hubs which intended to help professionals within the construction industry to learn about BIM and its benefits. Its purpose was to also get valuable feedback from professionals around the world, both using BIM and interested in BIM (Philip, 2012). Alongside the running of the Regional hubs is BIM4SME. BIM4SME is an organisation which is responsible for providing resources, best practice and knowledge to SMEs within the UK to get them ready for the government BIM mandate by 2016 (BIM4SME, 2015). BIM is proving a catalyst for growth for the SME community, helping them to move into new and bigger markets by unlocking new, more efficient ways of working (Smith, 2015).

4. RESULTS AND DISCUSSION

The preliminary data was collected through an online questionnaire survey and four semi-structured interviews among two quantity surveyors, one construction manager and one facilities manager. The response rate for the survey was 31%. The respondents are from construction backgrounds (55% quantity surveyors, 19% contractors, 13% consultants/directorate, 10% engineers and 3% architects). Having analysed the type of organisation that they are working, the result explains that 81% of them work for SMEs and 19% are from the large scale construction organisations. Further analysis says that 55% are private sector organisations, 39% represent public sector and 6% from other or freelance practices. 58% of them are using BIM in their current practices.

The majority of respondents understand BIM as '*information rich 3D model*', which '*enhance collaborative working' and improves 'project performance'* (in terms of time, cost and quality). More importantly, 62% of respondents agreed that the construction SMEs face number of difficulties when adopting BIM in to their projects. In contrary one of interviewees argues *"as long as SMEs are planning long term and not short term, they will find it just as easy as larger companies, if not easier. SMEs are usually used for short term projects, so they will have the opportunity to use BIM on so many different projects in a short space of time which will boost their experience, of cause depending on if the larger contractor or whoever is employing them are using it"*. Those challenges mainly appear in the areas of 'financial support' 'procurement arrangements', 'engagement, trust and support' and 'knowledge and practice'. Supportively, other three interviewees believe *"SMEs will struggle more as they don't have the required resources specially finances to help them if they get into any trouble during the adoption, also, they tend not to think long term and BIM is definitely something where you need to have a longer term perspective. Trust is a very big issue in the construction industry and without it you can't really expect BIM to work"*.

Having identified the challenges of implementing BIM within construction, the respondents were asked their opinions on how these challenges influence construction SMEs. The study uses 5 scale Likert Scale (0-not sure, 1- strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree, 5-strongly agree). The findings explain in Figure 1.

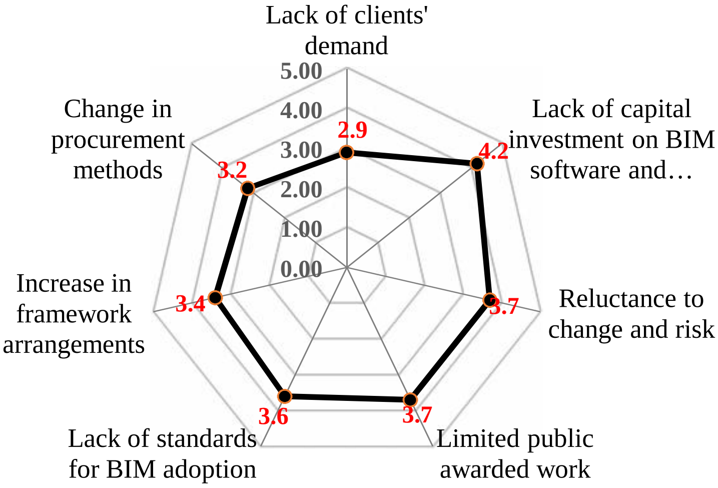

Figure 1: Challenges of Implementing BIM within Construction SMEs

The findings explain 'lack of capital investments on BIM software and training' as the most significant challenge that construction SMEs face when adopting BIM for their projects. Supportively, all the four interviewees explain that *financial aspects have huge implications of whether SMEs will find the adoption of BIM easy or not. Although, again if they plan long term and find that they can adopt it they will be able to have huge benefits.* Moreover 'reluctance to change' from the traditional methods/practices and 'less engagement is public projects' seem as the two of second best challenges. Interviewees identified 'reluctance to change' as a whole industry problem, however two of the four interviewees agreed that *"SMEs who are working for larger organisations so maybe this is due to them not being awarded their own projects which can be risky, if it is only the public sector that is pushing for BIM unless the private sector too start pushing it"*. In most cases, large scale contactors are delivering complete work packages without providing any opportunity for SMEs engage with them. However, one respondent to the survey noted that "*SMEs find BIM adoption easier as they can be much leaner and have less staff to work with; which should ensure that all members are on board and up to a set level of skill"*. Also stating that due to the amount of work they get from larger contractors at once, they may find it much easier to access many BIM projects, gaining more experience with BIM than larger organisations. Importantly another interviewee highlighted *"SMEs are now winning more public work than they did in the past so hopefully that won't be too much of a problem to them now"*. In addition, that 'lack of standards for BIM adoption in construction SMEs', 'increase in framework arrangements' and 'change in procurement method' identified as influential challenges. With compares to other challenges 'lack of client's demand' was given a least impact. Presumably, this will be a positive sign for BIM adoption within construction by assuring the clients awareness on benefits of BIM. In addition to aforesaid challenges, few respondents were noted 'main contractors self-delivering', 'unrealistic expectations', 'no clear direction' and 'lack of expertise' as other influential barriers to implement BIM within construction SMEs.

Moreover, the findings highlighted *financial concessions*, *support on BIM training and awareness programmes*, *opportunities for winning more public projects,* incentive-*penalty schemes* as the way ahead for encouraging SMEs to adopt BIM in their practice.

5. CONCLUSIONS

The barriers preventing construction SMEs to adopt BIM were revealed through this paper.

BIM has been described as a new way of working in the 21st century, which will bring many benefits to the construction industry. However, it has been widely argued that there are number of challenges, when it comes to implement within the construction SMEs. The results noted that the construction SMEs lacks the required knowledge and competencies on BIM, however until they gain such maturity they are reluctant to implement BIM within their practices. The key challenges appear in the lack of capital investment on software and training, limited public awarded work and reluctance to change.

The results explain SMEs are not being completely aware of BIM, and the cost implications, could mean that they have yet to implement a strategy to finance the adoption, so decisions could be prone to change when this awareness does reach the surface. Although not all SMEs have adopted BIM, it is important that they plan long-term and set targets to put themselves in a position to adopt BIM within their practices. It is highly recommended that the government should take initial actions on supporting the SMEs (through training, awareness programmes, standards and reforms) in hope to encourage them to integrate BIM within their professions. However, as SMEs contribute to the vast majority of the construction industry, it is highly unlikely that the government will fully endure such expenses but the concession schemes can be introduced. On the other hand, the limited public awarded work for SMEs is also identified as a key barrier to implement BIM within their practices. Therefore, it is worthy if future studies could focus on whether new reforms to the PQQ (pre-qualification questionnaire) have contributed to SMEs gaining more work within the public sector.

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IMPROVING COLLABORATION BETWEEN ACADEMIA AND INDUSTRY THROUGH USE OF THE KNOWLEDGE TRANSFER PARTNERSHIP

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ABSTRACT

Collaboration between the construction industry and academia has always been difficult. Both sides of the equation have different wants, needs and requirements and these are seemingly at odds with each other. However, it is well documented that, despite the challenges involved, the outputs of such collaboration are seemingly very successful. It is against this backdrop that the United Kingdom Government has recognised the importance of facilitating opportunities and helping in the development of models to assist in overcoming the gap between industry and academia. One of these models is the Knowledge Transfer Partnership (KTP). The KTP model specifically allows businesses to solve issues they have by accessing knowledge and expertise held by academic institutions that otherwise may be out with their reach. In this paper we demonstrate how the Scott Sutherland School (SSS) and Abertay Housing Association (AHA) fostered a partnership with the aid of KTP funding to test/ monitor a solution to upgrade some of their non-traditional housing stock. We found that a deep relationship developed during the initial stages of drafting the funding proposal set the foundation for the rest of the project to date. The partnership has allowed both parties to benefit - AHA has new found knowledge of the performance of their existing housing stock, whilst SSS has added knowledge of steel house behaviour to its expertise of other house types.

Keywords: *Collaboration; Funding; Knowledge Transfer Partnership.*

1. INTRODUCTION

It is well known that there has been a historical disconnect between the construction industry and academia (UKCES, 2013). Today, in what has become a global market, industry research and development has moved away from traditional in-house research (Lambert, 2003) while it is acknowledged that industry needs to become innovative in order to remain competitive (Jachimowicz and Umali, 2000). This has resulted in a need for both industry and academia to collaborate so that research outputs can be successfully translated into industry practice (Blismas *et al.*, 2009). Benefits of partnerships which cross this divide are not the sole preserve of the industry partner - the academic partner also gains from collaboration in the receipt of funding, fostering relations with industry, published outputs and the potential of tangible output of their research.

However, the challenges faced with bridging the gap cannot be downplayed. Jones and Clulow (2012) found the following obstacles:

- lack of trust over issues such as intellectual property;
- uncertainty about the potential benefits of working together;
- difficulty on both sides of finding the time for initial exploratory conversations;
- disparity between types of outputs that would make such collaborations seem worthwhile;
- businesses may be seeking saleable products, academics prize excellent research outputs and publications;
- universities may not find industry problems interesting enough to address;
- industry ascertains if a university could help them solve their business challenges.

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This paper describes one method available in the UK which promotes and funds collaboration between industry and academia - the Knowledge Transfer Partnership (KTP). The paper will be set out in three distinctive sections:

- a description of the KTP strategy and process,
- the development of a project where the Scott Sutherland School(SSS) has collaborated with Abertay Housing Association (AHA) in Dundee, Scotland
- brief analysis of initial outcomes of the project

The project in question evolved from a challenge AHA faced in the thermal upgrading of existing properties. They made an initial approach to SSS with a view to developing and testing innovative methods/ materials which would improve building performance without compromising the structure and fabric of their properties.

2. KTP PROJECT BACKGROUND

2.1. KTP BACKGROUND

The KTP is an initiative administered by Innovate UK, which facilitates the application of new knowledge, technologies and skills to improve a company's productivity and competitiveness. Innovate UK is an executive non-departmental public body, sponsored by the Department for Business Innovation and Skills (BIS). The Department for BIS is the Department for Economic Growth (BIS, 2016). The department invests in skills and education to promote trade, boost innovation and help people to start and grow a business. In 2015 Innovate UK celebrated its 40th year since its first project. The projects aim to develop innovative solutions to industrial challenges in order to aid a company's growth within their market.

Essentially the initial role of Innovate was to facilitate the "bringing together" of two disparate parties (industry and academia) so that each party could clearly see the many benefits that collaboration would bring.

Within each project there exists a trilateral relationship between; a KTP research associate, the knowledge base partner (academic institute) and the company partner. The KTP associate facilitates the transfer of knowledge from the knowledge base partner to the company, and they tend to be a recent university graduate. The knowledge base partner supplies the associate with the relevant knowledge for the project and assists in the development of research. The company partner, through facilitation of the project, is able to provide the knowledge base partner with raw data for research outcomes. Both parties provide the Associate with supervision throughout the project period. The company partner tends to be a business but can also be Local Authority, environmental or educational body. A fourth party, Innovate UK, oversees the process to ensure all parties are fulfilling their obligations and the project is progressingtowards agreed outcomes (refer Figure 1) (Innovate UK, 2015a).

There are over 800 partnerships running at any one time and over 900 associate projects (Galvez-Martos, 2016). These projects cover a broad range of industries, from the public sector, service industries to manufacturing plants.

2.2. KTP FUNDING PROCESS

The KTP is funded by the Innovate UK along with 12 other funding organisations. These funding organisations include Research Councils and a number of other Government departments (Innovate UK, 2015b). The KTP is designed not only to increase productivity and profit for the company partner but also to highlight opportunities, disseminate knowledge and bring together academia and industry, although it is expected that there will be a financial benefit to the company.

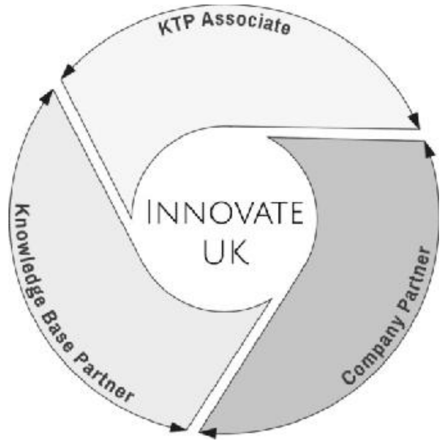

Figure 1: Diagrammatic Representation of KTP Relationships

Small Medium Enterprise (SME) projects can secure funding up to 67% from Innovate UK while large companies can secure up to 50%, in addition to a number of other funding streams within associated sectors (Galvez-Martos, 2016). It is often the case that the company partner will fund the remainder of the project. It is expected that there will be a financial benefit to the company whether it be through increases in profit, reduced production costs, introduction to new markets and/or an improved product. These benefits tend to outweigh the financial input from the company.

For a company to qualify the company it must employ more than 4 members of staff and the proposed project last between 12 and 36 months.

2.3. BENEFITS TO THE PARTIES INVOLVED

All of the parties involved in the trilateral agreement are expected to benefit from the relationship.

The associated benefits from structured training and experiential learning. There is access to a £4,000 training budget which allows the associate to acquire a variety of on and off the job training, also benefiting from two compulsory modules covering; management, finance, leadership and teamwork. They can also benefit from professional qualifications which vary depending on their area of expertise. Associates are also encouraged to undertake a higher degree during the term of the project. 41% of associates register for a higher degree, of which 67% pass their chosen degree (Galvez-Martos, 2016). Finally they gain professional experience in their chosen sector from being exposed to a variety of different work situations. 60% of associates are offered and accept a post at their host company upon completion of the project (Galvez-Martos, 2016). The KTP's focus on training and hands on experience equips the associate with an impressive skill set that will vastly increase their employment prospects.

The company partner benefits from the knowledge brought by the associate and knowledge base partner to solve a problem in an innovative way. The process of this may result in the production of new products, technologies, or processes that improve productivity and/or profitability. For every £1m of government spend the average benefits to the company amounted to an £4.25m annual increase in profit before tax (Galvez-Martos, 2016). The company benefit from the knowledge base partner's expertise and awareness of the funding streams available for projects such as this. Therefore they benefit from external funding that otherwise would not have been available. The knowledge developed during the project is disseminated to the company staff through training sessions, improving their expertise and the way they carry out their jobs. Once the knowledge is transferred to staff it will remain in the company and become part of the standard operating procedures ensuring the long term benefits. The associate is encouraged to become involved with the daily running of the business as well as their project which can improve the efficiency of the business. In addition to all of this, there is a clear expectation that the company partner will see financial benefit from the project outcomes - IT WILL MAKE PROFIT!

The knowledge base partner gains further insight and research into their existing body of knowledge and expertise. It is expected that the knowledge base partner will disseminate findings through academic journals conference papers, trades journals etc. Funding pays for academic input to the equivalent of half a day per week. It is also expected that new knowledge will feed into undergraduate and post graduate learning. On average, each KTP Associate project produces 3.6 new research projects and 2 research papers (Galvez-Martos, 2016). This adds to the existing catalogue of data already possessed by the Knowledge Base partner and accommodates continued research to be conducted. The production of high quality research in innovative sectors enhances the reputation and standing of the knowledge base partner among other institutions and potential industrial partners.

To summarise, there are a number of possible benefits to each party in the agreement. The associate gains expertise, knowledge, experience and improved employment potential. The company partner's primary benefit is expected to be profit gain, however there are also possible benefits from; better informed staff, new technologies, new products, funding and a generally more competitive business. The knowledge base partner benefits from further research and publications in one of their areas of expertise. As a result of this the academic reputation of the institute is elevated and becomes more attractive to future industrial research partners and prospective students.

3. EVALUATIVE CASE STUDY

3.1. PROJECT TEAM

This KTP project team includes; The Scott Sutherland School of Architecture and Built Environment (SSS) as the knowledge base partner acting as academic advisor, Abertay Housing Association, Dundee (AHA) as the host company acting as company supervisor and the associate, a recent graduate (BSc Hons. Building Surveying) of the School. In addition to this, the project has been appointed a representative from Innovate UK who oversees all of the KTP projects in the North East of Scotland.

3.2. PROJECT ORIGIN

The Scott Sutherland School of Architecture and Built Environment at Robert Gordon University has been involved in applied research in the field of building fabric upgrades for a number of years (Abdel-Wahab and Bennadji 2013; Buda *et al.,* 2013;Gutiérrez-Avellanosa and Bennadji, 2013). It was while presenting their findings from one such project at a Scottish Federation of Housing Associations (SFHA) conference in Scotland that it came to the attention of AHA. AHA were aware that the Energy Efficiency Standard for Social Housing (EESSH), which places a legal obligation on social landlords to achieve a minimum Energy Efficiency (EE) rating in their entire housing stock, was due to be enforced in 2020. The EE rating is measured in the Energy Performance Certificate (EPC). Many of the newer properties will already meet the new EESSH targets, which require an EE rating of between 65 and 69 depending on the house type and fuel source, while some of the older and non-traditional housing stock will struggle to meet these targets. With this in mind AHA identified a number of non-traditional steel frame houses that require a more innovative improvement solution to meet these targets. It was at this point AHA approached SSS and together they developed a research proposal to submit to innovate UK for consideration.

3.3. FUNDING APPLICATION

The process of securing funding for this project involved the incremental development of the proposal and this resulted in AHA and SSS meeting frequently to discuss the challenge, develop the research question and understand how working in collaboration will facilitate the development of a resolution. This formed the basis for the development of the research proposal.

Having identified the problem, the type of solution they would require and how they could achieve this in their research proposal, AHA and SSS then begin to explore the funding options available to them. SSS highlighted multiple funding streams available to a project of this nature to AHA and they began assessing their options. The result was, together AHA and SSS found that the KTP initiative was the most applicable to the needs of both parties and project itself.

A project proposal was developed by both parties collaboratively which included:

- A description of the project
- The project aims and objectives
- Proposed project outcomes
- Intellectual Property agreement
- And, a full breakdown of the project costs.

The project costs included; associate's salary, project consumables, any required software and hardware, associate training budget, the knowledge base supervisor's time and travel and subsistence. It also had to outline where profit would be made on the successful delivery of the project. It was very important to demonstrate the financial benefits to the company in order to secure the funding. It was then a question of presenting the proposals to Innovate UK and waiting to hear whether they had been successful.

The project secured 67% of the funding from Innovate UK and the remaining 33% was provided by AHA. Once the funding had been secured the project was ready to begin. An associate was appointed in August 2015 with slightly modified project outcomes to take account of progress made by a previous associate. The project is now nearing the halfway point of the 21 months program and the initial findings from a pilot scheme have begun to be collated and analysed.

A significant (but indirect) outcome of the funding application process was the development and cementing of the partnership between SSS and AHA. The application required substantial amount of details and both partners had to work together to ensure that the application was worthy of submission. By the time the funding bid was submitted, the partners knew each other extremely well and a close bond had been formed before the project had begun in earnest.

3.4. PROJECT DETAILS

The project is an investigation into the performance four types of steel frame dwellings in Dundee, Scotland. The properties in question are of non-traditional steel frame construction, built in the period between 1926 and 1928. Four types of steel frame properties have been identified on the site, although findings from the project will be pertinent to a wide variety of steel frame properties in many locations. Due to the nature of these properties there are a number of risks to building performance when applying standard wall insulation to them. AHA did not have previous experience of carrying out improvement measures to properties of this type, or the technical knowledge to effectively analyse the available options. AHA sought to acquire this knowledge through collaboration with SSS.

The initial project phases included for full surveys to be undertaken of each property type to identify design and defects specific to these properties. This information was gathered by the associate and added to the existing knowledge of the construction type in question. This provided a platform of knowledge from where to start the process of designing and analysing various insulation methods.

AHA, in conjunction with a third party designed three Internal Wall Insulation (IWI) solutions. The process of designing these solutions involved close collaboration with SSS and it was agreed that a period of testing and monitoring should be undertaken on a selection of pilot properties before the full implementation of a solution.

The pilot properties allowed the project team to strip the properties back to reveal the primary structure and identify the construction and condition. This process would prove invaluable as more properties were accessed and common defects noted. This added to existing research undertaken by the Building Research Establishment (BRE, 1989) which had also discovered similar construction and condition. As a result of the findings, changes were made to the three IWI solutions to make them more appropriate to the buildings.

The research/ testing strategy involved in-situ monitoring of a number of parameters and included:

- Air Tightness Testing (ATT),
- Infrared Thermography (IRT),
- Internal air quality measurement,

- Relative Humidity (RH) measurement,
- Air Temperature (AT) measurement,
- Heat flux measurement,
- Surface temperature measurement.

By measuring these factors over a period of over 12 months the effectiveness of each solution could be tracked and compared against alternatives.

Once the monitoring data has been analysed the most suitable option or options can be selected. As there are four types of steel frame properties in this area it is possible that more than one option will be required and in some cases it may be necessary to use more than one system in an individual property. As the works rollout for the full program of 90 non-traditional steel frame buildings the monitoring will continue. Then a maintenance plan can be designed around the findings to ensure the properties have the greatest life span possible.

3.5. BENEFITS TO THE PARTIES INVOLVED IN KTP PROJECT

There are many benefits to the parties involved in KTP project specifically; SSS, AHA and the associate, some of which are clear and others are more subtle.

AHA has benefited from the knowledge base partners substantial knowledge of similar projects and detailed analysis of proposed building fabric upgrades. The academic partner has brought a scientific approach to the investigation and identification of defects. This will ensure that, not only, are the upgrades providing the greatest improvement of life span of the properties but also in tenant comfort, health and reduced utility bills. AHA has also gained invaluable information from the monitoring process that has been undertaken throughout the pilot stage. This will allow them to create more effective maintenance programs to get the most out of these properties over the coming years. They have had the benefit of an additional member of staff dedicated to working on the project. The solution and, more importantly, the process of designing a solution can be disseminated by AHA as this problem is not restricted to homes in Dundee, but the UK and broadly speaking, the world. There is also potential to patent one of the insulation systems and sell the intellectual property rights to this.

The associate has gained a large amount of industrial experience and has been exposed to a wide variety of scenarios improving his understanding of the sector. The level of personal responsibility is far greater to that which would be possible in private practice and has developed the associate’s skills in areas pertinent to the project and his future career. The associate has the benefit of a training budget of £4000 as well as two 2 tailored training programs organised by Innovate UK. To date the associate has undertaken training in Air Tightness Testing (ATT), infrared thermography, project management, finances, leadership and team working. The associate has been encouraged to and has submitted an application for an MRES degree on the subject of the project, which will add to his academic competencies.

SSS have been involved in research on building performance improvement work for a number of years. It is expected that the outcomes of this project will add to the knowledge already developed at SSS. It also allows the research to be added to the universities course syllabus, disseminating the information to the next generation of young professionals.

Both SSS and AHA have benefited from the publicity that a project such as this attracts. To date both organisations have been involved in presentations about the project. In addition there has been attention from local and national MSP’s and local radio stations.

4. INITIAL FINDINGS

4.1. BACKGROUND TO MONITORING

The monitoring strategy within each of the pilot properties is outlined in section 3.4. The underpinning theory behind the selection of the specific elements being monitored is as follows: the temperature and

RH measurements across the wall fabric allow to ascertain if condensation is occurring within the cavity, the ATT undertaken before and after shows the improvement in the buildings air tightness, the air quality measurements allow to ensure, the building is not made detrimentally air tight, IRT surveys allows the visible improvements in the properties' heat retention, and the heat flux allows a comparison between theoretical and actual U-value measurements of the wall fabric.

The combination of in-situ and one-off monitoring methods allows to build a picture of how each of the IWI wall systems is performing and measure the level improvement each has on individual properties. This means that a critical analysis of each option can be undertaken, ensuring the most effective solution and can resolve any issues prior to the full works being carried out. The cavities within the pilot properties were free from ventilation in order to assess whether there is a need for it before undertaking the works in the remaining properties.

For the purposes of this paper, initial findings from one property within the pilot phase are presented.

Figure 2: Pilot Study Property (Dundee, Scotland)

4.2. RESULTS FROM INITIAL IN-SITU MONITORING

It is known that most species of fungi cannot grow unless RH exceeds 60% therefore maintaining an internal RH between 40-60% minimises the risk of adverse health effects (Arundel *et al*., 1986). In Figure 3, the results gathered over the first three months show that the average RH level lies within this parameter. It should however be noted that the max RH does exceed these parameters at isolated points. This shows that, despite the improvements in the air tightness of the building fabric (see section 4.3), there is still sufficient ventilation to maintain safe and comfortable indoor RH level.

The RH within the cavity is exceptionally high in this property, with the average values exceeding 90%, as can be seen in Figure 3, for almost the entire three months period. It must be noted that the cavity has not been vented so that the project team to assess its requirement. Exposed steel will corrode at 60% RH (Roberge, 2000).Therefore the very high values indicate that there is a high probability that corrosion will occur. With such high RH levels it is likely moisture will occur on the internal face of the steel, as a result internal timbers and exposed areas have been covered in protective water resistant membranes.

Figure 3 shows the average external RH ranges between 70-98%, this exceeds the 60% threshold required for steel to corrode. With this in mind the requirement for ventilation becomes immaterial, as potentially exposed steel will corrode at the levels naturally occurring externally. The process of installing ventilation could also increase the likelihood of exposed cut edges to this effect.

The internal air quality within the property is being monitored to assess the impact of the upgrades we are carrying out. CO_2 was chosen as the parameter to measure, this can be used as a benchmark for the levels of other gases present within the property. "CO_2 at very high concentrations (e.g. greater than 5000 ppm) can pose a health risk" (ASHRAE, 2013). As seen in Figure 4, the average CO_2 level does not exceed 1500ppm. This shows that the CO_2 level is not dangerous to occupants. It can be observed from the range of 90% of the data that the CO_2 level does peak and trough from this level. This is expected as the monitors were situated within bedrooms, where the CO_2 levels build overnight and clear during the day.

We are reassured that at no time does the CO_2 level exceed 3500 ppm. This suggests, as with the internal RH, that despite the thermal improvements the occupants' health or comfort within the property has not been jeopardised.

4.3. EPC AND ATT RESULTS

An EPC was completed for the property before any works had been undertaken. The result was an EE rating of 55 which placed it at the bottom of the 'D' band. Once the IWI, new triple glazed windows and new external doors had been installed within the property the new EE rating was 79. This placed the property in the top of the 'C' band and well surpassed the target EE rating of 65 required for this type of property in the EESSH. This is a vast improvement for properties of this type and by exceeding the EESSH targets help to ensure the properties will meet future EE targets set by government.

The EPC improvements are supported by ATT results from the tests undertaken before and after the completion of the works in the property. The pre-works ATT showed the property had an air permeability at 50 Pascals of 12.9 m³/h/m². This is a poor air permeability rating, however due to the age and construction of the property is in line with what would be expected. The post-works ATT show a reduction in air permeability of almost half, with a new air permeability at 50 Pascals rating of 7.6 m³/h/m². This is a great improvement especially given there has been no detrimental impact to the internal air quality, section 4.2.

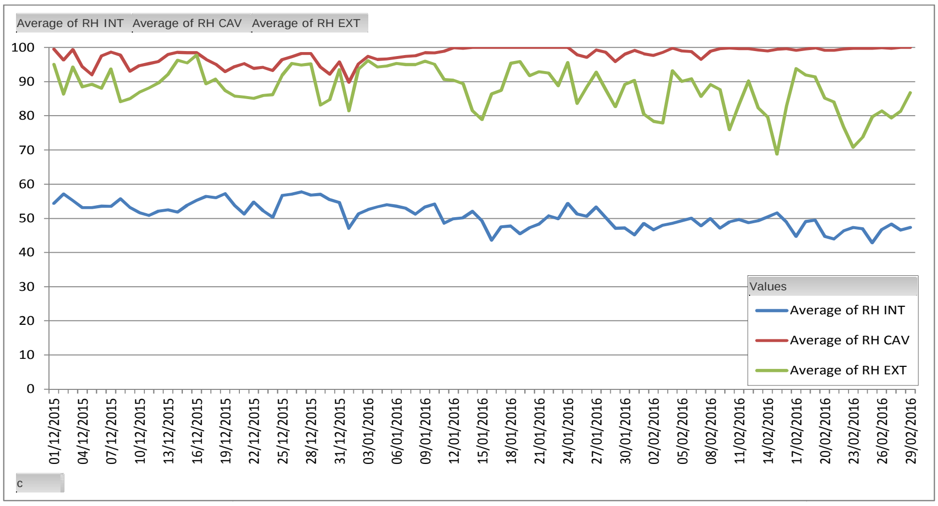

Figure 3: RH Readings over the Months of Dec 2015 to Feb 2016

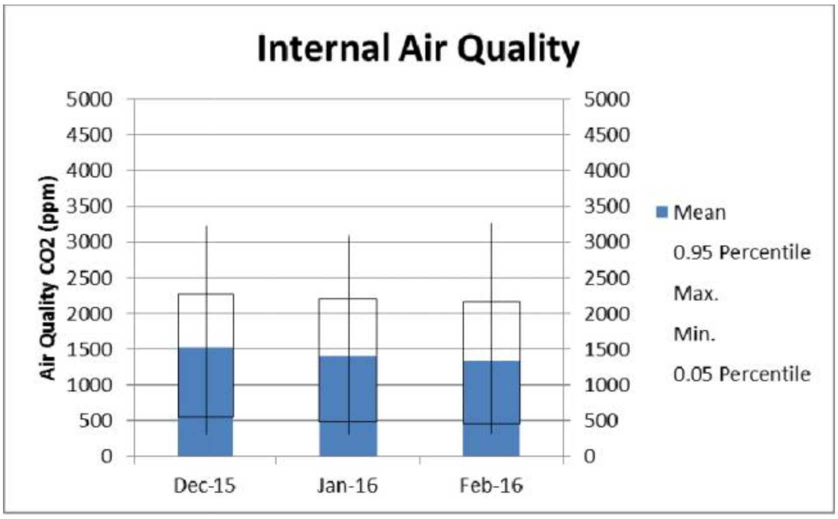

Figure 4: Internal CO_2 Readings over Dec 2015 to Feb 2016

Comparison of the before and after EPCs demonstrate the real cost savings within this property. Providing the same quality of finish and level of improvement within the remaining 89 properties, there is not only a cost saving benefit to individual tenants but to the local community as a whole. The real cost saving in heating and electricity to each tenant within one of these properties is £591.00 a year. Over the 90 properties in question this amounts to £53,190.00. With these tenants having an additional £591.00 per household a year, there is more disposable income to be spent in the local community. This results in a more affluent community with better local amenities. In addition to the financial benefits there are also environmental benefits, there is a reduction of 51 kg CO_2/m^2/year per household. Across the entire 90 properties in our project this amounts to a total carbon saving of 4590 kg CO_2/m^2/year. As environmental change becomes an increasingly important national and global issue, it is vital that improvements such as these are made to all underperforming properties.

5. SUMMARY

The KTP project between SSS, AHA and the associate is proving to be a success. Strong relations have been forged between the knowledge base partner and company partner. This has been the case from the early inception of the project which required them to come together to address the problem they were facing, through to the full implementation of the agreed project. All of the parties have learned in the progression of the project and that knowledge has been and continues to be successfully communicated between the whole project team. The knowledge being developed is innovative in its nature and of great benefit both academically and to the commercially. In addition to this the associate is acquiring a wealth of new skills, training and industry experience. This project has been a good demonstration of collaboration between industry and academia which has resulted in positive outputs for everyone involved.

5.1. WAY FORWARD

The project is due to conclude in April 2017 and the intention is to continue to collect and analyse data and communicate this to AHA. It is expected that results of the in situ tests will be disseminated through journal papers and conferences. On completion of the project, each party will report back to Innovate explaining how the outcomes have been met. The associate has commenced an MRes degree based on the project and will be expected to complete by the end of 2017.

When the project is at completion, it is intended to investigate the consequential benefits that the house upgrades have brought to the occupiers and to the local community. It is expected that there will be a reduction in energy consumption and associated costs and improved quality of life brought about by living in a warmer, healthier environment and without the strain of fuel poverty. There may be a knock on effect to the economy of the local community as the populace will potentially have more available spending money.

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INCORPORATING TACIT KNOWLEDGE IN PERFORMANCE MEASUREMENT SYSTEM IN A SRI LANKAN HOTEL

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ABSTRACT

Performance Measurement (PM) has been received an increasing attention over the past 20 years in the hotel industry. It is critical for the development of strategic plans and for evaluating the achievement of organisational objectives. A growing understanding of the limitations of financial measures has led the development of integrated systems and frameworks. Among the conventional models, Balanced Scorecard (BSC) is widely accepted and implemented in organisations. However, identification of Critical Success Factors (CSFs) and formation of BSC model into a practical context is based on several assumptions that could lead to failures. Tacit knowledge addresses the value of the expert's knowledge and specifies techniques to capture current context and changing needs of the organisation. However, the extent of literature on PM has failed to incorporate tacit knowledge into the PM models using any of the externalisation techniques due to several reasons.

Therefore, this study explored the method to incorporate expert's tacit knowledge for PM in the Sri Lankan hotel industry. The research problem was approached through a single case study with an action research phase in a five star hotel that successfully practice Performance Measurement System (PMS) in Sri Lanka. Semi-structured interviews were conducted among the experts in the hotel and combined three methods namely; archival analysis, ethnographic analysis and experts' participation to extract expert's knowledge in to CSFs identification process.

The case study findings revealed that hotel staff subconsciously carries out activities for externalising, preserving and developing their tacit knowledge. However, there is no evidence of considering tacit knowledge in the process of CSFs identification for PM in Sri Lankan hotel industry. Action research phase affirmed, at minimum, either the ethnographic or the interactive method could be used along with archival analysis method to represent both the explicit and tacit knowledge of the organisation to produce an effective PMS. The approach used in this study for incorporating tacit knowledge into performance measurement is adaptable to Sri Lankan hotel industry.

***Keywords**:* *Hotel Industry; Sri Lanka; Critical Success Factors; Performance Measurement; Tacit Knowledge Externalisation.*

1. INTRODUCTION

Kollberg *et al*. (2005, p.98) define that, "performance measurement system is a process of collecting, computing and presenting quantified constructs for the managerial purposes of following-up, monitoring and improving organisational performance". Hence, establishing proper PMS for an organisation is important. In terms of discovering the importance of PM, Kagioglou *et al*. (2001) state identifying and implementing PM has become a vital aspect in order to attract future investment, to increase share value and to attract high quality employees. Further PM enables the managers to make decisions based on facts rather than on assumptions and faith (Parker, 2000). It assists the managers to move towards the correct direction, to revise the business goals and to re-engineer the business process if needed (Kuwaiti and Kay, 2000; Hoek, 1998). With the above outlook, PM could be identified as a vital aspect for a company to

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identify the weaknesses of the organisation, to implement performance and to step forward for new directions. The next section discusses the application of PMS.

2. PMS PRACTICES: GLOBAL HOTEL INDUSTRY

Olve *et al.* (1999) categorise PMS into two groups as where first group adopts historical financial measures from accounting while the second group includes contemporary integrated systems that combine financial with qualitative and non-financial measures. Banker *et al*. (2005) for instance, mention that financial measures are used in the hotel industry because of their ability to reflect the effectiveness of current and former activities. According to Keown *et al.* (2008), one of the best ways to measure financial performance is to use financial ratios or metrics. Such ratios should reflect standardised accounting data in order to allow managers and financial analysts to identify the weaknesses and strengths of a company's performance. These accounting data include the Profit and Loss Account (Income Statement), the Balance Sheet Performance Measurement Systems Statement and the Cash Flow Statement.

However, some authors clearly identify problems and disadvantages of using only financial measures. Ghalayini and Noble (1996) found that such instruments are not related to business strategy and are unable to quantify improvement efforts (e.g. time reduction, customer satisfaction). In addition, Ittner *et al*. (2003) found that financial measures tend to be backward-looking, lack the ability to explain future performance and offer results about functions within the organisation rather than cross functions. Hence, the hotel industry could suffer from the limitations of financial Performance measures and may need to consider integrated PMS. The changes in internal and external environment have led to development of integrated systems and frameworks for measuring performance. The literature on PMS (Otley, 1999; Epstein *et al.*, 2000; Ittner and Larcker, 2001) offers various modern integrated models to measure the performance of the organisations, which generally include Balanced Scorecard (BSC), Business Excellence Model (BEM), Key Performance Indicators (KPI) and Capability Maturity Model (CMM).

Banker *et al*. (2005) explain how integrated PMS could be used in the hotel industry and introduce non-financial performance indicators that measure variables such as seat turnover, average stay per guest and occupancy rate. Also, Denton and White (2000) assert that strategic performance measurements for hotel organizations should be comprehensive enough to consider the disparate goals of owners and management, and factors such as customer and employee satisfaction can be used as potential performance measures. According to Wood *et al*. (1998), a primary success factor of hotel operations is assumed to be related to employee motivation, attitude and performance. Huckestein and Duboff (1999) regard the BSC as the systematic measurement tool that may align owners and managers' goals, assess management's effectiveness in a service operation and adequately measure both financial and non-financial results. Thus, it is clear that the demand for integrated performance measurement systems has grown as they help to capture the contribution of intangible resources to organisational performance in global hotel industry.

2.1. PERFORMANCE MEASUREMENT IN SRI LANKAN HOTELS

De Mel (2002 cited Sunderalingam, 2003) states, in Sri Lanka, PM has become a certainty in public sector organisations and Charted Institute of Management Accountants (CIMA) has already suggested the use of BSC in public sector organisations. Moreover, workshops have been conducted on BSC performance measurement by Sri Lankan Government and Distance Learning Centre. Taj Hotel is a good evidence of using BSC with the addition of employee satisfaction survey in PM in the Sri Lankan hotel sector (Avkiran, 2002). Further for hotel operations, White Lodging Services (WLS) and Hilton have modified the basic BSC framework for their organizations (Denton and White, 2000; Huckstein and Duboff, 1999). White Lodging Services Corporations is a corporate entity that manages Marriott's limited service franchises comprising Courtyard, Fairfield Inn and Residence Inn. The company started to implement its Balanced Scorecard system both at the corporate and property levels in January 1997. Not only that, the Hilton Colombo became the best hotel in Asia in the Balanced Scorecard category and the BSC of Hilton measures hotel's performance in team member satisfaction, team member training, guest service feedback and Hilton International's Hilton honours loyalty members' feedback (McPhail *et al.*, 2007).

Aforementioned researches reveal that BSC has been successfully applied to the Sri Lankan hotel industry to measure the performance. It further enhanced the application of BSC to the hotel industry and emphasised that BSC is an appropriate evaluation method for service performance. Since, BSC practitioners are available in Sri Lanka and plenty of workshops have been conducted in Sri Lanka promoting performance evaluation tool, more research on PMS using BSC model in Sri Lankan hotel industry will be worth and useful. Hence, next section describes BSC as a PMS, bringing both generic and hotel sector literature.

2.2. FEATURES OF BSC SYSTEM

The balanced scorecard is one of the most influential frameworks for organisational PM (Evans, 2004). Kaplan and Norton (1992) introduced this tool as a PMS comprising a set of different perspectives to provide a comprehensive insight into organisational performance. The BSC measures financial performance in conjunction with performance in relation to customers, performance on learning and growth and finally, the performance of internal business processes. The hotel literature highlights and appreciates the BSC system as a tool to measure the success of the organisation and to offer a road map that can tell managers how a strategic vision can be accomplished. In general, several studies of the hotel industry have found the BSC to be a valuable measurement tool (e.g. Brown and McDonnell, 1995; Hepworth, 1998; Harris and Mongiello, 2001; Phillips and Louvieris, 2005; Evans, 2005; Phillips, 2007). Further, several Authors developed BSC for the hotel industry using several CSFs which is discussed next.

2.3. CRITICAL SUCCESS FACTORS AND PERFORMANCE MEASUREMENT

BSC and critical success factors are intrinsically intertwined. When discussing this relationship, Kellen (2003) argues that at first, appropriate CSFs need to be identified in order to provide focus for performance measurement by using BSC system. Further, Haktanir and Harris (2005) pointed out the noticeable link between CSFs and performance measurement. Therefore, primarily proper CSFs are needed to be identified in order to use BSC model to measure organisational performance. Further, Key performance indicators (KPIs) also used in this model, which represent a particular value or characteristic that is measured to assess whether an organisation's goals are being achieved. Kellen (2003) states that KPIs reflect the CSFs (stakeholder needs and the expectations of the organisation) and KPIs to be effective, the organisation's CSFs need to be specific, measurable, agreed, realistic and time-based (Haktanir and Harris, 2005). Hence, the concept of CSFs in the context of PM and the hotel industry, which are considered necessary for organisational prosperity because of the impact they have on the organisation’s potential performance. Several studies (e.g. Louvieris, *et al*., 2003; Bourne *et al*., 2003 and Flanagan, 2005) identify CSFs using BSC model to measure the performance of the hotel industry, such as customer focus, staff, quality of service, profitability, budgetary control and customer relationship management. Once these have been identified, it is possible to develop methods of measuring the performance of these factors.

However, despite of high availability of literatures to identify CSFs using BSC model to measure the performance of the hotel industry, they seems to be inconsistent and fail to capture the changing nature of hotel sector over the time. However, one could raise the question that “then how Hilton hotel Colombo became the best hotel in Asia under the BSC category if it is inconsistent in nature?”. That was a comparative award rather than absolute award. Actually, Hilton hotel was given the award for BSC practices by comparing other hotels’ BSC practices, which does not mean that Hilton hotel’s BSC practices are perfect. Because, practically it is extremely complex to identify proper CSFs for BSC model, and to ease this task, BSC is developed with several assumptions that ultimately force to add some limitations over this model and these are discussed in next section.

2.4. LIMITATIONS OF BSC AND CSF

A key assumption in a BSC model is that an organisation’s strategy can be articulated and communicated openly throughout the organisation (Akkermans and Oorschot, 2002). It is also assumed that clear knowledge from archival sources represent the overall knowledge of the organisation (Porac *et al*., 2002;

Rucci *et al*., 1998). Further, this model fails to demonstrate how CSFs are identified and how the relationships among them are articulated (Rucci *et al*., 1998; Malina and Selto, 2004).

Overall, although BSC model is widely accepted and implemented in organisations, identification of CSFs and formation of BSC model into a practical context is based on above mentioned assumptions that could lead to failures. The key limitation of BSC model is that it identifies CSFs using archival records and does not capture current context and changing needs (Porac *et al*., 2002; Rucci *et al*., 1998). This research argues that CSF should be revised in an organisation from time to time and should include not just the knowledge from archival sources but also the knowledge and experience from the experts within the organisation. To build this argument this research brings insight from Knowledge Management (KM) literature into Performance Measurement (PM) next.

3. KNOWLEDGE RESOURCE IN THE ORGANISATION

According to Blackler (1995), knowledge is a fluid mix of framed experience, values, contextual information and it originates and is applied in the minds of experts. Nonaka and Takeuchi (1991) expressed that knowledge can either be tacit or explicit. Herrgard (2000, p.358) stated, "Organisations' knowledge resources can be described as an iceberg. The structured, explicit knowledge is the visible top of the iceberg, which is easy to find and recognise and therefore easier to share. Beneath the surface, invisible and hard to express, is a momentous part of the iceberg. This hidden part applies to tacit knowledge resources in organisations". Hence, knowledge within an organisation often becomes embedded not only in documents or repositories, but also in organisational routines, processes, practices and norms. In order to explore how this tacit knowledge could be externalised, it is important to understand the nature of tacit knowledge.

3.1. TACIT KNOWLEDGE AND ITS EXTERNALISATION

Polanyi (1966) described tacit knowledge as knowing more than we can tell or knowing how to do something without thinking about it, like riding a bicycle. According to Sigala and Chalkiti (2007), tacit knowledge is mainly in two categories namely; cognitive knowledge and technical knowledge. Cognitive knowledge comprises of beliefs, perceptions, ideals, values, emotions and mental models that are so ingrained in experts, which they are taken for granted. While technical knowledge encompasses the kind of informal and skills often captured in the term know-how and highly subjective and personal insights, intuitions, hunches and inspirations derived from bodily experience fall into this dimension. Externalisation is the translation of tacit knowledge to explicit knowledge. A process of externalisation includes conceptualisation, elicitation and ultimately articulation thus that a portion of a person's tacit knowledge may be captured in explicit form. Externalisation (tacit to explicit) requires knowledge codification and abstraction and it can happen via interactions such as brainstorming and experts' interviews and activities (e.g. by reflecting on lessons learnt from a project).

Senaratne and Sexton (2008) argue that certain tacit knowledge could be useful and deliver competition edge if externalised. Because when the person who possesses tacit knowledge leaves, the firm will lose its knowledge capital if fails to retain such knowledge within the organisation. The most significant work elaborating the management and measurement of tacit knowledge externalisation processes is the work by Nonaka and Takeuchi (1995). Their model illustrates that tacit knowledge is turned into explicit knowledge and vice versa in the externalisation stage in their SECI (Socialisation, Externalisation, Combination and Internalisation) model.

3.2. TACIT KNOWLEDGE EXTERNALISATION TECHNIQUES

Nonaka and Takeuchi (1995) suggested that tacit knowledge becomes explicit using techniques such as metaphors, analogies, cognitive map, hypothesis or models. One effective method of converting tacit knowledge into explicit knowledge is the use of metaphor. According to Lakoff and Johnson (1980), metaphor is pervasive in everyday life, not just in language but also in thought and action. Metaphors can communicate meaning when no explicit language is available, especially in regard to complex ambiguous experience. Analogy is another method of externalising tacit knowledge that reduces vagueness by highlighting the commonness of two different things. According to Nonaka (1994), analogy allows the functional operation of new concepts or systems to be explored by reference to things that are already understood. In this sense, an analogy enables to know the future through the present by assuming an intermediate role in bridging the gap between image and logic. Metaphor and analogy are often confused and the association of meanings and metaphor is mostly driven by intuition, and involves images.

A cognitive map is another technique that represents the individual's personal knowledge and own work experience (Bougon *et al*., 1977). The in-depth questioning allows the knowledge that goes unspoken in the organisation to be "mapped". Cognitive maps visualise such knowledge and communicate the visualisation to individuals, groups or organisations, thus converting tacit knowledge to explicit knowledge (Eden, 1992). Further, several methods are used in the literature to combine cognitive maps to visualise the knowledge of the organisation. Bougon *et al.* (1977) used an average of individual maps, Smith (1992) used participant group discussion and Abernethy *et al*. (2005) used multi method approach to build maps. All these authors created the final map by combining all the maps which generated through their respective methods to ensure all elicited knowledge are retained in the final map (Clarke *et al*., 2000).

Despite of having several techniques to externalise the tacit knowledge to make it explicit, each technique has its own merits and it is important to use appropriate techniques to externalise tacit knowledge based on the application. However, the extent of literature on performance measurement as described above only captures explicit knowledge of the organisation and fails to capture tacit knowledge into the performance measurement models using any of the externalisation techniques. Therefore, it is argued that incorporating tacit knowledge into CSFs identification process will lead to better performance measurement. However, the question of how to identify the CSFs by externalising tacit knowledge in addition to already available explicit knowledge is the challenge. As a result, this research attempts to address this challenge by exploring the method to incorporate expert's tacit knowledge for PM in the Sri Lankan hotel industry. Because, international hotel chains have been growing and most recently global chains have emerged. Moreover, competition has increased, which require more effective operational and business decision-making activities. This has led Sri Lankan hotels to increase their attention on PM and strategic implementation. In addition, literatures indicate that BSC is practicing in Sri Lankan hotel industry and plenty of award schemes available to determine the best PM practitioners. Hence, this research chooses the hotel industry since awareness of PMS will be immense in this particular industry than any other industry. Consequently, the research question that emerged from the above literature findings is that "how to incorporate tacit knowledge in performance measurement in Sri Lankan five star hotels?"

4. RESEARCH METHOD

Case study approach was selected for this research since emerged research question was centred on existing event where the relevant behaviour cannot be manipulated. However, researcher extended the case study with an action research phase when approaching the final output. Researcher incorporated three methods such as archival analysis, ethnographic analysis and expert's participation to develop causal performance maps to create a change for the organisation. Creating a change while doing a research is termed as 'Action Research'. However, this research not following a pure action research but it has stepped into an initial phase of action research study. As per research question, the unit of analysis or case for this study was "critical success factors". In order to avoid complexities associated with the experts who are employed in five star hotels, a single five star hotel was considered and four experts who involved in building PM system for the hotel were considered.

Selected hotel belongs to internationally well recognised hotel chain where Hotel Group operates approximately five hundred and twenty seven hotels in seventy six countries. Selected hotel is a five star hotel which is considered as a city hotel as well as a business hotel and located in Colombo Sri Lanka. As this hotel operating under the shadow of international chain, PM procedures are immense. Hence, this research selected this hotel as a case and relied on the experts who directly involve in PM related activities in this hotel. The first contact in the field was the Director HR of the hotel. He approved the research project and provided the resources needed to undertake the task. The Director HR also provided the research team with background information concerning the history and the internal structure of the hotel and provided access to relevant archival data (e.g. Dash Board, budget reports and routine operating statistics). He identified four key experts for the study who directly involve in PM related activities. The experts include the HR Manager, the Director Operations, the Revenue Manager and the Marketing and Business Development Manager. All of the experts are directly involved in formulating PMS for the hotel and have significant roles in resource management in the hotel function.

The goal of above mentioned method is to create one causal performance map for the hotel function. Several methods are used in the literature to combine maps. Bougon *et al*. (1977) used an average of individual maps, Smith (1992) used participant group discussion and Abernethy *et al*. (2005) used multi method approach to build maps. All these authors created the final map by combining all the maps which generated through their respective methods as it ensures all elicited knowledge are retained in the final map (Clarke *et al*., 2000). In this vein, researcher used few features of these methods and predominantly followed the research work and the approach of Abernethy *et al*. (2005) to develop a new method to extract expert's knowledge in to CSFs identification process.

4.1. ARCHIVAL STUDY

Yin (2003) mentions that the archival records can be used in conjunction with other sources of information in producing investigation. Hence, the current research used this method to collect all the performance measurement related data, which enabled to identify explicit CSFs in a five star hotel. After identifying CSFs, then factors were arranged based on the developed preliminary conceptual model (see Figure 1) to develop a causal performance map.

4.2. ETHNOGRAPHIC ANALYSIS

Interview guideline was used based on a common performance model where inputs are converted into outputs through a transformation process to achieve the objective of this research. Figure 2 illustrates a simple performance model with outcomes classified as either effectiveness or efficiency outcomes.

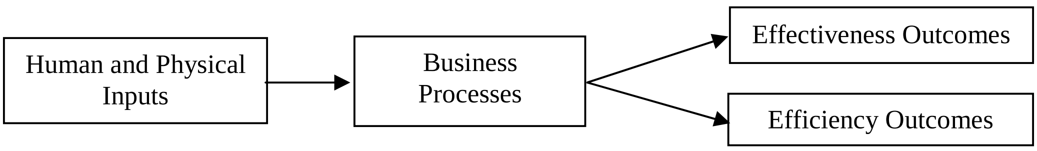

Figure 1: Preliminary Conceptual Model

The model illustrated in Figure 1 was motivated the questions in the interview protocol. Questions were designed to elicit "stories of performance", because stories are vivid, contextual devices for relating personal knowledge and experience. By telling stories of how the organisation functions and the factors leading to success, participants made explicit what might have remained tacit knowledge about goals, processes, performance and outcomes (Boje, 1991). Based on the interview outcomes, CSFs were identified, and then it was arranged based on the developed preliminary conceptual model to develop a causal performance map.

4.3. EXPERTS' PARTICIPATION

The third map-building method used the participants to map causal relations among CSFs. Thus, researcher met with the participants individually for a second time, and undertook the following steps to extract the experts' knowledge for the links between the CSFs:

provided each participant with a set of cards indicating CSFs which were developed from the transcripts of their prior interviews,

explained that these represented CSFs or activities based on their comments in the prior interview, carefully defined each factor by using specific comments and examples from their prior interview, established mutual understanding that the specific comments reflected the particular CSFs, and requested their input on how these factors were inter-related (e.g., "look at these factors or activities, see how they fit together, whether there are relationships among them and position them in time sequence, is there something that you do at one point in time that influence other factors later").

Each participant positioned the cards on a piece of paper and placed or drew arrows between them as appropriate to reflect their causal knowledge. At the same time, note was taken down for the accompanying discussion to capture the rationale behind the relations discussed. Participants were able to revise their positioning of the labels and causal arrows as often as they wished during the interviews. Researcher made no attempt to finalise any map until the participants were satisfied and declared it finished and a good representation of the relationships among the CSFs.

4.4. DATA ANALYSIS

Study used the three complementary methods to analyse qualitative data collected from the interviews in order to create causal performance maps to explore the method to incorporate tacit knowledge into performance measurement in the hotel. All three methods started with performance stories collected in the first round of interviews. The first method relied on the archival analysis of the collected performance measurement related data. The second method reflected the traditional, ethnographic interpretation of first interviews and interview context. The third method used the experts themselves to visually build causal performance maps with cards containing CSFs that had been extracted from their interview transcripts. In the first and second methods, researcher used the data to develop the causal performance map. In the third method, experts were involved in building and validating their own maps. Then, as shown in Figure 2, all three methods were combined to create a final causal performance map to represent the overall knowledge of the organisation. This approach insured that all obtained CSFs and linkages are retained in the final map, which enabled to demonstrate the influence of tacit knowledge towards building of performance measurement system. Hence, Content analysis was used to achieve the final outcome of the research.

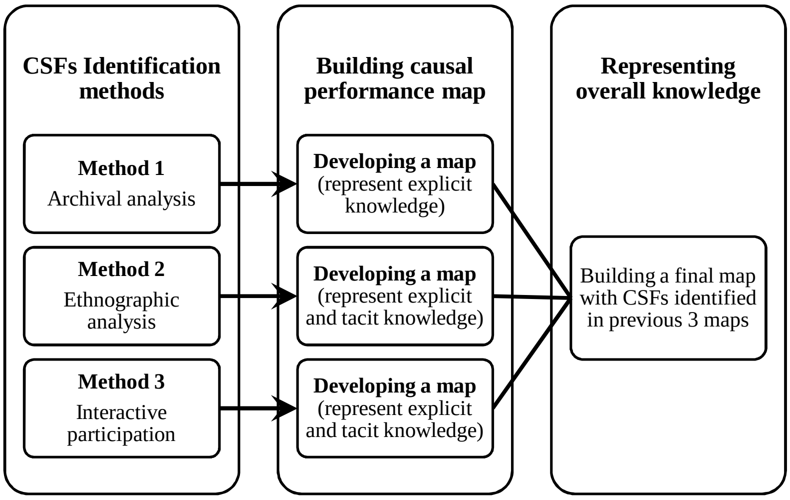

Figure 2: Process of Case Study with a Phase of Action Research Approach

As a data reduction method, code-based content analysis was used in this study to capture important concepts from the transcripts and for effective interpretation. This study selected the software program NVivo 7 for coding function to simplify the works relating to content analysis. Cognitive mapping, which is a network technique, was selected for data displaying process within this study. Cognitive maps visualise knowledge and communicate the visualisation to individuals, groups or organisations that helps to convert tacit knowledge to explicit knowledge (Eden, 1992). One type of cognitive map that captures judgments about the link between actions and outcomes is a causal map. Building a causal map is a means of converting individuals' tacit knowledge to a model of explicit CSFs and their interrelations. In causal maps, the nodes are the constructs that the individual feels important and the arrows show the relations among the constructs (Atkinson and Bowman, 2001). A causal performance map can be viewed as a cognitive map of organisational success. CSFs and arrows represent the links among inputs, processes and valued outcomes. In this manner, cognitive mapping provided data to support the development of a PM system for the fulfilment of this research. By tapping the knowledge of individuals within an organisation, a causal performance map described the CSFs and relations among them. This map made possible to define measures that are potential candidates for inclusion in a PMS system.

5. RESEARCH FINDINGS

Method 1: Archival Analysis

The first causal performance map derived in this study results from the currently identified and practicing CSFs in the selected five star hotel. Currently identified and practicing CSFs in the hotel represent the explicit knowledge of the organisation (refer Table 1 for CSFs). For the confidentiality, researcher did not include the BSC of the selected hotel and only CSFs are extracted in this research with the permission of the hotel management. Each observed linkage was evaluated by reading the relevant transcript sections to subjectively assess whether the observed linkage is coherent or spurious. Only those links with at least seven logical links are retained in the map (refer Figure 3).

Table 1: Critical Success Factors of the Hotel

Communication	Recruitment	Performance Reviews
Department Status	Retention	Networking
Department-level Financial Outcomes	Teamwork	Process Constraints
People and Technology Constraints	Training	Satisfaction
Employee Satisfaction	Empowerment	Leadership

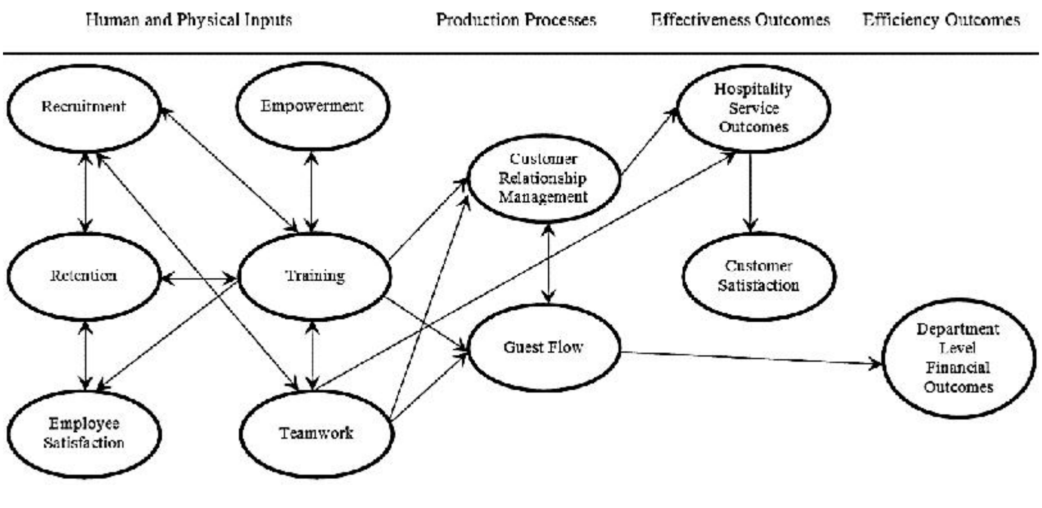

Figure 3: Process of Case Study with a Phase of Action Research Approach

Method 2: Ethnographic Analysis of Interview Data

Figure 4 describes a more complex map that reflects interpretations of the importance of expressed causal linkages beyond the more restrictive method 1. This includes nine additional CSFs such as Leadership, Communication, Performance reviews, Networking, Customer profiling, Service contributions, Staff as drivers of innovation, Department Status and Hotel’s financial position. These are recognised in the model where at least one interviewee expressed as important but hotel fails to identify and practice none of these CSFs hence, they were not captured in method 1. Customer profiling is one of the nine additional

CSFs is unique to the map that is included in the production processes category in method 2 but not in methods 1 or 3, which follows. Finally, Figure 4 identifies four additional external factors such as Quality staff unavailability, Downfall in tourism, Location advantages and Market segmentation that are outside the span of control of the hotel function that influence performance.

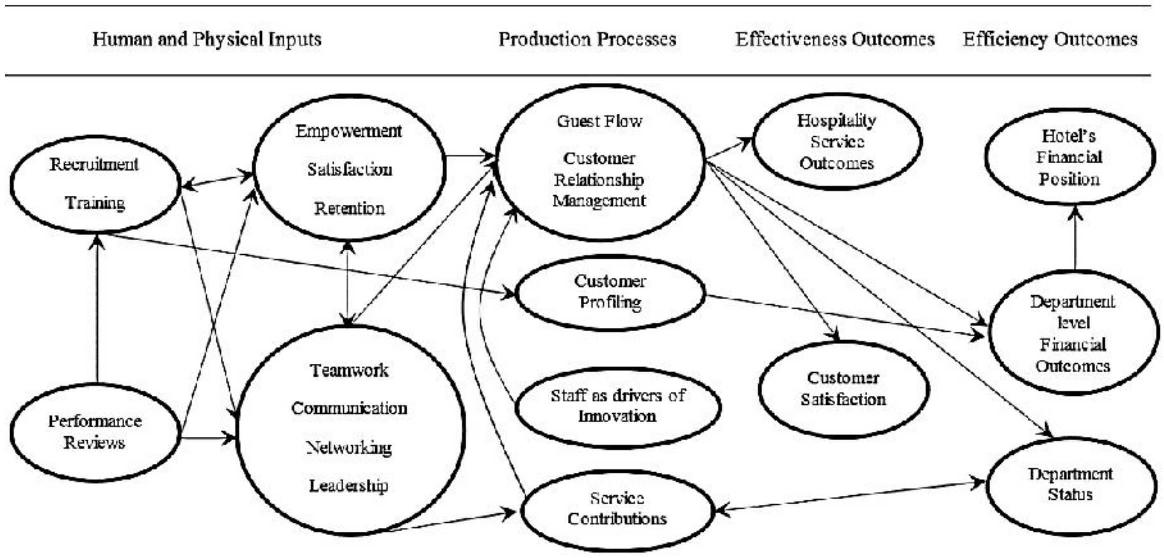

Figure 4: Ethnographic Analysis of Interview Data

Consistent with Figure 3, Figure 4 exhibits relations among CSFs within each category. Also consistent with Figure 3, human and physical inputs affect production processes and effectiveness outcomes while production processes affect effectiveness and efficiency outcomes. Unique to this causal performance map is the bilateral relation between production processes and efficiency outcomes. The causal performance map generated using ethnographic analysis of interview data is consistent with the map generated by archival analysis method. Additional CSFs were identified and a recursive relation was found between two categories.

Method 3: Interactive Mapping by the Experts

The overlaid individuals' map into one causal performance map is shown in Figure 5. As in Figure 4; Figure 5 represents the most general inclusion of CSFs and relations obtained from participants. In addition, individual map expressed in participants' own terms were combined into one common map when definitions clearly matched. The level of complexity of Figure 5 undoubtedly reflects the number of cards provided to the participants. Participants were provided with a set of cards (18 on average) reflecting the most commonly cited CSFs in their own initial interviews. This purposeful research design judgment makes the task descriptive but also keeps the cognitive complexity of the task within reasonable limits, although the maximum feasible number of cards for the task was not apparent. Participants were free to create additional CSFs cards beyond those provided by the researcher and three participants each added only one. Participants appeared to be comfortable working with the cards provided; whether they could have worked effectively with more cards is unknown. Figure 5 adds several important features to the previous maps. One CSF that is unique to this map is Occupancy rates. Even though it was not mentioned during the first round interviews, participants created this CSF during the map building process. Two additional bi-lateral causal relations were added in this map. When building the map, participants noted recursive relations between human and physical inputs and production processes and between human and physical inputs and efficiency outcomes. Participating in Service contribution programs affects employee training, communication and peer reviews while efficiency outcomes affect the department's ability to recruit employees. Figure 5 introduces a feedback loop from outcomes back to inputs which demonstrates that result of the efficiency outcome feeds to human and physical inputs to maximise the efficiency of the organisation and it becomes a continues process.

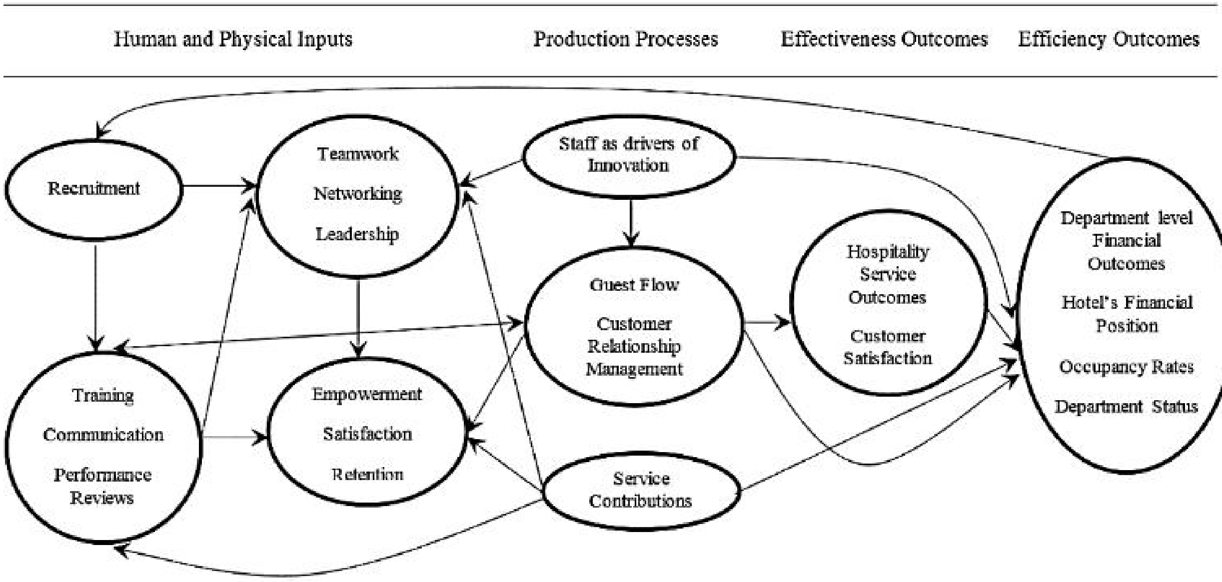

Figure 5: Interactive Mapping by Participants

5.1. *Incorporating Tacit Knowledge into CSFs Identification Process by Combining Three Methods*

Once again, the most general combined map is created, effectively layering Figures 4 and 5 upon Figure 3. Figure 6 displays this combined casual performance map, which reflects the full set of counted, contingent and elicited CSFs and their relations (Clarke and Mackaness, 2001). The causal maps; archival, ethnographic, or participant interaction are complementary. The archival analysis method created a map of causal links defined in the hotel BSC model and it reflects the explicit knowledge of the hotel. This map served as an objective core. The ethnographic approach expanded the map to include more CSFs and recursive causal relations. The participant interaction method again added a new CSF and two additional recursive causal relations. While this is not the same as cross validation from independent data, the combined method uses three assessments of the causal relations reflected in the data. This method results in a more inclusive extraction and articulation of the causal linkages implicit in the participants' initial causal performance maps than any single approach. Combined method enhances the possible descriptive validity of the map in Figure 6. This complex causal performance model reflects the complicated nature of the hotel function studied here, which (like most business units) is a complex entity. Figure 6 has clearly shown the impact that tacit knowledge made to this CSFs identification process. Hotel managed to identify only 11 CSFs and 2 external factors with its explicit knowledge but after the influences of tacit knowledge, the research managed to identify 21 CSFs and 6 external factors.

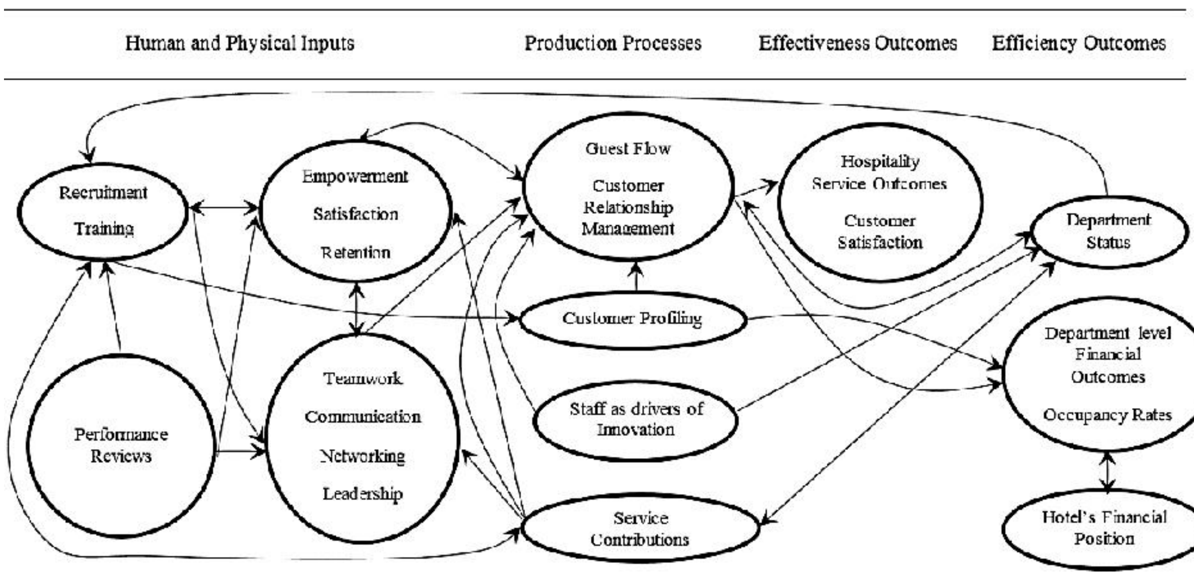

Figure 6: Triangulated Causal Performance Map

However, one may raise the question that “by identifying more CSFs, will it lead to better performance measurement?” Actually, these 21 CSFs were identified based on the causal relationship where each factor contributes towards achieving the primary objective of the organisation. For example, Training is one of the CSF that identified by the hotel however it fails to identify the employee performance review factor which is a vital CSF to determine whether particular employee require training or not and it contributes to check the effectiveness of training as well. Fortunately, with the inclusion of experts’ tacit knowledge, employee performance review factor is identified in Figure 6. Similarly, 21 CSFs identified in the final map carries value reasons for the selection and it will certainly lead to better PM.

6. CONCLUSIONS

Researcher found out the method to incorporate tacit knowledge in to PM in the hotel industry which was the primary aim of this study. To achieve this, researcher used interviews as a common source of mental data but combined three independent approaches to the analysis of the data to enhance the validity of the causal performance map. With inclusion of tacit knowledge in to PM, 21 CSFs were identified based on the causal relationship where each factor contributes towards achieving the primary objective of the organisation. However, explicit knowledge managed to identify only 11 CSFs where some are not frequently practiced by the organisation. Therefore, it could be concluded that it is effective to incorporate tacit knowledge in PM in a Sri Lankan five star hotel and tacit knowledge externalisation techniques such as stories, discussions, metaphors, analogies; etc. could be used during data collection process and cognitive map could be used to represent the tacit knowledge of the experts. To ensure an effective PMS, perhaps, at minimum, either the ethnographic or the interactive method could be used along with archival analysis method to represent both the explicit and tacit knowledge of the organisation. Therefore, it is important to develop guidelines to facilitate how tacit and explicit knowledge can be practically used to develop PMS and enhance the overall performance of the hotel industry. The approach used in this study for incorporating tacit knowledge into PM is adaptable to Sri Lankan hotel industry. It is also noted that the findings in this study was consistent with the findings of Abernethy *et al*. (2005).

However, there are several potential limitations to the study. Researcher used limited numbers of experts to develop the causal performance map to incorporate expert’s tacit knowledge for identifying CSF for PM in the Sri Lankan hotel industry. It is thus possible that the map is not truly representative of the hotel function (or similar programs) but only reflects the views of the respondents selected. The model is built on qualitative data and may thus be subject to both interviewee and interviewer bias. Researcher attempted to address these data limitations by adopting three alternative methods to extract the causal model. Data also collected until the fulfilment of the research and the “stories” from set of experts were consistent. The developed causal performance map might not be generalisable outside the hotel function. However, the prime objective of the research study was not to develop a generalisable map but rather to identify the method to incorporate tacit knowledge in performance measurement in Sri Lankan hotel industry to prove the effectiveness of knowledge externalisation in developing PMS. Furthermore, all such maps are idiosyncratic to specific settings. It is possible, however, that the basic elements of the causal performance map are generalisable across hotel programs.

Further research can be directed towards assessing if this is the case. This would enable the development of a more general “hospitality” causal performance map for use in multiple programs within the hotel industry. The outcome of such research has the potential to make a significant contribution to the management of the hospitality services. Three steps are required to develop such system. First, it is necessary to identify suitable measures (KPIs) for each CSF in the causal performance map, thereby converting the causal performance map into a performance measurement system. Second, the statistical significance of the CSFs needs to be established. This will enable an identification of the most critical performance drivers among the array of CSFs. Third, top management needs to assess the costs and potential accuracy of on-going measurement of these CSFs. While there are costs associated with the design and implementation of a performance measurement system based on causal performance mapping, the process in itself ensures that the tacit knowledge impacted in core operating units is converted to explicit organisational knowledge. This is an important way the organisation can build its organisational capabilities.

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INDUSTRY ATTRACTIVENESS OF OUTSOURCED FACILITIES MANAGEMENT SERVICES IN SRI LANKA

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ABSTRACT

Buildings should be habitable, safe, durable, energy efficient and adaptive to use though it is expensive to manage. The specialized team of Facilities Management (FM) is thus invited to create a comfort built environment that strongly supports the core business of the organization. The emergent trend of outsourcing FM services has become widespread topic in the field of built environment though it is relatively new to the Sri Lankan context. Hence, this study aims to examine the attractiveness of the market for 'FM services' in Sri Lanka as a primary step. Porters five forces analysis was developedat the line-of-business industry level to analyse the existing market. A comprehensive literature review was carried out on a broader perspective with the purpose of getting familiarise with the research phenomena. In order to examine the attractiveness of the outsourced FM market two FM professionals; one from an International FM company and the other from a Local FM company, employed at the strategic level were interviewed. The research findings revealed that the market for FM services in Sri Lanka is long been considered as a niche market with a slower growth and is still in its infancy. Two companies, a local and a global company are dominating in the industry. The Porter's five forces indicated that average bargaining power of client; less bargain power of suppliers; less substitutes; lower level competition thus there are few barriers to enter the market. However, it is clear that the boundaries of the market have not been defined yet; hence the new entrants have the freedom to define their own market share. This study urges to define the market for outsourced FM services and further, FM companies can get the benefit of this analysis in order to formulate successful business strategies to enter and sustain in the market.

Keywords: *Market Competition; Outsourced Facilities Management; Porter's Five Forces.*

1. INTRODUCTION

The ever-increasing competition for new construction works, increased number of aged buildings and the changing need of building occupants have created a vacuum for efficient and effective management of the built environment. Buildings' owners or users are hunting for favourable solutions of lower operational costs and less risks through effective and efficient management of building related support services, without compromising their business performance (Shohet and Lavy, 2010). Thus, the buildings' owners used to delegate or outsourced their building management operations to a specialised Facilities Management (FM) team. The practice of outsourcing FM services has been encouraged mainly by the promise of getting better service at lower costs compared to producing the services in in-house (Ventovuori and Lehtonen, 2006). It is therefore a massive demand for the outsourced FM industry has been created and it has been gradually broadening its capabilities with a rapid growth around the world. The market for outsourced FM services is large and growing, estimated at more than $500 billion globally. The market is segmented by provision of services to include single service (65% of the global market), bundled services (23%), and Integrated Facilities Management (IFM) service (12%) (Little, 2016). The market for outsourcing bundled and Total Facilities Management services were valued at just over £18.5 billion in 2013 in UK (AMA Research, 2016). Jensen (2010) report cited that €53 billion for the total potential FM market in the five Nordic countries. The Swedish, Finland, Norway, and Denmark

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FM market was €23 billion, €12 billion, €9 billion, €8 billion, and €0.7 billion respectively. Tan *et al*., (2014) mentioned that the building maintenance is becoming a major market in Hong Kong due to the declining investment in new construction projects, investment in maintenance and repair work in recent years in most developed countries.

According to Raghunathan and Bera (2014), the concept of outsourcing FM is at its emerging stage in Sri Lanka. There is a slight growing trend towards outsourcing FM services over the traditional in-house FM departments in Sri Lankan business organisations. Numbers of local and global FM companies are evolving in the industry. Some of the companies have survived in the market while some companies have retreated and some more companies are aiming to establish. The recent developments in FM industry have heightened the need for analysing FM outsourced market in Sri Lanka which has not paid attention by the recent researchers yet. The study is therefore aims to assess the prevailing competitiveness of FM outsourced industry in Sri Lanka to identify whether the outsourced FM industry is attractive or unattractive to invest.

2. LITERATURE REVIEW

This section explores the relevant literature in the research arena with major focus is given to four areas; FM in general, FM in a business context, FM market in Sri Lanka and finally Porter's five forces theory.

2.1. FACILITIES MANAGEMENT

Facilities Management is a profession that has ascended as a significant proponent in the built environment. According to Alexander (2003), FM entails the integration of people, technology, and support services to achieve an organization's mission.Wiggins (2010) defined FM as a management function concerning three interrelated elements of business, i.e. premises, support services and information technology. FM covers an extremely wide field of activities including physical issues of built space, services, technology, maintenance, modification and adaptation; the human and business concerns of facility purpose, function and use, security, safety, comfort and environmental health; it covers the financial issues of property investment, asset value, the costs and benefits of occupancy (Nutt, 1999). Followed by Nutt (2000) revealed the primary function of FM as the resource management, at strategic and operational levels of support. The same report stated that the management of financial resources, human resources, physical resources, and the management of the resources of information and knowledge identified as the generic type of resources that are central to the FM functions. Thus, FM is an integrated approach of maintaining, improving, and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of the organisation (Barrett and Baldry, 1995).

There are common themes and approaches to FM including 'outsource', 'in-house' or 'partial outsource or in-house', regardless of the size and location of buildings (Atkin and Brooks, 2009). The arrangements of FM functions may relate to the particular personality, needs, circumstance and environment of the organisation at the time (Chotipanich, 2004). An effective FM encompasses multiple activities under various disciplines, combine resources, and it is vital to the success of any organization (Noor and Pitt, 2009). In the beginning of 21st century, when the property is recognized as a cost-center that can contribute to profit (Shohet and Lavy, 2010), the novel strategies or approaches of FM were highly demand driven. In global context, FM is identified as a most mandatory function within the building industry so that it spreads widely transforming its traditional shapes into most demand function catering to contemporary business environment. The next section discusses the evolvement of FM in business context.

2.2. FM IN A BUSINESS CONTEXT

The ever-increasing competition for new construction works, declining investment in new construction projects, high investment and focus on maintenance and repair work, need of maintaining those existing buildings that are still in good conditions and many other factors have created to emerge and continually stay FM market around the world (Tan *et al*., 2014). FM has established itself as a key service sector, with a diverse and highly-competitive market of FM contractors, in-house FM teams, FM vendors, FM consultants and professional FM institutions (Tay and Ooi, 2001). Accordingly, FM has been transforming its role and functions to respond building industry vacuums at any given time. According to Alexander (2003), a market for facilities service is developing rapidly, with increasing emphasis on management roles. FM companies and consultants are developing new value added services with the growing need of clients. Sustainability and energy management solutions, customer satisfaction, maintain better environmental conditions, measuring key performance indicators, different types of contracts for risk sharing are few prospects of clients from the FM outsourced companies (Tan *et al*., 2014; IFMA, 2011). In addition, International Facility Management Association (IFMA) (2011) reported that trends towards FM service providers have been recently changed primarily due to the global economic recession.The trends are to lower the FM contract price due lowest rental rates, use of performance based and gain sharing structure and change suppliers to make pricing concessions due to pressure on client cash flows and etc. Further it was revealed that client prefers to sign flexible and short term negotiated contracts allowing to re-position it with the future growth (IFM, 2011). However, FM has to incorporate sustainability, innovation and intelligence to provide a high standard of living and working environment for people in future context (Tan *et al*., 2014).

With the demand driven growing trend, firms have moved to the FM market using different strategies or approaches. Tan *et al*., (2012) proposed that the contractors could sustain business in long-term by entering to the FM market. The contractors shall reconsider the share of the maintenance in their business as there will be more opportunities in building maintenance, repair and renovation than new construction. Further, a single service supplier could expand their business towards bundled services and further to IFM service providers as shown in Figure 1 (Denali Group, 2013). The Figure 1 illustrates the growth of IFM suppliers and other industry profiles. The growth in the single service has moderated due to high outsourcing rates and pricing pressures while IFM demand is expected to remain strong as companies continue to consolidate their FM services (Little, 2016).

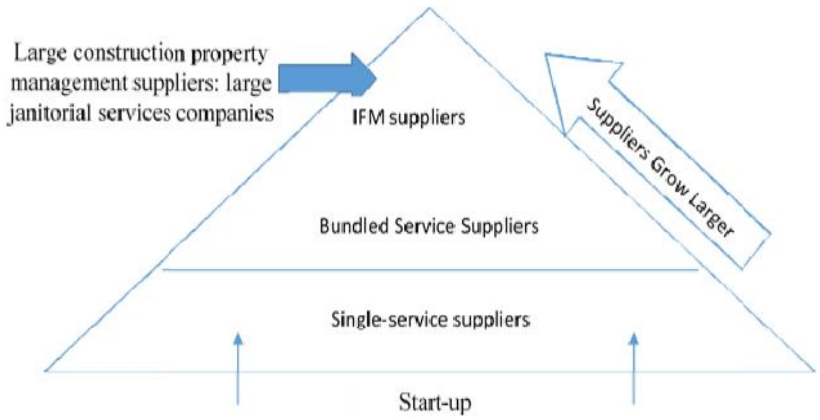

Figure 1: IFM Supplier Progression
Source: Denali Group (2013)

According to AMA Research (2016), the development of FM market has been positively influenced by the trend to outsource an increasing array of services, with a gradual shift towards 'bundled service' and Total FM contracts adding to contract values. PFI/PPP (Public Private Partnership) schemes have provided significant impetus for growth over the last decade with Design, Build Finance Operation (DBFO) schemes commonly incorporating long-term in UK. According to the Denali Group (2013), USAFM industry remains highly fragmented and competitive and highlighted the following factors of the competitive market.

- *Price and the quality of service: The low cost of entry in the facility services business intensifies the marketplace,*
- *Large number of service providers: A large number of regional and local owner-operated companies, located mostly in key cities in US.*
- *Low product differentiation: the scope of service offerings*

- *Competition from building owners*
- *Availability of a large pool of labour*
- *Moderate growth in prices of materials and purchases for facilities management services*
- *Service providers have been looking to expand their service offering to attract new customers and increase the opportunity of extending their present contracts*

The Denali Group (2013) further highlighted the key demand factors of FM services industry:

- *Economic Activity: Positive trends in macroeconomic indicators induce investment by both government and private sector, drive corporate profits, and widen service sector growth, directly driving facilities services demand.*
- *Occupancy: Improvement in office absorption and decrease in office vacancy rate indicates growing demand for offices, and thus affects facilities services demand.*
- *Employment: High unemployment rate impacts facilities management industry negatively as bankruptcies and shutdowns impact the demand for facilities management*

KPMG (2015) highlighted competitive characteristics of Real Estate and Facilities Management (REFM) outsourcing market as follows,

- *Many firms prefer to bundle their REFM services under the fewest number of service providers and operate under an integrated model to further reduce costs, drive consistency, and improve governance, controls, service level agreements, KPIs, and performance reporting.*
- *The key for buyers defining outsourcing goals is to ensure that their scope and level are practical and achievable given the nature of the outsourcing effort and in the context of buyers' own outsourcing skills and capabilities.*
- *Tactical REFM services (e.g., workplace and facilities services, lease administration, facilities management) are the activities most commonly outsourced.*
- *A growing number of service providers are demonstrating advanced capabilities to integrate into existing business operations to provide more high-value and strategic services in terms of services offered*
- *Organizations are increasingly seeking bids for services and considering alternative providers rather than simply renewing the contract with existing providers to ensure that buyers are getting the best price available for the services in scope and are best leveraging the current capabilities in the market.*
- *A most REFM outsourcing contracts are three to five years in length to provide buyers the flexibility to swap out providers*
- *A variety of factors affect service provider profitability including deal scope, transition costs and time frames, exchange rates, wage inflation, and buyer pricing sophistication*
- *The biggest factors impacting contract profitability are buyer pressure on pricing and aggressive competitiveness between providers, along with some buyer pull-back on more profitable discretionary services and an increased focus on cost cutting over process improvement work*

A growing competitiveness within the FM service sector raised a necessity among FM providers to differentiate the services they provide from their competitors, which can be achieved by giving attention to the specific needs of their clients (Cardellino and Finch, 2006). Tay (2006) discovered that both hardware, i.e. facilities and software, i.e. business philosophy of the organisation are important to enhance its competitive position with the FM. Tan *et al*. (2014) highlighted the fact that client's satisfaction, certification of company, reliability of service, quality of service, and company reputation as critical success factors of FM service organizations. Jensen (2010) noted that the combination of internal (corporate function under constant reformation in accordance with the development and the changing needs of the core business) and external market (outsourcing and the business strategies of a range of different types of provider companies) give strong dynamic forces for the field of FM practice.

Furthermore, AMA Research (2016) highlighted the fact that there has been a trend for large FM companies to make strategic acquisitions in order to increase their range of services and competitive position, the more difficult trading conditions have also influenced this trend to consolidation. This trend has accepted with the national or global coverage favouring larger multinational FM providers. The key to advancement will be maintaining high standard of services in core activities whilst adding value by offering enhancements and differentiated services. Although, these concepts are still novel to the Sri Lankan context, FM market is evolving steadily in Sri Lanka. The next section discusses how FM market has been evolving in Sri Lankan context.

2.3. FM MARKET IN SRI LANKA

Sri Lanka is proactively investing in various infrastructural projects, from improving transport networks to telecommunications and electricity generation. This has resulted the construction sector steadily increasing its stake in the Sri Lankan GDP from 7.6% in 2009 to 10.3% in 2013 (Raghunathan and Bera, 2014). According to Mayank and Robin (2009), there is a healthy demand for office and residential space in the Colombo real estate market with the growth in the textiles and apparel industry finance, insurance and information and communication technology hotels and restaurants sector. These sectors may look for a quality space environment. Raghunathan and Bera (2014) cited that, not only Colombo area, but also in out of Colombo areas have high demand for quality space environment with the growth of new real estate projects. With real estate costs being the second largest cost component after human resources for the services industry, awareness for it amongst office occupiers and developers regarding various cost-saving opportunities is important (Raghunathan and Bera, 2014). Thus, Sri Lankan property market seeks for specialised teams cater to the growing demand of FM.

According to Raghunathan and Bera (2014), the concept of outsourcing FM is at its nascent stage in Sri Lanka. Companies have historically adopted more of an in-house model with an ‘out-tasking’ approach in which single services such as cleaning, catering or maintenance, are delegated to external providers. The FM industry is still evolving in Sri Lanka, the shortage of qualified talent, benchmarking data and high-quality service providers and suppliers could create challenges in the quality and consistency of services. So far, also, there has been little attention paid on this. It is therefore assessing the competiveness of the FM outsourced market in Sri Lanka together with its strengths, weakness, opportunities and threats is a timely requirement. In this context, Porters’ five force theory is suitable to assess FM outsourced market competitiveness. Accordingly, the next section briefly elaborates underlying principle behind, Porter’s Five Force theory and how it is used in this study.

2.4 PORTER’S FIVE FORCE THEORY

In 1980, Michael Porter introduced five basic competitive forces that defined the competition in an industry as shown in Figure 2. According to Porter (1980), the collective strength of these forces determines the ultimate profit potential in the industry, where profit potential is measured in terms of long run return on invested capital. Not all industries have the same potential. They differ fundamentally in their ultimate profit potential when the collective strength of the forces differs. In 2008, Porter has updated the five forces by mentioning that the five forces framework is to understand strategic implications for individual firms within an industry (Porter, 2008). Various authors have interpreted the theory favourably and adversely. However, this study applied the theory in order to assess the outsourced FM industry in Sri Lanka in terms of customers, suppliers, substitutes, potential entrants and competitive rivalry.

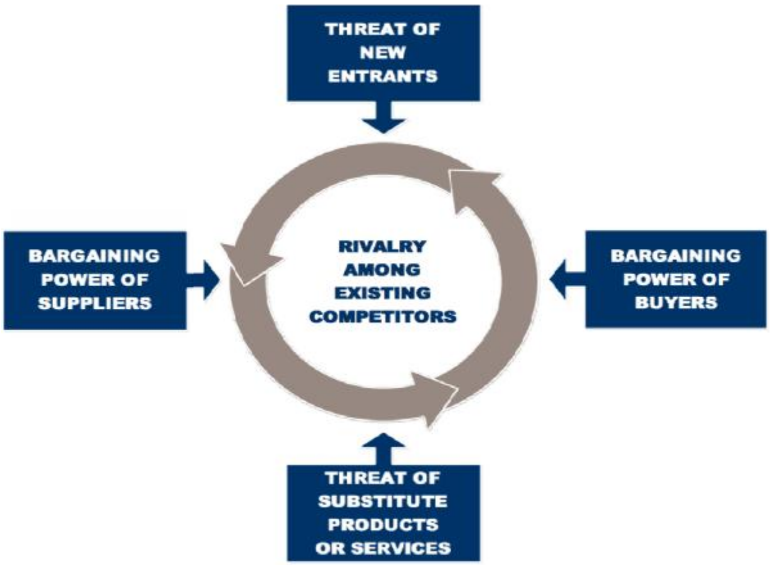

Figure 2: Forces Driving Industry Competition
Source: Porter (1980)

3. Research Methodology

The study was structured in several steps. A comprehensive literature review was carried out on a broader perspective with the purpose of getting familiarize with the research phenomena. This was mainly taken place to identify the outsourced FM industry and its growing trends in both local and global arena. Interview guidelines were developed based on the findings of the literature review. The interview guideline mainly consisted of two stages; namely; general information, existing FM industry. In order to examine the attractiveness of the outsourced FM market, the two expert interviews were carried out with experienced industry professional. The selection of experts was screened to the organisations which outsourced total FM services. It was found that few local and foreign companies exist in Sri Lanka. Corporate level persons from both local and foreign companies were selected for the study (refer Table 1). Semi structured interviews were carried out with them to assess the existing outsourced FM market in Sri Lanka. Finally, content analysis was used to streamline the findings of two respondents into five forces of Porter's theory.

Table1: Respondent Profiles

Respondent	Year of Experience	Company Profile
Respondent 1 (R1)	23yrs	The respondent employed in a premier property development and investment holding organisation based in Sri Lanka. They are mainly delivering FM services to two of Colombo's most iconic developments. In addition, they manage facilities ranging from commercial, retail to residential.
Respondent 2 (R2)	16yrs	The respondent employed in a global real estate services firm specialising in commercial property and investment management, providing comprehensive services for real estate management, which has recently established in Sri Lanka.

4. Data Analysis

The findings from two expert interviews were discussed under Five Forces introduced by Michel porter. Those will be the basis for following discussion. There are five headings, namely; Threat of new entrants, Threat of substitute, bargaining power of buyers, bargaining power of suppliers and finally competitive rivalry. The aim of this study is to analyse the existing FM outsourced industry in Sri Lanka in terms of its competitiveness. Michel Porter introduced five forces that would determine the competitive position within the market. This section discusses the prevailing market of outsourced FM in Sri Lanka.

Threat of New Entrants

Various strategies have been used to enter the Sri Lankan FM market by local and international companies. R1 employs in an organisation which is managing and operating one of the largest high rise buildings in Sri Lanka for more than 15 years. Having seen the opportunity in the industry and their potentials to survive in the industry, the company expanded its' operations as a FM services provider. The very first FM business of the company was a residential property which was invested by the company itself. According to one of the respondents (R1), the reputation that was built over the years, competent human resources and physical resources have supported to enter the industry easily. R1further mentioned that "*entering to this industry was very easy as we have proven our capacity over past years by maintaining the largest building which enables to maintain the trust for the client*". R2 employed in a foreign company which is new to the Sri Lankan FM industry, mentioned that "*being a multinational company with competent resources make easy to enter the market*". This company has used a Greenfield investment strategy where the company was originated by itself while bearing risks associated and cost to enter the market. R2 mentioned that "*we didn't face any challenges or issues to catch the Sri Lankan market since there is no government restrictions, or rigid legal framework or political interventions*". This view was accepted by the R1 as well. However, both respondents explained that companies have to possess huge financial resources to enter the market. R2 is uncertain about the economic stability of the country. Thus, R2 is doubt about the exchange rate risk, inflation rates and other price fluctuations from a point of view of an international company. However, both organisations are currently satisfied with the return, company growth and success in the FM market. Moreover, both respondents accepted that the industry is not matured and it is in growth stage whereas it is easy for new companies to enter the market. There are huge opportunities in the market for both international and local companies.

Threat of Substitute

It is obvious that the property owners have three options to obtain FM services; either in-house or outsource or partial in house or outsource. According to respondents, most of the buildings are allocated in house staff to carry out FM services. The respondents believed that this will be changed in near future where there will be a huge growing demand for outsourcing FM services among all building sectors. R2 stated that "*who likes to bear the burden or take responsible of the burden, thus, most are looking for a company to delegate their FM services for a reasonable price*". This was very similar to the idea of R1 where R1 was of the opinion that "*considering my past few years of experience, more buildings are interested to outsource FM services to a specialised team. This is profitable than employing in-house staff*". Hence, it can be safely concluded that there is a less threat from the substitute service of in house.

Bargaining Power of Buyers

The outsourced FM market is relatively small in Sri Lanka. Buyers of this industry are property owners or clients who wish to procure FM services. In Sri Lanka, there is a large pool of clients in different property categories such as hotels, retail, hospital, residential and other and these clients have different expectations. According to the R1, property owners in residential buildings or condominiums are mostly outsourcing their operations comparing to other property owners. This is also proved by the fact that most of the clients of R1 and R2 are from residential sector. R2 serves for the clients of office buildings, manufacturing, corporate and other commercial properties. R2 further mentioned that "*we got lot of business by word of mouth, and when some reputed organisations accept outsourcing prior to in house, there is high tendency to follow the same trend by other companies well*". Accordingly, both respondents are expecting growing future demand from the different client categories due to transformation of clients' perceptions or trends as well as the new constructions. Hence, it is apparent that there are huge customers for this industry though less number of FM outsourced companies exists in the industry.

The discussion revealed that the FM services are provided through the contracts of minimum one year period. The parties can negotiate the contract terms according to their preference. Trust and performance of the service provider may directly stimulate to break or renew the contract period. Client can switch to different contractors after a prior notice. Further, client and service provider mutually decided the contract price. Determining the price is critical for both parties. Respondents highlighted that client has a higher ing power in deciding the contract prices.

According to respondents, Sri Lankan clients are not well aware of the concept of FM. R2 mentioned that "*clients request different levels of services and they have different expectations as they do not have any idea on what is FM*". Thus, FM service providers generally explain their services, capacities and service outcomes to their clients about the benefits in addition to their business. The study revealed that both companies of R1 and R2 are very selective on deciding the clients. R2 said "*I don not want troublesome clients. Thus we focus mostly on genuine customers where we can negotiate*". This demonstrates the fact that the service provider is more powerful within an environment of uneducated clients about FM. However, when it comes to a selective approach, client has high bargaining power for obtaining FM services than the service provider.

Bargaining Power of Suppliers

Current practice of the industry is FM companies subcontracting some of the services to suppliers upon winning the main contact. In this industry, suppliers are single service providers such as security, cleaning, pest control, building maintenance, office equipment service and other facilities related services. The study discovered that there are number of suppliers or sub contracted parties in the industry and most of them are local companies. However, respondents are not satisfied with the quality of the service and performance level of suppliers. This was confirmed by R1 stating that "*I doubt whether these suppliers are resourceful and they have sufficient technologies or knowledge to perform their task. In further, we are having scarcity of quality suppliers*". Due to the lack of experts and availability of large pool of suppliers, the bargain power of the suppliers is less in the industry. Therefore, it would be a new challenge for them to compete in the industry and there is a need of developing their capacities in terms of quality, time, technology, performance etc.

Competitive Rivalry

The defined Sri Lankan market for outsource FM services is yet to be discovered. More FM companies have initiated their business recently and need to expand limits of the FM market. Local companies who were providing a single FM service, have extended their portfolios by providing total FM solutions. The in-house FM units which have long being operated and managed high rise buildings having identified its full potentials and capabilities, have converted their business centres to delivering total FM solutions. Property developers or real estate companies and construction companies have diversified their business risks and expanded the market by entering to total FM services industry. Moreover, international FM companies have initiated business in Sri Lanka with growing demand for FM services. Number of local and foreign outsourced companies exist in the industry and many more companies are expecting to establish. It was discovered that two companies which were selected for this study are dominating the market due to its financial and reputational capacities. However, the competitors are having different strategies. The reputation, quality of the service, financial resource, human resources and brand loyalty enable FM companies to compete in the industry. However, it was found that there is a cold war among these companies.

5. DISCUSSION

The choice of in-house or outsource FM services is a critical decisions taken by the property owners. It is obvious that there are advantages and disadvantages of both the approaches though various facts contribute for the decision. However, in Sri Lanka, there is a slight growing trend towards outsourcing FM services and therefore there is an emergent market for the outsourced FM organisations to cater to the growing demand. Number of organisations are approaching the market and delivering their services according to their own strategies. Hence, the study intended to investigate the prevailing competitiveness in the industry through the Porter's five forces analysis. Figure 3 presents the features of the existing FM outsourced industry in terms of five forces which were discussed in the aforementioned section. It was revealed that it is easy to enter the market as there are less political, governmental and legal aspects though companies required to possess a strong financial and human resource base. Further, there are different types of clients in different property sectors and their bargaining power is average due to the large pool of untapped customer requirements. The industry is price sensitive. There is no differentiation strategy other than the in-house approach. Though there are many suppliers exist in the industry, their power is less. Even though there is a slight competition prevails among the existing FM companies, the market is attractive for innovative and expert FM service providers.

Business organisations cannot always succeed in their business operations of this industry. According to respondents, several foreign and local companies have failed in this industry. It is therefore companies' decisions to identify its target market and potentials. R2 mentioned that "*this industry in Sri Lanka is Virgin, and there is lot more to grow in this industry*". However, it is evidenced that there are great opportunities in this industry and the respondents are expecting more demand for the FM businesses in the future.

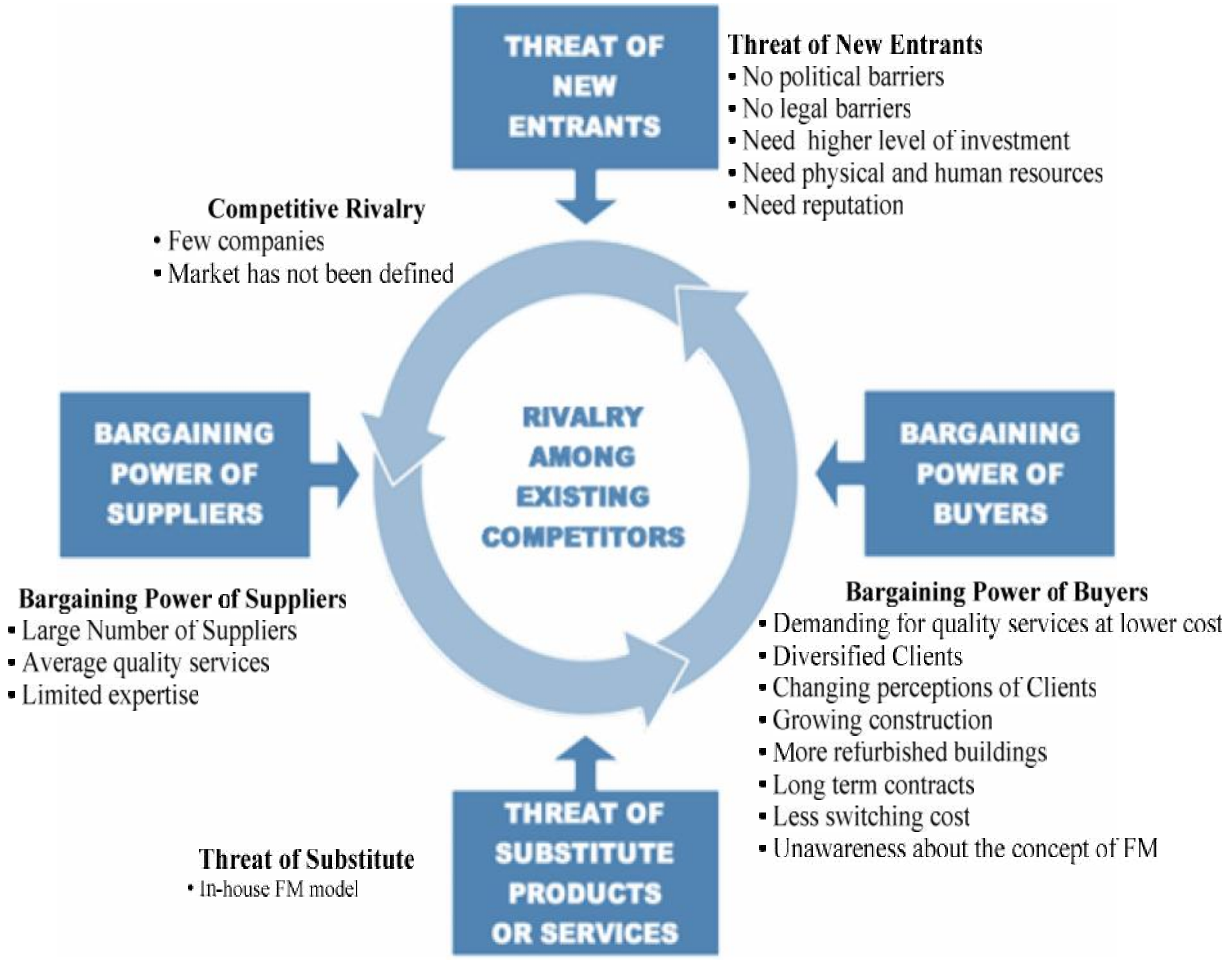

Figure 3: Outsourced FM Market in Sri Lanka: Porter's Five Forces

6. CONCLUSIONS AND RECOMMENDATIONS

FM market in Sri Lanka is long been considered a niche market that has not been widely considered by industry professionals or researchers. The growth of the FM industry in Sri Lanka is very slow and the market is still in its infancy. The definition of FM is poorly understood and it is not being practiced in an appropriate way. It was apparent that foreign companies and local companies are operating as a FM service providing companies and this has become most interesting topic in the field of built environment. Specially, there is a growing trend for outsourced market within the Colombo region due to the massive ongoing construction projects, urban development projects, and new investments on infrastructure development projects. Considering the opportunities and the vacuum of the market, more and more foreign and local companies are aiming for the industry. Thus, this study intended to assess the competitiveness of the existing outsourced FM market in Sri Lanka. The Porter's five forces analysis is enabled to identify the industry competitiveness and attractiveness. According to the findings, the market is attractive for investors. However, investors require financial resources and competent enough human resources to sustain or gain profitability within the market. Changing perceptions of property owners for the decision of outsourcing FM services is creating large number of clients and more opportunities for the FM service providers. There is cold war in the industry among few FM service providers for the existing market which is defined by their own. In fact, the industry is attractive and welcoming resources in order to expand the boundaries of the market. However, the FM business organisations should build up their own loyalty, trust and resources to gain competitive advantage in order to make profits in the industry.

7. FURTHER RESEARCH

This study is a preliminary investigation of analysing the outsourced FM services market in Sri Lanka. The researchers are expecting to expand the study in order to identify market entry strategies, product diversification strategies and critical success factories for business performance for FM service industry in Sri Lanka.

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INTEGRATING DISASTER MANAGEMENT PERSPECTIVE INTO ARCHITECTURAL DESIGN EDUCATION AT UNDERGRADUATE LEVEL - A CASE EXAMPLE FROM TURKEY

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ABSTRACT

The paper highlights key points and problem areas associated with integrating management perspective into the architectural design education. Architects with appropriate training can easily broaden their traditional roles to enhance the capacity of the society to respond to disasters through efficient, sustainable, socially and culturally responsible designs. However, the number of undergraduate and post-graduate programs which integrate disaster management perspective into their curriculum as a long-term proactive strategy to build resilience is very low. Based on experience from a series of Construction Project Studios' with different themes and scenarios at Istanbul Technical University, Department of Architecture, the paper compares the typical design process with a disaster-focused process to highlight the differences. There are a couple of key issues in the educational context to integrate disaster management perspective into the architectural education: a shift towards a more collective problem solving space in the design studio along with an intellectual familiarity with the problems of contemporary society; an understanding of the heterogeneity of the needs and characteristics of different vulnerable groups; an adequate background knowledge to filter and adapt common design principles and norms, so that they are relevant to disaster and project scenarios; and a familiarity with technical solutions patterns such as open prefabrication and adaptive re-use. The findings may show directions for future educational research, where little empirical evidence exists.

Keywords: *Architectural Design Education; Built Environment, Disaster Management; Disaster Preparedness.*

1. INTRODUCTION

Disasters, whatever their origin, can be traumatic events for a society, causing extensive loss of life and other large scale material/non-material losses, and disrupting its normal functioning (Malalgoda *et al*., 2010). Many scholars agree that the scale of threats facing the contemporary cities have escalated in recent decades. The vulnerability of the marginalized groups, especially those struggling with poverty in the poorly built urban environments have raised due to economic, demographic and socio-political changes (Bosher and Dainty, 2011; Owen and Dumashie, 2007; Lloyd-Jones *et al*., 2009).

Built environment professionals and the universities are often thought to take critical roles in the disaster management process in cooperation with governmental and non-governmental stakeholders (Amaratunga and Haigh, 2010; Llyoyd-Jones, 2009; Thurairajah *et al*., 2011). Technical know-how and the routines of the built environment professionals concerning the design, construction, planning, procurement and management of the built environment facilities have a clear relationship with the disaster management initiatives and they can significantly contribute to the prevention and minimization of disaster losses if they broaden their traditional roles (Thurairajah *et al*., 2011; Malalgoda *et al*., 2010) with appropriate training (Amaratunga and Haigh, 2010). Bosher and Dainty (2011) argue that "a diverse range of hazards are likely to become more significant in future years and so it has become incumbent upon those responsible for planning, designing and constructing the built environment to take account of these threats as a core part of their professional activity."

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However, disaster management concept is relatively new to the built environment discipline, especially for the architectural designers, “except its regular concerns on effective and strong structural designs” (Thurairajah *et al*., 2011). The number of undergraduate and post-graduate programs which provide disaster management education is very low (Thurairajah *et al*., 2011) signalling the ignorance of the role of built environment professionals (Bosher and Dainty, 2011). Scholars and various international agencies have called for curriculum changes/re-design to incorporate disaster management perspective and skills into the education programmes (Thurairajah *et al*., 2011; Bosher and Dainty, 2011 for additional references). Ideally, these programmes can be multidisciplinary to blend know-how from engineering sociology, architecture, anthropology, finance, management, and other fields; so the professionals can gain familiarity with both the hard and soft dimensions of the disaster management phenomenon (Cage *et al*., 2009).

Based on a series of construction project studio works at undergraduate level, this theoretical paper aims to contribute to the ongoing debate on the integration of disaster management perspective into the architectural design education, as a long term proactive strategy. After a brief summary of the background literature and focusing on the role of architectural designers in the disaster management process, the paper aims to highlight some key points and problem areas based on different project themes or ‘technical solution patterns’ such as post-disaster camp planning, temporary urban housing, adaptive re-use.

2. DISASTER MANAGEMENT CYCLE AND THE ROLE OF ARCHITECTS

Disaster management is defined as a “collective term encompassing all aspects of planning for and responding to disasters, including both pre-disaster and post-disaster activities” (CERO, 2004). Researchers often highlight a “paradigmatic shift” concerning the approaches to manage and avoid disasters: from reactive to pro-active. The former refers to “response-driven” strategies, which typically focus on rapid mobilization of resources and response to disasters, such as “saving lives, providing emergency relief and marshalling resources for restoration and reconstruction” (Bosher and Dainty, 2011). Pro-active strategies, with a more holistic and long-term approach, place emphasis on “disaster preparedness, hazard mitigation and vulnerability reduction rather than the often reactive focus on disaster management and relief. to address pre-event vulnerabilities” (Ibid.). The priorities for action adopted in The World Conference on Disaster Reduction held in January 2005 in Hyogo, Japan, shed light on how this paradigm shift can be realized and put into practice at national and international levels (Lloyd-Jones, 2009): ‘Education to build a culture of safety and resilience at all levels;’ and strengthening disaster preparedness for effective response at all levels with a special emphasis on preventative strategies are among those major priorities (Ibid.).The term disaster management cycle (DMC) refers to the process that consists of four interrelated phases of disaster management (March and Leon, 2013; Thurairajah *et al*., 2011; Malalgoda *et al*., 2010): prevention/mitigation and preparedness; response/immediate relief and recovery. The latter is called the ‘rehabilitation/reconstruction phase (Thurairajah *et al*., 2011). These phases may be separated by unplanned gaps (Llyoyd-Jones, 2009) or they may be overlapped and “they operate as a closed loop because a major aim of hazard management is to learn from experience and feedback” (Malalgoda *et al*., 2010). Bosher and Dainty (2011) argue that if the relationships between the different phases of this cycle are misunderstood, there is the risk of developing inappropriate disaster responses. Targeting favoured communities instead of the most affected people or being part of overly influenced efforts that are non-conducive to the attainment of social/physical resilience are among the examples of inappropriate responses.

What kind of roles can the architects take throughout the disaster management cycle? What kind of skills do they need to possess? For some authors like Glass (2008), the role of architectural designers is particularly interesting due to their potential to influence the specifications and configuration of materials (Bosher *et al*., 2007). Among the few studies that are concerned with such questions, Lloyd-Jones (2009) focused on the issue and provided a comprehensive summary of the possible roles of architectural designers along with other professionals. Table 1 shows the diversity of the roles that architects can undertake over the DMC. However, while there are researchers who highlight the need for the integration of disaster management perspective into the architectural curriculum (Cage *et al*, 2009; Thurairajah *et al*., 2011), the body of literature which addresses these questions appears relatively scarce. Cage *et al*. (2009) argue that there are few countries where architecture students gain skills to design for disasters. If we conceive shelter or housing just a delivery problem, the authors contend, there may not be a need for the architect. For architects to be part of the solutions, they need to learn how to talk to people and collaborate with other disciplines. Developing post-disaster solutions, however, may require different skills than a commercial practice (Ibid.) and an ability to understand the contextual differences between normal vs disaster situations (Thurairajah *et al*., 2011). Consequently, "architects might have to 'unlearn' their usual approaches and relearn new ways of working to be effective", where the ability to engage in collective problem solving becomes especially critical (Cage *et al*., 2009). Except for such limited number of remarks, however, there appears a knowledge gap regarding the educational dimension of disaster phenomenon and the current weaknesses of the academia to integrate relevant strategies into the design education. So, what kind of a framework can help us contribute to a theoretical discussion on the issue? This is a methodological question.

Table 1: Roles of Architects in the Disaster Management Cycle

Phases	Activities
1. Risk and vulnerability assessment	▪ Assessment of the way people build in the area, their use of dwellings, community facilities and other buildings; ▪ Pinpoint historic and culturally important buildings at risk.
2. Disaster risk reduction and mitigation	▪ Facilitate community surveys and advise on the planning of community shelters and dwellings.
3. Disaster preparedness and pre-disaster planning	▪ Provide advice on building use in the event of hazard.
4. Emergency relief	▪ Design relief shelters for dwellings as well as larger structures for essential services such as medical facilities and vulnerable groups that need special accommodation such as the sick and injured. ▪ Develop survey methods to facilitate the repair and reconstruction of dwellings, vital facilities, community buildings and heritage buildings.
5. Early recovery-transition	▪ Provide an assessment of traditional patterns of use of space, building materials and technology; work as part of social survey teams. ▪ Advise on the selection of building materials and technology that are part of the compensation package. ▪ Work with social development agencies to carry out surveys with community groups and households for which shelter needs to be provided. ▪ Establish footprints of dwellings and other typical and key buildings; draw up local area layouts and site planning in consultation with communities and local authorities. Ensure overall appropriateness to local culture. ▪ Design and layout of transitional shelter. Ensure such shelter is appropriate to social and religious custom. ▪ Volunteer architects to train other volunteers and manage design and planning process. Volunteers also required to be trained for building and construction. ▪ Project management focusing on design and provision of transitional shelter. ▪ Monitor and plan spending on building and construction.
6. Reconstruction	▪ Design and planning of landscape elements. ▪ Work with households and communities to ensure that housing is allocated according to needs and preferences appropriately. ▪ Advice on building related regulations. ▪ Design and building technology for dwellings including covered, open and semi-open spaces and vegetation. ▪ Supervision and advice as the buildings are constructed.

	▪ Develop interface between infrastructure and buildings/boundaries. ▪ Provide training in construction, retrofitting and maintenance of dwellings, non-dwellings. ▪ Oversee the delivery of dwellings/ community facilities with the assistance of community groups and the delivery of facilities such as hospitals with specific clients. ▪ Identify the contribution communities are making to dwellings and non-dwellings and feed that into cost model.
7. Post reconstruction development and review	▪ Review and revisit dwellings and non-dwellings, observing the way people are changing their life-style and habits in relation to the use of buildings. Ensure safe and sustainable adaptations. ▪ Undertake life cycle studies of reconstruction projects and plan for their eventual replacement; work with existing communities to design new developments that reduce their hazards. ▪ Advice on reducing operational and management costs. ▪ Identify regular housekeeping and maintenance procedures to avoid major repair. ▪ Provide training in building design, construction and extensions for professionals as well as communities.

Source: Lloyd-Jones (2009)

3. RESEARCH METHOD

There are different school of thoughts regarding the nature of architectural design studio: For some scholars, design studio is a place where reflection-in-action is key and it is a nonlinear, complex and an anti-rational process, where learner and the ‘coach’ gradually come to understand each other. According to this view, “end of design would become an open horizon of values and possibilities - not a solution to a problem” (Wang, 2010). Where design is seen as a ‘problem solving’ process, from a traditional point of view, it typically consists of interrelated and cyclical phases starting with the identification of problems/objectives (Figure 1). For the purpose of this paper, taking design as a problem solving process could allow a simple and practical comparison with a typical design studio process and highlight the differences and potential problem areas concerning the integration of DM perspective into an educational environment. Empirical observations, the basis for such a comparison, were based on a series of construction project studio works with different themes and scenarios at Istanbul Technical University (ITU), Department of Architecture. ITU has five departments in total including architecture, industrial products design, urban and regional planning, interior design and landscape architecture. There were two main motivations behind the initiative to integrate disaster management concept into the current undergraduate curriculum of ITU, especially in a mega city like Istanbul which is statistically on the verge of a catastrophic earthquake and is struggling with a large number of refugees - more than 2.5 million people following the political instabilities and wars in the Middle East: (1) to build/raise awareness among architecture students before they graduate and practice in the industry, and (2) to develop an inventory of root/core technical design solutions to be inputs for future disaster preparedness and research initiatives, in collaboration with selected stakeholders. The following sections summarize the experiences from the studio works of different semesters. Table 2 includes short descriptions of selected projects from different semesters to illustrate the diversity of the problems/themes to address as part of architectural design efforts.

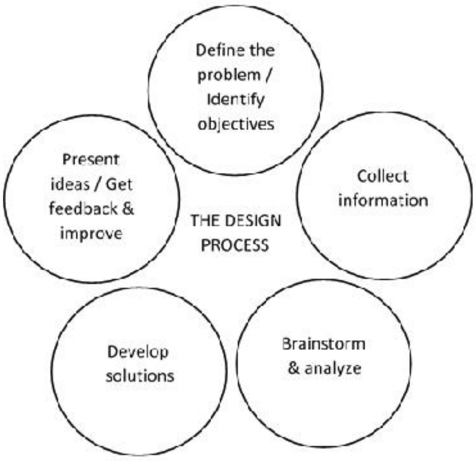

Figure 1: The Typical Design Process

Table 2: Selected Examples of Undergraduate Design Projects

Theme	Scenario
Post-disaster camp planning	Considering the fact that many architectural design solutions units fail to meet the needs of families of varying size in emergencies, the design intervention strategy sought flexible solutions for different demographic scenarios and plan layouts for camp planning (see URL 7 of Annexure I).
Temporary multi-storey urban housing	The project scenario was based on a couple of assumptions: (i) it can be more difficult to find appropriate locations for the horizontal development of housing units after a catastrophic disaster, so vertical solutions can be relatively advantageous when *top-down* governmental strategies are immediately needed; (ii) it can be easier to cost-effectively meet safety and accessibility requirements in multi-storey building which may function as ‘neighborhoods’ in appropriate locations, in addition to providing common and service areas to meet the psychological needs of masses (see URL 8 of Annexure I).
Adaptive re-use of a steel frame building as a temporary student dorm	Project scenario focused on the transformation of a 3-year old steel-frame building located at the ITU central campus to offer a temporary housing solution for about 500 students. The project sought answer to the following question: ‘How can we quickly create an additional housing capacity for students in case of a disaster (i.e. a big earthquake), assuming that the building will keep on serving its original function after a year or more following the event?’ (see URL 9 of Annexure I).
Adaptive re-use of a historical bridge as a rehabilitation center for women and children	Creating spaces for craft production with women’s labor was the major focus of the design strategy, considering the psychological contributions of production – i.e. the positive effect of ‘being a productive person’- in addition to meeting the immediate financial needs of disaster victims (see URL 10 of Annexure I).
Adaptive re-use of a two-storey neighborhood bazaar as a disaster operations center	The project aimed to transform a two-story steel structure - a local district bazaar - ground floor of which partly serves as a car park every week day, into a local disaster operations center - many of which are likely to scatter around the city following a large earthquake (see URL 11 of Annexure I).
Temporary neighborhood bazaar	The scenario focused on the development of a temporary neighborhood bazaar for small business owners, who are often among the most disadvantaged groups after disasters as their bankruptcy rate is significantly higher relative to the medium and large enterprises (see URL 12 of Annexure I).
Other projects	There were other projects focusing on relatively more systemic interventions such as the design solutions to benefit from the logistical capacity of railway networks according to different disaster scenarios (i.e. transportable prefabricated units to build temporary schools, medical facilities, food distribution centers, etc.); adaptive re-use of concrete pipes as temporary shelter, among others

4. A COMPARISON WITH A TYPICAL DESIGN PROCESS

Considering the phases of a typical design process (Figure 1), the following section highlights the specific features of a disaster-prone architectural design process in an educational setting.

Define the problem / identify objectives - This is the stage, where students gain familiarity with the key concepts of disaster management - i.e. resilience, Disaster Management Cycle (DMC), disaster preparedness, disaster psychology, and others). Using a commonly accepted terminology can be quite instrumental at this stage. Various resources such as the recently published glossary by the Disaster and Emergency Preparedness Presidency (AFAD) of Turkey appeared quite valuable for the participants of projects whenever a consensus on terminology was needed (URL 1 of Annexure I).

Raising awareness on the potential roles of architectural designers in the DMC appears critical in the early steps. One major cognitive barrier here is the widely shared view among the students that architect's roles are confined to developing individual prefabricated units for emergency or temporary housing. Such an isolated view of the architect's roles may be unsurprising for many, considering the typical emphasis placed on 'individual space' and an 'architecture of ego' in a traditional instructional environment. An understanding of the general context appears critical to "go beyond unit" and assess the wider role of architect. This is necessary, first, to build awareness on the idea that a design solution which might be influential under certain circumstances may become less efficient or totally dysfunctional when the disaster scenarios or needs change. Accordingly, there are multiple patterns of architectural design solutions for different disaster scenarios. Second, people with disabilities, sex workers, divorced women or other groups can easily find themselves in a disadvantaged position after a disaster. Understanding and appreciating the heterogeneity of vulnerable or targeted groups in terms of their characteristics and needs requires an intellectual familiarity with the problems of a contemporary society. "The widening separation of architecture from the humanities" as Wang (2010) observed, can be one of the barriers to building such an intellectual capacity. D4D, however, requires skills such as collective problem solving; understanding living patterns and value systems of vulnerable groups; developing empathy with people and gaining more familiarity with the psychology of masses, in addition to that of individuals. Otherwise, architectural design is less likely to result in an enhanced capacity of a society to respond to disasters through efficient, sustainable and socially-culturally responsible solutions. Considering that social media can easily support and disseminate this perspective, a Facebook group was started (URL 2 of Annexure I) to function as a digital extension to the design studio to build/raise awareness on the political, technical, social, cultural and historical dimensions of the disaster phenomenon. This group now has members from different universities and disciplines, some of whom have actively taken part in the process at different semesters.

To address the diverse needs of vulnerable groups, an ability to assess the relevancy of available technical solution patterns or themes (see Table 2) is another critical issue. For example, both bottom-up and top-down (community-based/participative) strategies are available to provide temporary housing. While the former generally deploys small number of units through local efforts, top-down strategies aim to deploy large number of units in the shortest period of time. Quick response to housing needs of people helps establish a sense of dignity, identity and privacy, and it helps people return to normalcy through daily activities such as working, cooking, housekeeping, socializing and school (Felix et al., 2013; Aslan and Cosgun, 2008). Post-disaster camps, on the other hand, might be at the bottom of the hierarchy of governmental intervention strategies. However, they are often inevitable solutions as evidenced by the current political crisis which urged Turkish government to host more than 2.5 million refugees from Syria and Iraq in recent years. Adaptive re-use pattern can also be a very efficient intervention strategy due to its potential to provide relatively low-cost and rapid design solutions. Governmental organizations can quickly transform buildings such as schools, sports halls or shopping centres to meet the needs of the displaced masses. In the relevant literature, adaptive re-use of existing structures is classified under the "collective centres" category as one of the transitional settlement options or typologies. Also referred to as 'mass shelters', collective centres are generally located in pre-existing structures such as public buildings and community facilities including schools; barracks; community centres; town halls; disused factories; gymnasiums; hotels; warehouses; disused factories; and unfinished buildings (İdemenet al, 2016). In addition to the re-functioning of an existing building, adaptive re-use can take the form of a transformation of artefacts (i.e. transformation of cement water pipes or shipping containers into shelter or service units). Awareness on these technical solutions patterns is key to developing a perspective for students to 'go beyond unit'.

Collect information and develop scenarios - Identifying and getting in touch with the relevant governmental/non-governmental organizations (NGOs) and individuals with different expertise for collaboration can be critical at this stage. In the case of ITU, informal interactions (i.e. individual communications by students) and formal interactions (i.e. invitation by ITU) were quite useful to benefit from the extensive on-site experience of various experts. AKUT Search and Rescue Association (URL 3 of Annexure I); Turkish Red Crescent Society (URL 4 of Annexure I); and individuals with different backgrounds such as interior designers, industrial designers and urban planners were among the actors that provided valuable expertise at different semesters.

Acquiring knowledge on regional disaster scenarios is part of the data collection stage. In particular to Istanbul, for example, geographical proximity to sea was among the major site selection criteria at different semesters since the majority of the urban population cluster in areas which are within five-kilometer range from the Marmara Sea and the disaster scenarios predict that most of the main roads will be out of function in case of a large earthquake. Accordingly, developing design solutions close to coastal areas and using water ways was a priority in many cases (see URL 8, URL 10 and URL 12 of Annexure I). Supporting the design studio efforts by different collaboration and learning channels can facilitate the sustainability of efforts to build/raise awareness about disaster management. In the ITU case, benefiting from the potential of social media was extremely conducive. Resource pooling via cloud storage systems (i.e. Google Drive), a closed project blog and a Facebook group (URL 2 of Annexure I) facilitated the ease of access to many resources such as scholarly papers, media news, international standards, and exchange experience with projects' participants. This repository includes many examples/readings on the different aspects of disaster phenomenon such as disaster psychology, which is a critical issue to understand the role and the tools of 'returning to normalcy'. Without an adequate understanding of the role of contextual factors, the students cannot be able avoid the pitfall of approaching the problem merely from a techno-centric perspective.

Brainstorm and analyse ideas - Students were encouraged to get in touch with and receive feedback from potential users and site visits were arranged for the analyses of project locations. While the communication with governmental bodies is essential to grasp regional disaster scenarios and projections, collaboration with NGOs, which are directly related to the project themes, is crucial to benefit from their extensive on-site experience. For example, a seminar by Turkish Red Crescent Society was very helpful to clarify the common problems associated with camp planning (see URL 7 of Annexure I). In another case, an interview with an experienced member of the AKUT Search and Rescue Association helped to clarify the architectural program of a temporary disaster operations center project (see URL 11 of Annexure I). Small business owners were interviewed to identify their priorities and expectations, when the students were developing the architectural program for a temporary neighborhood bazaar project (see URL 12 of Annexure I). PhD students and colleagues from different departments of ITU were involved with both the brainstorming sessions and the design processes.

Develop solutions - Cage *et al.* (2009) contend that "architects might have to 'unlearn' their usual approaches and relearn new ways of working to be effective", where the ability to engage in collective problem solving becomes especially critical. According to Keitsch (2012), "the call to examine practices and methods as well as values and norms is growing louder" in architecture, accompanied by a call for interdisciplinary cooperation and teamwork to address the complexity of problems. Team working skills are important not only for interdisciplinary collaboration, but also for collaborative problem-solving. ITU experience suggests that an efficient process can involve the following steps: Providing individual space and the discussion of individual design proposals; developing a common understanding and identification of needs; division of labor for teamwork; returning back to individual level or 'individual space' whenever needed to explore alternative views and approaches; and disseminating information on different technical matters, once a group consensus is reached. For some of the students however, who are very much used to exploiting an individual space throughout their architectural education, movement between the individual and collective problem solving levels were painful at times. In such cases, efforts were paid to alter the misperception that collective problem solving is a threat to the use of individual space for developing creative solutions. Respectively, readings on team working and conflict resolution were part of the projects' resource pool.

The technology dimension of D4D efforts has multiple facets. Technological paradigm of the disaster management cycle, especially in the case of top-down intervention strategies, is generally based on fast, flexible and modular design solutions. Most of the top-down approaches rely on prefabricated, mass-produced and standardized solutions (Felix *et al*., 2013). Open prefabrication systems might be appropriate solutions in many cases, which are based on the provision of standardized components in factories and their transfer to the construction sites "to allow various possibilities of assembly into different forms and configurations" (Abulnour, 2013). Open prefabrication brought a variety of advantages to analyse horizontal or vertical growth scenarios in the student projects (see URL 7; URL 11 of Annexure I). On the other hand, the adaptive re-use of buildings require different types of solutions when compared with the new construction processes (see İdemen *et al*, 2006). For example, the assessment of the capacity of a building or structure to meet new/additional functions may require additional effort (see UR1 9, URL 10 and URL 11 of Annexure I). Interestingly, neither the prefabrication systems, nor the adaptive re-use patterns find themselves adequate place in the current architectural design education, and ITU is not an exception.

Filtering architectural principles and norms through the special requirements of disaster situations can be difficult and time consuming for many students at this stage. Especially for temporary housing projects, students should gain familiarity with some well-recognized norms (The Sphere Project, 2015).to understand how D4D context varies from a typical residential building project. Collaboration with industrial designers can be quite useful to develop efficient design solutions for micro and small spaces, where the victims share lives for considerable durations under traumatic conditions. A thorough understanding of the dynamics of public spaces and the consumption/living patterns of various vulnerable groups will be valuable intellectual assets at this stage.

Present ideas / Get feedback and improve design - Relevant external and internal stakeholders should ideally take place in these stages, before architectural solutions are finalized.

5. CONCLUSION

Many authorities share the view that hazards are likely to become more significant in future years due to ecological, political and economic crises. Although education is considered as a proactive and long-term strategy to build resilience at all levels due to the paradigmatic shift in the disaster management field, an overwhelming majority of the architects graduate without an adequate knowledge of disaster management perspective and skills. A quick analysis of the literature suggests that design-for-disaster (D4D) is not considered as an integral part of the disaster management cycle except for concerns for strong structural designs. Architects can more efficiently take role in the process to enhance the capacity of the society to respond to disasters via sustainable and socially/culturally acceptable design solutions. ITU experience suggests that there are a couple of key issues in the educational context to achieve this goal: (i) shift towards a more collective problem solving space in the design studio along with an intellectual familiarity with the problems of contemporary society; (ii) an understanding of the heterogeneity of the needs and characteristics of different vulnerable groups especially in collaboration with the representative NGOs; an adequate background knowledge to filter and adapt common design principles and norms, so that they are relevant to disaster and project scenarios; (iii) a familiarity with different technical solutions patterns such as open prefabrication and adaptive re-use. A thorough understanding of the local disaster scenarios is a prerequisite for any kind of design effort to be able to adapt general design principles and norms and put them into practice. Current tendencies show that urban areas will be increasingly threatened by disasters in the near future (e.g., The Sphere Project guidance document on 'Using Sphere Standards in Urban Settings' was being piloted when the authors submitted this paper in May 2016). Future efforts should focus on alternative approaches and methodologies in higher education system to help convert these standards into professional knowledge. Finally, more systemic interventions such as making D4D part of accreditation processes are likely to generate quick results in integrating disaster management perspective into the higher education system.

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URL 9: Figure 4: Transformation of the Central Lecture Hall into a Student Dorm. Available from:-https://drive.google.com/file/d/0B-6upb4OsaVmakRJc0JuUWp5ZkU/view?usp=sharing

URL 10: Figure 5: Transformation of the Historical Galata Bridge into a Rehabilitation Centre. Available from:- https://drive.google.com/file/d/0B-6upb4OsaVmUjVfUVk0TUotb1U/view?usp=sharing

URL 11: Figure 6: Transformation of a District Bazaar into a Disaster Coordination Centre. Available from:- https://drive.google.com/file/d/0B-6upb4OsaVmT3JuSEwyeFFBbEk/view?usp=sharing

URL 12: Figure 7: Temporary Neighbourhood Bazaar for Small Business Owners. Available from:-https://drive.google.com/file/d/0B-6upb4OsaVmYy05UkEwNEFzLTg/view?usp=sharing

INTERACTIONAL ANALYSIS FOR TWO-PARTY RISK ASSESSMENT IN PUBLIC PRIVATE PARTNERSHIPS (PPP)

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ABSTRACT

Public Private Partnerships (PPP) have been increasingly used over the past years. However, problems have arisen with the increased use of this procurement strategy. These problems usually occur as a result of various risks that manifest over the long duration of the project. These include risks at the macro, market and project level specific to PPP projects. Examples include concessionaire default in loans for the Sydney Airport Rail Link project, bank refusal to loan the concessionaire for the Channel Tunnel Rail Link project in the United Kingdom and high interest loans on private debt for the Taiwan High Speed Rail project. Identifying risks in previous projects would lead to a risk registry that would help in understanding the sequence of events as well as the parties involved. Case studies have suggested that the outcome of the identified risks can be linked to the interaction of the parties in a PPP project. Parties to the risk in a PPP project include owner or government, developer, financier, sponsor, supplier, architect, subcontractors, contractors, non-governmental organizations (NGOs), media, authorities and regulatory, politicians, workers, end-users and experts. In this paper, game theory is used to analyse the interactions between parties to understand dynamic outcome of the associated risks in PPP project because of the actions taken by the parties to the risk. The scenarios of risks are defined based on actions and their transaction cost as well as outcomes and their payoff. Strategies would be developed and simulated to propose mitigation plans to address risks.

Keywords: *Game Theory; Interactional Analysis; Public Private Partnerships; Risks.*

1. INTRODUCTION

Public Private Partnerships have seen an increase in usage as a delivery method. The concession period of PPP projects is usually a long duration of 20-100 years and involves multiple parties, which increases the chance of risk occurrence. In a PPP project, these parties include government, private company, lender/financial institution and operators. In cases of risks, these parties interact together to resolve the issue. These risks have been studied in various literature for certain project types or phases. Risk assessment is important for PPP projects in order to control high risks, minimize their effects and prepare mitigation plans. Each risk that occurs instigates actions from the parties involved. Interactions between parties in a risk scenario determine the outcome of the situation and the benefit for each party. In this paper, we discuss the use and importance of interactional analysis and focus on the context of a PPP project. The paper presents a case study of the railway project in Tanzania in order to showcase how interactional analysis can be used to understand the possible strategies and determine the best course of action.

2. LITERATURE REVIEW

Use of PPPs has been increasing over the years. Sarmento and Renneboog (2014) defined eight sectors where PPPs have been used: “traffic, healthcare, culture and sport, administration, defence, justice, education and others.” Different risks manifest in construction projects, which becomes especially complex in PPP projects that span long durations of 20-100 years. Khallaf *et al*. (2016) identified 75 risks and classified them into three categories: macro/country, market and project risks. These risks manifest throughout the different project phases and may lead to renegotiation of project parameters. Examples of

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such risks include: monetary inflation, bureaucratic delays, risk management practices of parties and insolvency of contractor/operator (Khallaf *et al*., 2016). These risks not only plague the projects, they also plague the country itself. For example, Colombia awarded the first batch of highway PPPs in the 1990s and suffered due to: lack of a specified roadmap which led to inability to expropriate the required land, lack of bidders, projects were awarded based on preliminary studies that were performed which lacked a lot of detail, lack of financing of the concessionaire which the government did not check and incomplete contracts that lacked mechanisms for conflict resolution (Engel *et al*., 2003). This led to a failure of many of the PPPs.

According to Domingues and Zlatkovic (2015), the main reason behind contract renegotiations is the complex risk sharing mechanism. Parties renegotiate in order to reduce their losses due to a risk occurrence or to increase their profits in an opportunistic manner. Renegotiations can occur due to various reasons such as incomplete contracts, inadequate regulations and inadequate public sector management (Cruz *et al*., 2014). These renegotiations are affected by the risks that occur in the project as well how the parties interact to deal with these risks. Interactions between parties can aggravate or reduce the risks and outcomes related to them. Naderpajouh (2013) studied the interaction between parties in an international project. This interactional analysis approach is very valuable in quantifying the results of the actions of each party in a situation of negotiation.

Interactional analysis applies the concepts of game theory to study the interactions between different entities and how their choices affect their payoff as well as the payoff of others. Game theory is a method to study the interactions between people, which can be simulated in order to study the outcomes involved. The analysis of these interactions helps in understanding decision-making to create strategies (Neumann and Morgenstern, 1944; Glumac *et al*., 2015). These interactions are seen as a game where the players are the actors in a situation. These players take actions sequentially that affects their payoff received. Researchers have used game theory to study the interactions between parties in different situations (Asgari *et al*., 2013; Eleftheriadou and Mylopoulos, 2008; Madani, 2010; Samsura *et al*., 2009; Zlotkin and Rosenschein, 1989). Table 1 shows a list of the studies that used game theory. It can be seen that game theory is a reliable method that has been used for to study interactions of actors in different fields.

Table 1: Researches that Applied Game Theory to Study the Interactions of Parties

Source	Description
Asgari *et al*. (2013)	Proposed a game theory framework to model resource sharing and management among subcontractors
Madani (2010)	Applied game theory to address conflicts in managing water resources.
Samsura *et al*. (2009)	Used game theory to model the behavior of actors in situations of decision-making related to land development.
Eleftheriadou and Mylopoulos (2008)	Implemented game theory to a case study of negotiations between Greece and Bulgaria on Nestos/Mesta Transboundary River.
Zlotkin and Rosenschein (1989)	Applied game theory to multi-agent negotiation

Table 2 lists the studies that used game theory to address scenarios in Public Private Partnership projects. Some of them enforced the use of game theory in PPPs (Scharle, 2002; Kargol and Sokol, 2007); some studied the financial aspects in PPP projects (Ho, 2006; Kennedy, 2013), while others addressed risks that occur (Naderpajouh, 2013; Zou and Kumaraswamy, 2009).

Table 2: Game Theory in PPP Projects

Source	Description
Scharle (2002)	Discussed PPPs and emphasized the importance of the gaming perspective to understand PPPs
Ho (2006)	Studied when and how government will rescue a distressed project and what impacts government's rescue behavior has on project procurement and management using Game Theory
Kargol and Sokol (2007)	Presented a descriptive method in order to link the theoretical aspects of PPP to game theory
Zou and Kumaraswamy (2009)	Presented a basic summarized theoretic approach for understanding risk allocation in PPP projects in terms of Take/Transfer a risk
Chen *et al*. (2012)	Presented a Game Theory model to analyze the Taiwan High Speed Railroad project to examine how developers implement different strategies during project stages to alter the contract's conditions in order to continually creating competitive advantage after they have been awarded the contract
Kennedy (2013)	Applied Ho's (2006) model to "Metronet - London Underground PPP" project
Naderpajouh (2013)	Applied game theory and simulation to model emergent risks from the interaction of project developer and social opposition.
Glumac *et al.* (2015)	Applied a game theory experiment to brownfield PPP projects in three cases of negotiations: "building claim, future land use and reparcelling of the land"

3. METHODOLOGY

Naderpajouh *et al*. (2014) proposed the use of game theoretic concepts to study emergent dynamics between actors and applied it to a case of social opposition of an infrastructure development project. In this paper, game theory is used to model the interactions between two parties to a PPP project. The parties are considered actors that play a sequential game, taking turns choosing actions. Each action has a payoff for each actor. This payoff is based on transaction costs for their choice of either a formal or informal action that they incur. Examples of informal actions include protests, while formal actions include litigation. Transaction costs are unique to each actor so they have their own cost for informal and formal transactions. In this case study, we focus on a scenario between two parties: the union and government. Studying the relationship between these two parties helps in understanding the negotiation process, possible courses of action and the resulting payoff. The relationship between these two parties is important because it affected the project, led to instability and later public resentment of the project.

4. CASE STUDY

In this paper, we build a hypothetical model based on the dynamics associated with the case of the Tanzania Railway Concession project. A need for rehabilitation, development and operation of the railway drove the need for this project (IFC, 2016). Based on several studies performed by a private consultant and also by the World Bank from 1997 to 2000, a framework of PPP was suggested for execution of the project (Phipps, 2009). In 2007, RITES of India won the concession from the Government of Tanzania. A new entity named Tanzania Railways Limited (TRL) was formed between RITES - with 51% shareholding - and the Government of Tanzania with 49% for the operation of the railway transport for 25 years (Tito, 2016). A Governmental agency, RAHCO (Reli Asset Holding Company) was formed and tasked with monitoring contract compliance and managing the rail assets.

There was a long duration of 10 years between the decision to undergo a PPP and the actual signing of the contract. During that period, there was no investment in infrastructure so the workers were uncertain about their jobs. The concession was re-bid three times, which affected the workers and investors and showed the government's lack of commitment to this delivery method (Phipps, 2009). Problems started with the request of the "Tanzanian Railways Association Workers Union" (TRAWU) to increase salary, with threats of going on strike if their needs were not met (Shlyk, 2009). TRL agreed to negotiate with the Government to solve this issue, however, their meeting was not fruitful and no decision was made. Due to the lack of action from these two parties, TRAWU followed their promise and went on strike. TRL and the Government of Tanzania were forced to make a decision to appease the union. Eventually, the Government decided to contribute to the salary increase.

It is important to understand how the decisions made by the Government of Tanzania and by TRAWU affected the union workers, concessionaire and project outcome. In this paper, we focus on the interactions between the union (TRAWU) and public (Government of Tanzania or GoT) because of the significant impact their individual choices made on the project. Studying these interactions ex poste in this project sheds light on the choices that each party had, what they chose and the effect of these choices. Using an established case aims at validating the proposed framework in order to enforce the importance of its use. Figure 1 shows the possible actions of the parties in each phase in time. The game starts with TRAWU having a choice of either “no action”, thereby leaving the conditions as is, i.e., status quo, or taking informal action, which is requesting a salary increase and threatening to strike. If TRAWU decides to take “informal action”, GoT then makes a choice of either “no action” and accept their request or taking “informal action” and requesting to meet with TRL to discuss this. In case GoT takes “informal action”, the next move is up to TRAWU (due to their dissatisfaction of a lack of decision by GoT and TRL) and they either take “no action” or take a “formal action” by going on strike. In response to TRAWU’s strike, GoT either goes to settle the subsidy request or takes formal action by terminating the concession contract.

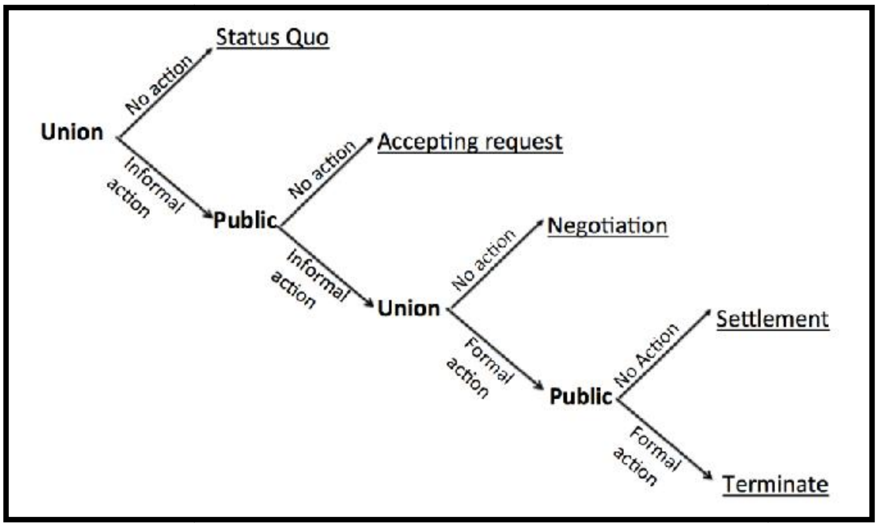

Figure 1: Game between Union and Government

Simulation is performed in order to observe the results from varying the parameters in different scenarios (Naderpajouh *et al.*, 2014). Using the Anylogic software, simulations are performed based on the hypothetical scenarios in order to explore the probability of ending at each node and the expected payoff for each party. Four cases are tested: base case, case of high transaction costs for TRAWU, case of high transaction costs for GoT and case where there is slightly less bargaining power of TRAWU. Figure 2 shows the results of the simulation performed and associated probability distributions where the black bars represent the union and the white bars represent the public.

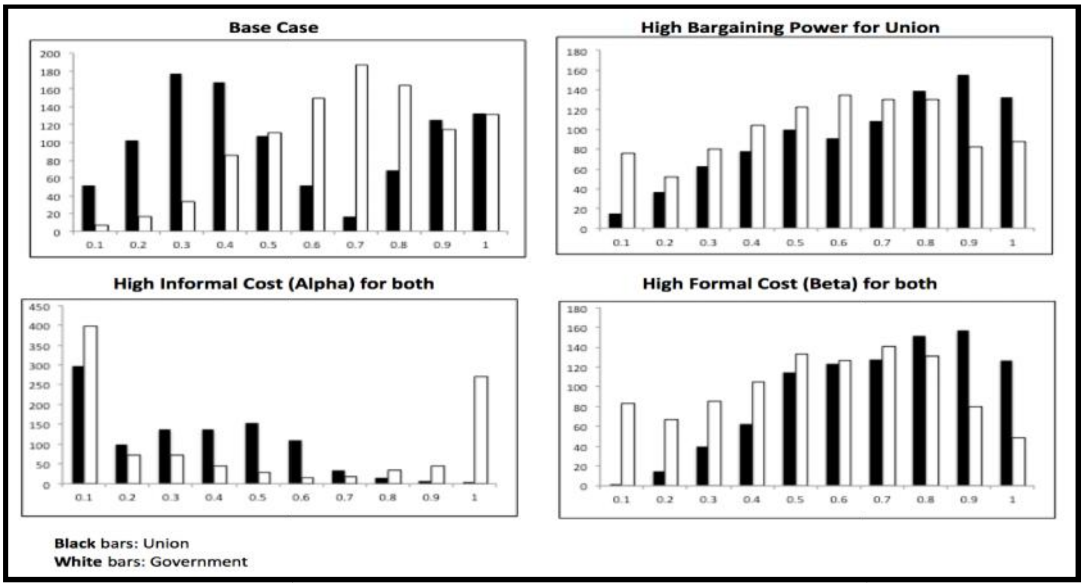

Figure 2: Simulation Results (Distribution of Outcomes for Union and Government)

5. DISCUSSION

Figure 2 shows the results of 1,000 simulations for the hypothetical examples as discussed below:

1) Base case without changing any parameters.
2) High bargaining power for union shown by increasing the percentage of negotiation: this results in an increase in the percentage of negotiation from the base case. It can also be seen that the payoffs shift towards the right, which means an increase in payoffs.
3) High informal cost for both parties: this causes an increase in the number of times that "status quo" was chosen since an increase in informal cost makes the parties less likely to reach that phase.
4) High formal cost for both parties: this increases the chance of ending up in "accepting request" and "negotiation" highly since the parties do not want to choose formal action for its extremely high cost.

These simulations show the result of varying the parameters such as bargaining power for the actors (2nd scenario), informal transaction cost (3rd scenario) and formal transaction cost (4th scenario). From the 1,000 simulations conducted, the possibility of ending at each node was calculated. Table 3 shows the results of the count of how many times we would end up in each node for the four hypothetical scenarios. It can be seen that when the informal cost is high, the probability of avoiding it and settling for status quo is higher than in other cases. When the formal cost is high, the probability of avoiding it is high so the game shifts towards negotiation. This table shows four chosen scenarios where the parameters are changed to see the effect on the probability of choosing this node and to see the payoff received.

Table 3: Probability of Ending at Each Node

	Base Case	High Bargaining Power for Union	High Informal Cost	High Formal Cost
Status Quo	0	2	192	1
Accept request	244	196	242	186
Negotiate	721	756	566	813
Terminate	34	46	0	0

6. CONCLUSION

This paper discussed the use of interactional analysis to simulate actions of parties in a risk and presented a case study for the Tanzania Railway project. The interactional analysis framework was targeted for cases of two parties in a PPP project and the results of the simulation showed the probability of ending up in each node for 4 cases: base case, high bargaining power for union, high informal cost for both parties and high formal cost for both parties. These results can be used by the parties to understand their best strategies in any given scenario. The framework was used to analyse the interactions in the Tanzania project ex poste to endorse its use for PPP projects and suggest its use a priori in the future in order to understand each party's possible choices and assess the impact of these choices on the inherent risks before taking a course of action.

This framework can be adapted and used for any project and any delivery method. More simulation scenarios can be adapted in order to show a wide spectrum of possible actions and develop a portfolio of the actions and resulting outcomes, which would help in future decisions. The authors are currently working on applying this model to more case studies and also expanding the model beyond its two-party interactions. This would be a more complex set-up but would shed light on the multiple parties involved in a negotiation scenario and how their interactions and choices affect their gains/losses in a PPP project.

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INVOLVEMENT OF CONSTRUCTION MANAGEMENT PROFESSIONALS IN PROPERTY LEVEL FLOOD ADAPTATION

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ABSTRACT

Flooding is a significant concern across the UK that has caused property damage, economic impact and health and safety concerns. The national climate change risk assessment for the UK projects the risk of flooding to increase in the future, and thus flood risk management is identified as an area that requires serious action. Whilst community level flood protection measures have been and are being put in places where there is an economic case for such intervention, the need for implementing property level flood adaptation (PLFA) is increasingly highlighted. This industry is worth £2.1 billion globally; with a forecasted UK growth at a rate of 7.1% by 2017-18. The aim of this research is to identify the ability of construction managers to provide PLFA advice to homeowners. Interviews were conducted with 10 professionals currently involved in flood adaptation product/service provision to gather their views on construction manager involvement within this niche area. Majority of participants interviewed accepted that construction managers could enter the PLFA industry. However, there has been a lack of evidence that suggest that construction managers have played a key role in this field. The paper suggests that there are several barriers that have resulted in the lack of involvement of construction managers in the PLFA industry. Previous research recognises lack of relevant skills and knowledge required to provide PLFA advice as a key barrier, this is supported by participants interviewed mentioning that the qualification, knowledge and training required were a barrier for construction managers to enter into the PLFA industry.

Keywords: *Construction Industry; Construction Managers; Flooding; Property Level Flood Adaptation; UK.*

1. INTRODUCTION

Flooding is a global occurrence that has caused widespread destruction, economic damages and loss of human life. In 2010 alone; 178 million people globally were affected by floods (Jha *et al*., 2012), and scientific evidence suggest that this increase is due to the combination of climate change, population growth and development pressures (Environment Agency, 2009; Jones *et al*., 2013).This phenomenon has reflected on the UK, in England alone over 5.2 million properties are at risk of flooding (Environment Agency, 2009), and government data has shown that the situation is likely to worsen as average global temperatures increase, and properties continue to be built on flood risk areas (Soetanto *et al.*, 2008; Environment Agency, 2009). The concerning issue is that not only have these events have caused large scale property damages, they have had a physical and mental effect on homeowners (Ranger *et al*., 2011).

The Environment Agency, on behalf of the UK Government, is working on building new and maintaining existing flood defences. However, there are an estimated 50% of homes in flood risk areas that still remain unprotected (Bichard and Kazmierczak, 2009). The costs of community-level flood protection measures and the inability to protect every home through these measures, the governments' aim is to shift people from relying on community-level solutions to more on property level flood adaptation (PLFA) (Environment Agency, 2009).

Flooding in the UK has required insurers to pay out £4.5 billion to people affected within a decade (ABI, 2010). According to the Association of British Insurers this pay-out is an increase of 200% on the £1.5 billion paid in the previous decade (ABI, 2010). UK insurers have always played a vital role in managing the financial risks of flooding (Crichton, 2008), but their liabilities are limited to the reduction of tangible

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impacts of flooding; whilst, the intangible impacts are left for homeowners (Rotimi, 2014). There is also the issue that not all homeowners have the availability of insurance as a result of being located at a high risk area. In June 2013 the UK Government and ABI announced a new system of insurance called ‘Flood Re’, guaranteeing the availability of insurance for homeowners at flood risk areas (DEFRA, 2013a). But the scheme appears to have less emphasis on the role of public risk management (Surminski and Eldridge, 2014), rather focusing on sharing the financial burden of flooding. The existence of ‘Flood Re’ may reduce the urgency to prevent and reduce risks, but the concept may lead to a false sense of security (ABI, 2016).

There is significant potential for construction managers to enter into PLFA market, but there is a lack of evidence to suggest that they have. An exploratory study was undertaken using both primary and secondary data to investigate the ability of construction managers to provide PLFA advice and identify the options, opportunities and barriers for construction managers in this sector. The objectives were to;

- Explore whether construction managers could enter the PLFA market,
- To assess the current level of involvement of construction managers at PLFA, and
- To investigate the enablers and barriers for construction managers to enter into the PLFA market.

2. LITERATURE REVIEW

2.1. FLOOD RISK AND PLFA IN THE UK

Flooding in the UK has caused extensive damages, impacting both the economy and human lives. In England alone, one in six (over 5.2 million) properties are at risk of flooding (Environment Agency, 2009). The government data has shown that the situation is likely to worsen as average global temperatures increase, and properties continue to be built on flood risk areas (Soetanto *et al*., 2008; Environment Agency, 2009).The major floods in the UK have been estimated to put £200 billion of asset at risk of flooding (Treby *et al*., 2006; Hardaker and Collier, 2013). According to Association of British Insurers (ABI) this pay-out is an increase of 200% on the £1.5 billion paid in the previous decade (ABI, 2010). It has resulted in UK insurers to pay out £5.8 billion since 2000, and a total of £8.43 billion since 1990 in insurance claims (ABI, 2014). UK insurers have played a vital role in managing the financial risks of flooding (Crichton, 2008), but their liabilities are limited to the reduction of tangible impacts of flooding on households; whilst, the intangible impacts are left for homeowners (Rotimi, 2014).

Traditionally, flooding has been included as a standard feature in general property insurance in the UK. This has allowed property owners to use general property insurance as the primary source of risk management against flooding. But the continuous increase of pay-outs has caused the insurance industry to review this practice, and introduce specific arrangements for flood insurance. In June 2013 the UK Government and ABI announced a new system of insurance called ‘Flood Re’, which is scheduled to start in 2016. The aim is an industry-run, not for profit scheme, which will cap the maximum amount paid by the 2% (350,000) of households who will meet the eligibility criteria (DEFRA, 2013a; ABI, 2016). Although the scheme guarantees the availability of insurance for homeowners in flood risk areas (DEFRA, 2013a), there are exclusions. Properties built after January 1st 2009, will not be covered by the scheme, as the government believes not to incentivise home-building in flood risk areas after that period (ABI, 2016), as this will reduce developers justifying and selling their properties in flood risk areas. There has also been several reports against this scheme, stating that it appears to have less emphasis on the role of public risk management (Surminski and Eldridge, 2014), but rather focusing on sharing the financial burden of flooding. This is not a sustainable solution going forward, especially in a changing climate and rising flood levels (ABI, 2016). The existence of an insurance scheme may reduce the urgency to prevent and reduce risks, but the concept may lead to a false sense of security (ABI, 2016), so PLFA methods are an urgent need.

An estimated 120,000 houses are built in England each year (DCLG, 2014), 25% of which may be at risk of flooding (BRE, 2014). According to BRE (2014), due to pressure on land and the need to encourage economic growth, development take place in flood risk areas. The growing concern is that local planning regulations in the UK take minimal or no consideration of flood adaptation. Planning may necessitate the need for some restrictions in regards to resistance or resilience measures, but these are not always adhered to at the construction stage (BRE, 2014). A government review, led by Lord Taylor, recommended that "planning practice guidance on climate change and flood risk should be a priority for re-issue in an updated and streamlined form, helping to make the planning system swifter and more accessible" (DCLG, 2013).

The Environment Agency, on behalf of the UK Government, is working on building new and maintaining existing flood defences, but given that, there are an estimated 50% of homes in flood risk areas that still remain unprotected (Bichard and Kazmierczak, 2009). The government admits that not all areas could be protected due to cost and practical reasons. Its aim is to shift people from relying on government solutions and more on PLFA (Environment Agency, 2009). Although theoretically this shift seems quite promising, there is little evidence to suggest that any significant action plans have emerged to implement this in practice (Ingirige and Wedawatta, 2014). DEFRA (2013a) states that every £1 spent on adaptation represents four times its value in potential damages avoided. It will allow homeowners to be better prepared for future flood events, improve their safety and minimise financial losses. It will also encourage insurers to reassess flood-adapted areas in order to provide more affordable insurance. Therefore, there is an urgent need for PLFA and for individual property owners to take action.

2.2. PROPERTY LEVEL FLOOD ADAPTATION (PLFA)

PLFA measures are categorised into either resistant or resilience measures. Resistance measures can be either manual or automatic measures, which are designed to keep out, or at least minimise, the amount of water that enters a building (DEFRA, 2005). Resilience measures seek to reduce the consequence of flooding and the cost of repairs after the flood (DEFRA, 2005). Its aim is to minimise damage to the structure, interior and furnishing of a building when floodwater enters the premises (Pitt, 2008). The benefits of PLFA measures can be gained by different stakeholders; for insurers it's the tangible benefit of reduction in future claims (Joseph *et al*., 2011). In the case for the government is that it will allow them to focus on critical locations for large scale flood defence developments. For homeowners there are several benefits including financial cost and the reduction or elimination of intangible impacts such as:

- Reduction in stress and anxiety rate (Reacher *et al*., 2004);
- Reduction in the deterioration of physical and mental health (Reacher *et al*., 2004);
- Reduction in depression cases following flood event (Reacher *et al*., 2004);
- Inability to move house immediately after flooding (Warren *et al*., 2011);
- Stress of living in alternative accommodation (Warren *et al*., 2011).

Although there are several benefits of PLFA measures to be gained by different stakeholders; barriers have drastically reduced the current uptake of them. A report by DEFRA (2008) reveals that homeowners are deterred from installing PLFA measures due to them being unattractive and a constant reminder of the flood risk they have to live with. A report by LCCP (2009) states that retrofitting of buildings may be held back by barriers which are partly due to planning and hidden costs and partly due to the lack of information and incentive available. While government involvement can be the solution to behavioural barriers and market failure, government processes and public policy failures can themselves be a barrier to adaptation. Additionally, the lack of availability of competent construction professionals who can provide valid PLFA advice to home owners has also been identified as a barrier in previous research (DEFRA, 2008; Wedawatta *et al*., 2012).

2.3. CONSTRUCTION MANAGERS AND THEIR INVOLVEMENT IN FLOOD ADAPTATION

Construction Management is recognised for being associated with the 'Built Environment' sector (CIOB, 2010). A construction manager has the role of overall planning, coordination, and control of a project from beginning to completion (Dictionary of Architecture, 2012). The functions of a construction manager typically include the following (PM Hut, 2008):

- Specifying project objectives, performance requirements and selecting project participants,
- Maximising resource efficiency through procurement of labour, materials and equipment,
- Implementing operations through effective co-ordination and control of planning, design, estimating, contracting and construction of the whole project,

- Developing effective communication and mechanism for conflict resolution.

A construction managers' skill-set such as planning, designing and implementing, would be highly effective in PLFA. An example is demonstrated in the study carried out in developing countries whereby UK construction managers provided aid after a natural disaster (Jones *et al*, 2009). The report showed that using construction managers more widely in disaster mitigation was highly successful and that the relevant professional skills and expertise of construction managers can be applied at all stages of disaster management, including flooding. This practice has not been the case in the UK; there has been some progression in the form of including construction managers in debates regarding climate change and sustainability, however there has been minimal involvement of construction managers in regards to PLFA (Bosher *et al*., 2007; ABI, 2010). According to Bosher *et al*. (2009) and Haigh and Amaratunga (2010) construction managers can play a vital role in PLFA. Their involvement in the industry is important in understanding a resilient built environment, especially in the increase of flooding. A study by Emissions Strategy Solutions (2011), found that construction managers advice could be effective in raising awareness for PLFA. It would not only create a potential income source but also a value addition for their service. To support this statement, a survey by Wedawatta *et al*, (2012) says that in the future communities will rely more on the advice and assistance of building contractor - i.e. construction managers.

The increase in climate change, the global market for PLFA is worth £2.1 billion (DEFRA, 2013b), and the forecasted UK growth in this area is at a rate of 7.1% by 2017-18 (DEFRA, 2013b). The market is expanding and it is an area where construction managers will benefit substantially, but there is a lack of evidence that suggest that they have. A statement by Economics of Climate Resilience Project, suggests that this gap is due to construction managers lacking in the relevant knowledge and competencies to carry out PLFA advice (DEFRA, 2013b). There is also no formally recognised qualification, national training or approved standard for PLFA (DEFRA, 2014).

3. RESEARCH METHOD

3.1. DATA COLLECTION

A qualitative approach was adopted in conducting the primary research for this paper. This method has been known to provide details about human behaviour, emotions, and personality characteristics that quantitative studies cannot match. Research sought to obtain complex textual description of construction managers' experience and knowledge in PLFA, whilst simultaneously obtaining their personal opinions and emotions. Semi-structured interviews were conducted, as the research questions in hand favoured this method. Semi structured interviews allowed to pursue an idea or response in more detail (Gill *et al*., 2008). This form of gathering information has been successful in previous studies where professionals were questioned on disaster related issues, for example Malalgoda *et al*. (2016). Themes covered in semi-structured interviews included flood adaptation products/services provided, knowledge requirements to provide these, barriers and enablers to entry, how to provide flood adaptation knowledge and qualifications, etc.

3.2. INTERVIEW SAMPLE

There were a total of ten participants that were interviewed, all from different organisations and are actively involved in providing flood adaptation products/services, and are from companies specialised in those aspects. Out of these, 4 respondents had over 5 years of experience working in the flood industry. Although approximately half of the interviewees had around 2 years of experience in the flooding field, there were no significant differences among the responses provided. The sample is consistent with the expansion of flood adaptation industry during recent years, where new/experienced professionals have entered the industry quite recently.

Table 1: Interview Participants

Code	Job Title	Qualifications	No. of Years in Construction Industry	No. of Years in the Flood Industry
Participant 1	UK Manager	▪ MA in language – French, English and History	5 Years	5 Years
Participant 2	Operations Manager	▪ No formal qualifications	25 Years	2 Years
Participant 3	Divisional Director	▪ Masters in Civil and Environmental Engineering ▪ Member of ICE and CIWEM	23 Years	17-18 years
Participant 4	Director/ Construction Manager	▪ NVQ in bricklaying ▪ Flood Professionals BSI KiteMark course	20 Years	10 Years
Participant 5	Associate in Civil Structures	▪ CEng MICE	18 Years	7 years
Participant 6	Director/ Construction Manager	▪ BEPEC Course ▪ BSI Accredited Surveyor	27 years	4 Years
Participant 7	Director/ Construction Manager	▪ BSI Accredited Surveyor ▪ BPEC Certified	8 Years	2 Years
Participant 8	Marketing and Advertising in Flood Adaptation	▪ BSc Communication Studies, Marketing Communications	5 years	2 Years
Participant 9	Director/ Construction Manger	▪ Qualified Joiner ▪ BEPEC Accredited ▪ BSI Kitemark Accredited	37 years	4 Years
Participant 10	Director/ Construction Manager	▪ No formal qualification	20 Years	2.5 Years

3.4. DATA ANALYSIS

The data obtained were analysed using a thematic analysis approach. It is a qualitative analytic method for identifying, analysing and reporting patterns (themes) with data (Braun and Clarke, 2006). This method allowed organising and describing the qualitative data obtained from the semi–structured interviews in detail and interpreting various aspects of the research topic. Using themes, enabled to capture important data in relation to the research question and represent levels of patterns with the data obtained from semi-structured interviews. An example where this has been carried out is a report by DEFRA (2012) on the evaluation property level flood protection scheme, where it worked really well. In the analysis, determining the percentage for each products or service is based on the number of interviewees that mention each product/service. For instance out of 10 participants interviewed, if 7 participants mention a certain products/service, it is then classed as 70%.

4. FINDINGS AND ANALYSIS

4.1. CONSTRUCTION MANAGERS AND FLOOD ADAPTION INDUSTRY

Participants were asked whether they thought construction managers could enter the PLFA industry, and 9 out of 10 participants felt that they could. Participant 4 commented "*construction managers could definitely enter this industry; they have the right background knowledge and skill set to enter*." Participant 6 supported the statement by mentioning that "*construction managers can definitely enter this area; they* *have the building knowledge and the skills to deal with complex and sophisticated projects on demand*." Although there is a lacks of evidence that suggest that construction managers have played a key role in flood adaptation, the opinions of fellow construction professionals suggest that they could play a key role within this industry. Furthermore, the reports by Haigh and Amaratunga (2010); Emissions Strategy Solutions (2011) and Wedawatta *et al*, (2012) back the participants statement that construction managers involvement within this industry could be highly beneficial for both the industry and the professionals themselves.

The remaining participant interviewed did not entirely disagree with this view. For instance, Participant 5 mentioned that "*it's not that construction managers won't be able to enter this industry, it's just that their skills set would come to better use on larger projects*."

4.2. FLOOD ADAPTATION PRODUCTS

In order to identify the ability required for construction managers to provide PLFA advice, participants were asked the products and service they or their organisation provided in relation to PLFA.

Table 2: Flood Adaptation Products

Products	Participants who mentioned they provide this product(%)
Flood Barriers	70%
Flood Sump & Pump System	100%
Flood Walls	60%
Flood Doors	70%
Flood Gate	90%
Flood Accessories	100%
BSI Kitemark Products	50%
Both Resistance & Resilience Measures	90%

Table 2 identifies the most common products mentioned by all participants; the products identified are from the interview data; the percentage gives the identification of the number of individuals that mentioned each product. The results showed that organisations provided similar products; the variation was that some firms used BSI Kitemark products, whilst others either manufactured their own or used various different manufacturers. The interesting notion was the contrasting opinion on the standard of products between some participants. For instance, participant 1 who works for a flood barriers manufacturing firm mentions that "*We manufacture our own products; they have been tested to meet the highest standard and efficiency in comparison to what is out there*." However, other participants felt completely different; participant 4 stated that "*We provide our customers with only BSI Kitemark products, because we feel they provide the highest standards*." This is supported by participant 6 who stated "*I only use Kitemark products because I find they actually work*". There is a conflict of opinion in which products are the most effective to use in PLFA. There could be several reasons behind this, one which is mentioned by participant 7 and 8 that flood products are not off the shelf; they are bespoke, so every house would have different measurements and requirements. As a result, it is difficult to have one set of product for everyone; it all depends on the property, area, and flood conditions. An alternative reason could be that the flooding issue is relatively new in the UK especially in some districts, and there are no set guidelines by the government or agencies to what type or standard a flood product should adhere to. Instead professionals are working on the basis of their personal experience and manufacturers influences. If this is the case, it is not the most effective way forward for the industry, as a report by the Environment Agency and DEFRA (2012), reveals that construction professionals lacked the necessary experience and training to deal effectively with flood related products and services, and may not yet have the skills necessary to understand the standard that is required for PLFA products. Additionally, participant 9 mentioned that "*All manufacturers think their products are best on the market, while it may be for certain situations, it might not be for others. So it needs to get away from the manufacturers and more into independent advisory*."

The difference in opinion regarding products could be the source of confusion for construction professionals and homeowners. There is a requirement for the government or regulatory body to implement a standard of quality and efficiency for manufacturers to work against and for PLFA professionals to adhere to. The principle could be similar to building standards and regulations, and this will allow homeowners to have confident in the products available on the market.

4.3. FLOOD ADAPTATION SERVICES

Participants were all asked the services they or their organisation provided in regards to flood adaptation. Table 3 depicts the most common services mentioned by participants; the services identified are from the interview data; the percentage gives the identification of the number of individuals that mentioned each service.

Table 3: Flood Adaptation Services

Services	Participants who mentioned they provide this service (%)
Flood Surveys & Advice	100%
Environmental Impact Assessment	40%
Flood Training Service	30%
Feasibility Study	40%
Detail Designs	60%
Technical Design	40%
Drainage Design	70%
Fluvial and GIS Modelling	40%
Risk Assessment and Site Investigations	60%
Structural Work	60%
Hydrology, Ecology and Water Quality	50%
Groundwater and Catchment Management	60%

The results indicated that there are several similarities between participants in relation to the services they provided, for example flood surveys and advice. However, what was noticed was the correlation between participants who worked for SME's mentioned similar services (flood surveys/advice, detail and drainage designs, and ground/catchment management), and participants who worked for large organisation did the same (environmental impact assessments, feasibility studies, technical design, risk assessment/site investigations, structural work and hydrology, ecology and water quality). These results give an indication about the flood industry, and the service that could be provided may depend on the size of the organisation. This could be due to several reasons, one which could be that SME's have limited capital and resources to provide complex and sophisticated service in comparison to larger firms. For instance, larger firms may have a variety of experienced employees from different backgrounds which enables them to provide different services. This variation could make it difficult for professional such as construction mangers to understand what specific knowledge or competencies are required in order to provide PLFA advice. The industry as a whole, including the government and agencies will need to address this issue to ensure that smaller businesses have the opportunity to learn and develop key skills to be able to provide a variety of service to compete within the industry. This will also make it clearer for professionals entering the industry the specific knowledge and competencies required to enter the market.

4.4. BARRIERS FOR CONSTRUCTION MANAGERS IN PLFA INDUSTRY

Participants were asked the barriers they felt that prevented construction managers to enter into the PLFA industry. The findings show that a wider majority of participants recognised market failure and lack of information as key barriers. Participant 1 mentioned that "*the flooding issue is relatively new within the UK in comparison to other countries, resulting in the lack of information available for construction professionals to take a step towards entering this market professionally and legally*." Participant 2 supports this by stating that "*the information and guidance out there is limited to give a clear indication* *for construction managers to enter into the PLFA market*." Participant 4 continues this further stating that "*not all professionals understand the processes and legalities involved to enter this industry. I was fortunate to find Flood Professionals BSI KiteMark course that helped explain all that, but these courses aren't accessible around the country. The government and agencies involved haven't done sufficient enough to provide the relevant information and guidance for professionals to take a step into this industry without taking a personal risk*." Participant 2 continues to say that "*the market failure has prevented professionals such as construction managers to enter the industry and stay within their comfort zones, but this is not the underlining issue, the lack of professionals has encouraged the so called unprofessional builders to enter and provide low quality workmanship which not only cost consumers additional money to rectify but puts their lives at risk*." The statements from participants in the PLFA industry suggest that in the UK there has been a lack of support, processes and guidance for construction professionals to enter into PLFA market. The professionals in the industry have mentioned that "*it has not been an easy*" process to enter, but have been down to their perseverance and determination that has enabled them to enter the industry.

The finding also shows that a majority of participants mentioned that the lack of support towards qualifications, knowledge and training required were a barrier for construction managers to enter into the PLFA industry. Participant 1 mentions that "*construction managers have an all rounded knowledge of the built environment, but the PLFA sector requires specific qualifications, training and knowledge, not having the support in obtaining these criteria's will defer any professional*." Participants 6 continue this further by stating that "*not understanding the qualifications, knowledge and training required to enter this industry could be a huge barrier for not only construction managers, but for any construction professional. It will prevent them from understanding if they have the capabilities and knowledge to take a step towards this industry*." This is something the government and agencies will need to address in order to attract professionals towards this industry and prevent cowboy builders dominating the field.

Finally, the two other barriers mentioned by participants were behavioural barriers and lack of incentive. Regarding behavioural barriers participant 1 stated that "*professionals may feel that as they have never worked in this industry, they may not have the capabilities or expertise- thus they don't wish to explore this area.*" In regards to the 'lack of incentive' barrier, participant 2 states "*if the government provided some sort of training grant or equipment funding scheme, it would have encouraged construction managers to take a leap into this area*". Participant 3 continues this and states that "*better government incentive schemes need to be introduced to encourage construction managers to enter into the PLFA market, otherwise they will continue to stay within their markets they feel comfortable*."

5. CONCLUSION

Research from several reports and participants interviewed suggest that construction managers can play a vital role in PLFA. Their involvement could be effective in understanding a resilient built environment and raising awareness for the industry. Additionally it would not only create a potential income source but also a value addition for their service. The primary research suggests that a wider majority of participants in the PLFA field believe that construction managers could enter the PLFA industry and that future communities will rely more on their advice and assistance. However, there has been a lack of evidence to suggest that they have played a key role. What has been identified is that there has been some progression in including construction managers in debates regarding climate change and sustainability, however there has been minimal involvement in regards to PLFA.

There are several barriers that have resulted in the lack of involvement of construction managers in the PLFA industry. The primary research suggests that a majority if participants recognised market failure and lack of information to be key barriers. It has not only resulted in construction managers to stay within their comfort zones, but has also encouraged unprofessional builders to enter the industry, adding health and safety risks as another concern. The recommended option would be for the government to provide the relevant information required for construction professionals regarding the industry. Secondly, put in place strategies to control, support and monitor construction professionals to enter the PLFA industry with the relevant qualifications, insurance and documentations.

The lack of support towards qualification, knowledge and training required were mentioned by both primary and secondary data as barriers to PLFA industry. The recommendation would be that the government and relevant professional bodies to address this issue by implementing recognised qualifications, national training or approved standard for PLFA. Not only that, it needs to be formally available and accessible to all professionals in order to attract them towards this industry and prevent cowboy builders dominating the field.

Finally, behavioural and lack of incentive were mentioned by participants as barriers to enter into the PLFA market. In order to mitigate this and attract construction managers, the government and appointed bodies need to implement strategies to provide information, guidance and support to educate construction professionals about the PLFA market and how their skill-set could be relevant within the industry. Furthermore, an incentive programme towards helping professionals start in this industry will encourage them to take the initial step.

To understand the ability required for construction managers to provide PLFA advice, participants were asked the products and services they provided in relation to PLFA. The results showed various opinions to which products are the most effective. With this in mind, the recommendation would be for the government or regulatory body to implement a standard of quality and efficiency for manufacturers to work against and for flood adaptation professionals to adhere to. The principle could be similar to building standards and regulations, and this will allow homeowners to have confident in the products available on the market. In relation to services, the difference noticed is the separation in the services that is provided in relation to the size and resources of an organisation. Based on this the recommendation would be for the government to ensure that smaller businesses have the opportunity to learn and develop key skills to be able to provide a variety of service to compete within the industry. Additionally, it will make it clearer for professionals entering the industry the specific knowledge and competencies required to enter the market.

For further research, the recommendation would be to look into the knowledge and competencies required for construction managers to provide PLFA advice, because the research obtained indicates that at the moment construction managers' lack of relevant knowledge and competencies required to provide PLFA advice. Another recommendation would be suitability and effectiveness of flood adaptation products; because this research indicates that at the moment there is a difference of opinion between professionals to what products are suitable for certain flood adaptation measures.

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IS CONSTRUCTION GETTING QUICKER?

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ABSTRACT

Construction time performance has been a frequent topic of discussion in the literature and government reports in which the performance of the UK construction industry has been reviewed. It is evident that construction duration is one of the measures by which the success of a project is measured and there has been a great deal of research to develop reliable methods of predicting construction duration. There has been significant research identifying factors which have an effect on the duration of a construction project but little research has been undertaken which considers the changes in construction duration over time. This paper reports on a desktop study considering project duration by collecting data from the Building Cost Information Service (BCIS) and modelled in a general linear model (GLM) and an analysis of variance (ANOVA) to investigate the relationships between the contributory factors for construction duration for projects constructed in the UK between 1995 and 2014. The paper draws a conclusion which suggests that the meeting of the targets set in Construction 2025 of a reduction of time by 25% is unrealistic is drawn; counter intuitively the duration of construction projects in the UK was seen to have increased between 1995 and 2014.

Keywords: *Construction Duration; Building Cost Information Service (BCIS); General Linear Model (GLM); Analysis of Variance (ANOVA); UK.*

1. INTRODUCTION

The construction industry in the UK accounts for over 280,000 businesses, 3 million jobs, and contributes approximately 6.4% in value added (BIS, 2013; ONS, 2014). The industry reports by Latham (1994); Egan (1998); Wolstenholme (2009) which gave a review of the problems and recommendations for the industry highlight the importance of this. Latham (1994) explained that cost overruns and delays in the construction industry are largely related to the adversarial contract relationships which often lead to dispute. In the report 30 recommendations were made to address the industry problems and the Construction Industry Board was set up as one of the outcomes (Latham, 1994). There had been some improvements when the Egan (1998) report was published, however these improvements were not considered to be significant enough. Egan (1998) proposed targets of cutting construction cost and time by 10% each year, and highlighted the importance of setting such targets and creating measures of project performance. Similar concerns were raised just over 10 years later by Wolstenholme (2009) who found that only 48% of respondents believed the projects they work on are completed to time. In order to encourage the construction industry to change its approaches public sector projects were identified to be exemplars of best practice.

This paper reports on research which considers the modelling of factors that influence contract period and to identify if construction has got quicker. The data were collected from completed public and private sector projects over a twenty year time period which allowed a contrast to be made between the two sectors and an assessment over the time period; this supported some tentative conclusions about the effect the interventions have had. Prior to data collection a review of extant literature was undertaken to identify the significant factors influencing contract periods and approaches to modelling contract time.

Much of the previous research concentrates on the relationship between construction cost and construction time (Martin *et al*., 2006; Kaka and Price, 1991; Kumaraswamy and Chan, 1995; Mak *et al*., 2000). Kaka and Price (1991) in particular considered the relationship in some detail using Building Cost Information Service (BCIS) data and found that there is a positive correlation between the two variables. To improve client satisfaction it is clearly important to accurately predict the duration of a construction

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project (Blyth *et al*., 2004). The majority of research focuses on the overall construction duration (Bhokha and Ogunlana, 1999; Boussabaine, 2001; Chan and Chan, 2004; Pewdum *et al*., 2009), whereas Blyth *et al*. (2004); Nguyen *et al*. (2013); Zhang *et al*. (2004) focus primarily upon individual construction activities. There are two main types of techniques for modelling the duration of a construction project and these are simulation techniques and multiple linear regression modelling.

2. SIMULATION TECHNIQUES

2.1. *ARTIFICIAL NEURAL NETWORKS*

Bhokha and Ogunlana (1999) applied artificial neural networks (ANNs) to forecast construction duration. The ANN links give weights to various inputs which provide an output through a logistic transformation function to capture a decision making process (Bhokha and Ogunlana, 1999). Pewdum et al. (2009) also use an ANN to predict the construction duration of highways projects in Thailand. Bhokha and Ogunlana (1999) acknowledge that ANNs lack user friendliness and explanation facilities. Moreover, Lowe *et al*. (2006) found that ANNs had a greater percentage error in all models apart from one when compared to the regression models in their study. Zhang *et al*. (2004) utilise fuzzy discrete-event simulation which looks at the activities of constructing buildings to model the uncertainty in construction duration.

2.2. *MULTIPLE LINEAR REGRESSION MODELLING*

Greenwood and Shaglouf (1997) considered a number of models to predict construction and conclude that the planning methods used by the client are generally the most accurate, with multiple linear regression being the most effective out of the remaining models. Chan and Kumaraswamy (1999) applied multiple linear regression to predict the construction of high-rise public housing projects. The study by Blyth *et al*. (2004) also produced low error levels of 15% for activity level predictions and 7% for overall duration. Moreover, according to Blyth *et al*. (2004) the multiple linear regression model is the most suitable method to establish the relationship between variables for a statistically small sample size. In order to establish an analytical framework to test the hypothesis that construction is getting quicker, the influential factors had to be identified.

3. INFLUENTIAL FACTORS

3.1. *COST*

The first notable research on the relationship between construction time and cost was that by Bromilow (1969) when Bromilow's time-cost model was introduced. Kaka and Price (1991) utilised data from the Building Cost Information Service identified that the relationship changes depending on the type of project and type of client being considered. Mak *et al*. (2000) further updated Bromilow's time-cost model for Australian projects built between 1991 and 1998. The K-value in the time-cost model was found to be correlated with the state economic indicators, suggesting that when there are longer construction periods when the economy is doing well (Mak *et al*., 2000). The most recent study showing the relationship between time and cost was conducted by Martin *et al*. (2006) who confirmed the relationship using a data set of 2500 projects constructed between 1998 and 2004; this research was the basis of the BCIS model.

3.2 *FLOOR AREA*

The floor area is a factor which affects the duration of a construction project (Bhokha and Ogunlana, 1999; Blyth *et al*., 2004; Martin *et al*., 2006; Chan and Chan, 2004; Chan and Kumaraswamy, 1999; Elhag and Boussabaine, 1999; Greenwood and Shaglouf, 1997; Kumaraswamy and Chan, 1995; Lowe *et al*., 2006; Walker, 1995).

3.3. PROCUREMENT METHOD

Blyth et al. (2004); Martin *et al*. (2006); Chan and Chan (2004) identify that the method of procurement used has an impact on the duration of the project. Although according to Boussabaine (2001) design and build projects have a longer duration, whilst other procurement methods have little effect.

3.4. COMPLEXITY OF PROJECT

Another group of factors highlighted by researchers related to the complexity of a project and can include the construction methods and methods of contractor selection (Bhokha and Ogunlana, 1999; Blyth *et al*., 2004; Martin *et al.,* 2006; Chan and Chan, 2004; Chan and Kumaraswamy, 1999; Lowe *et al*., 2006; Walker, 1995). Boussabaine (2001) found that the selection method of negotiation in particular has a higher tender price and duration. Likewise Zhang *et al*. (2004) consider construction duration uncertainties related to the construction method such as weather conditions, equipment properties and supply of materials.

3.5. FUNCTION OF THE BUILDING

Clearly the function of a building as well as the client it is being built for has an impact on the duration of construction (Bhokha and Ogunlana, 1999; Blyth *et al*., 2004; Martin *et al*., 2006; Chan and Chan, 2004; Lowe *et al*., 2006). Furthermore Bhokha and Ogunlana (1999); Blyth *et al*. (2004); Martin *et al*. (2006) suggest that the location of the building effects the construction duration.

3.6 OTHER FACTORS

There has been a great deal of research into modelling and predicting the duration of construction projects (Blackman and Picken, 2010; Bromilow, 1969; Bromilow *et al*., 1988; Kaka and Price, 1991; Walker, 1995; Chan and Kumaraswamy, 1999). However there has been very little, if any, research into whether construction has become any quicker over the past twenty five years, following on from the aforementioned seminal reports.

4. RESEARCH APPROACH

The main focus of this study was to investigate whether construction periods were getting shorter over time. It was decided that a 20 year period would sufficient to investigate this, particularly as this would show any impact of the Latham, Egan and Wolstenholme reports. Data from the BCIS on projects constructed between 1995 and 2014 were collected and variables such as those identified above were recorded. In order for the data from the BCIS to be interpreted easily it needed to be formatted. For the projects to be comparable the contract value was adjusted for location (UK mean) and the quarter in which it has been priced the values were rebased to the final quarter of 2014 (Kaka and Price, 1991).

5. DATA COLLECTION AND ANALYSIS

5.1. DATA COLLECTION

The database was used to collect newly built projects in the UK between 1995 and 2014 from the public and the private sector which could be analysed to achieve the research aim. The public sector was represented by buildings built for education such as schools, universities and libraries, and the private sector projects were made up of supermarkets, factories, hotels, offices and sports facilities. In total 604 private projects and 886 public projects were collected. The frequency tables which show how many of these projects were built in the years being investigated is shown in Appendix A. Furthermore, many of the variables being considered were categorical variables with a large number of categories. These variables, such as location, were reduced into a smaller number of categories so that it could be reasonably seen how they affect the contract period. It was also required that these variables were coded so that they could be included within a model, the variables are shown in Appendix B.

5.2. DATA MANIPULATION

Results of a general linear model are very difficult to interpret if large numbers of variables and categories are used. Hence, the detailed BCIS data was collected into groups based on similar projects. The categorical variable of time that was considered was the year in which the projects contract value was priced. To help determine suitable groups of years a graph of the mean contract period for each year between 1995 and 2014 was considered for both the public and the private data. Four year periods were subsequently selected to be used in the general linear model to investigate the trend of contract period over the year groups. The variable for year was condensed into the four year categories 1995-1998, 1999-2002, 2003-2006, 2007-2010 and 2011-2014 which are coded as 1, 2, 3, 4 and 5 respectively The categorical variables for the public data and the private data are summarised in Appendix C. The coding of the independent variables can be viewed in Appendix D.

5.3. DATA ANALYSIS

A general linear model was used to investigate the relationship between the agreed contract period and the year in which the project was priced, the method of contractor selection, and whether the project was public or private. This was selected as it allowed for an interpretive approach to the quantitative analysis. A planned contrast was utilised to investigate whether there was polynomial relationship in contract period with respect to year. Moreover, the interactions between the variables in the general linear model were investigated to determine whether the trend in the length of contract period is similar for the different categories of variable or not. Furthermore for the BCIS data the distribution of the variables was checked and the rebased building cost was transformed using a logarithm.

6. RESULT AND DISCUSSION

6.1. THE GENERAL LINEAR MODEL

The general linear model (GLM) is a mathematical model which allows for all of the statistical tests of hypotheses such as t-tests, analysis of variance, correlation and regression analysis to be applied in broad analytic framework (Rochowicz, 2014). Support for the use of such a framework rather than separate isolated tests was found (Maxwell and Delaney, 2004; Rochowicz, 2014).

6.1.1. SELECTING THE INDEPENDENT VARIABLES

The ultimate aim of this research was to investigate the change in contract period over the years 1995 to 2014. Hence the categorical variable year was included in the model. Furthermore, the ANOVA model was used to analyse whether the contract period follows a linear trend with respect to year. The selection of contractor method was included in the ANOVA model as an independent categorical variable to test for the significance of the relationship between contract period and the contract selection method.

6.1.2. ANALYSING THE MAIN EFFECTS

Effect of contractor selection and project type

After running the GLM for the full factorial model it was important to consider the main effect of each of the independent variables. The output from SPSS can be observed in Table 1. The F-ratio and degrees of freedom for the model and the residuals can be reported in the form $F(dfM, dfR) = value$ where F represents the F-ratio, dfM are the degrees of freedom for the model and dfR are the degrees of freedom for the residuals (Field, 2013). The p-value of this ratio was considered to be significant if $p<0.05$. There was a significant main effect of the year in which the project was constructed when the method of contractor selection and project type was ignored, (4,1451)=3.888, p=0.004. This main effect was considered further in the planned contrast to help evaluate how the contract period changes for the different time periods and is reported below. For the variable for selection of contractor (3,1451)=3.218, p=0.022 which was also a significant p-value. Therefore the method of contractor selection also influences the contract period when whether a project is public or private, and the year in which the project was built is ignored. Moreover it was clear that the main effect of the project type (public or private) was not significant, (1,1451)=1.696, p=0.193. This suggests that the contract period for the project does not differ depending on whether the project is public or private. However, it is misleading to interpret the main effects of the independent variables when there is a significant interaction in the model (Field, 2013).

Table 1: Full Factorial ANOVA

Dependent Variable: Contract Period (Weeks)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	50957.176a	38	1340.978	4.723	.000
Intercept	516802.378	1	516802.378	1820.079	.000
YearPeriod	4415.868	4	1103.967	3.888	.004
ContractorSelection	2741.526	3	913.842	3.218	.022
PublicPrivate	481.705	1	481.705	1.696	.193
YearPeriod * ContractorSelection	3425.126	12	285.427	1.005	.441
YearPeriod * PublicPrivate	894.369	4	223.592	.787	.533
ContractorSelection * PublicPrivate	2943.613	3	981.204	3.456	.016
YearPeriod * ContractorSelection * PublicPrivate	1529.751	11	139.068	.490	.911
Error	412004.140	1451	283.945		
Total	2791053.000	1490			
Corrected Total	462961.316	1489			

Interactions between independent variables

To establish whether the time period had an influence on the contract period of a public sector or private sector project and analysis of the interaction of the year of construction, contractor selection and project type was required. The interactions between the independent variables were analysed using the F-ratios in the same way as the main effects. For the interaction between year and method of contractor selection, (12,1451)=1.005, p=0.441 which was not a significant p-value. Therefore the effect of the year group on the contract period of the project was not significantly different for the different contractor selection methods. Furthermore there was a non-significant interaction between the year group and the project type (public or private), (4,1451)=0.787, p=0.533. Hence it can be concluded that the effect of year group on the agreed contract period is the same for public and private projects.

Impact of contractor selection

The interaction between the method of contractor selection and public or private project was significant, (3,1451)=3.456, p=0.016. It was found that the effect of the contractor selection method on the agreed contract period was significantly different for public and private projects. When further analysis was undertaken for the public sector projects it was found that those public projects which used two stage projects were generally longer, however selected competition lead to a longer contract period than both open competition and negotiated. This interaction can be broken down using simple effects for the interaction between the contractor selection method and the project type (public or private) analysis to look at the effect of the project being public or private at each level of the selection of contractor (Field 2013). The output from the simple effects analysis can be viewed in Table 2. The analysis indicated that there was a significant difference in contract period between public and private projects when selected competition and open competition are used (p=0.000 and p=0.031 respectively). On the other hand there is no significant difference between public and private projects for those that were negotiated (p=0.987) and for those using two stage tendering (p=0.320). Finally the three way interaction between all of the independent variables was non-significant, (11,1451)=0.490, p=0.911. This suggests that the effect of the selection of contractor method and the year group on contract period does not differ between public and private projects.

Table 2: Simple Effects Analysis for the Interaction between Contractor Selection Method and Project Type

Univariate Tests

Dependent Variable: Contract Period (Weeks)

Recoded selection of contractor		Sum of Squares	df	Mean Square	F	Sig.
1	Contrast	24785.176	1	24785.176	86.070	.000
	Error	426763.263	1482	287.964		
2	Contrast	1335.116	1	1335.116	4.636	.031
	Error	426763.263	1482	287.964		
3	Contrast	.072	1	.072	.000	.987
	Error	426763.263	1482	287.964		
4	Contrast	285.375	1	285.375	.991	.320
	Error	426763.263	1482	287.964		

Planned contrasts

Planned contrasts were undertaken to investigate how the agreed contract period differed across the factors. A simple contrast was used to compare the contract periods of each of the methods of contractor selection to selected competition. In addition, a polynomial contrast was used to investigate how the contract period changed across the year groups from 1995 to 2014. The SPSS output for the polynomial contrast for the year group is shown in Table 3. The output for the linear trend gave a significant p-value of p=0.037 which suggested that the contract period changes with the year group in a linear fashion.

Table 3: Polynomial Contrast of Year Group

Contrast Results (K Matrix)

Recoded year Polynomial Contrast			Dependent Variable: Contract Period (Weeks)
Linear	Contrast Estimate		5.356
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		5.356
	Std. Error		2.560
	Sig.		.037
	95% Confidence Interval for Difference	Lower Bound	.334
		Upper Bound	10.378
Quadratic	Contrast Estimate		-3.681
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		-3.681
	Std. Error		2.428
	Sig.		.130
	95% Confidence Interval for Difference	Lower Bound	-8.444
		Upper Bound	1.082
Cubic	Contrast Estimate		-4.013
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		-4.013
	Std. Error		1.935
	Sig.		.038
	95% Confidence Interval for Difference	Lower Bound	-7.809
		Upper Bound	-.216
Order 4	Contrast Estimate		.360
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.360
	Std. Error		1.713
	Sig.		.824
	95% Confidence Interval for Difference	Lower Bound	-2.981
		Upper Bound	3.741

Table 4: Marginal Means of the Variable for the Year Group

1. Recoded year

Dependent Variable: Contract Period (Weeks)

Recoded year	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	36.344	2.208	32.013	40.676
2	37.258	1.776	33.774	40.742
3	42.927	1.659	39.672	46.182
4	45.721	1.570	42.641	48.801
5	40.883	3.036	34.928	46.838

By observing the marginal means for the variable for year shown in Table 4 it can be seen that the mean contract period increases between 1995 and 2010. However, the mean for 2011-2014 shows a decrease again. This decrease could be the reason for the significant p-value for the cubic trend in the polynomial contrast (p=0.038). Overall the polynomial contrast can be concluded as significant, (4,1451)=4.323 with p=0.002. The contrast did not suggest a decrease in contract period as was suggested by Government reports. In fact the results of the analysis suggested the opposite.

7. CONCLUSION

The General Linear model found that the main effects for the year and the method of contractor selection were significant, whilst the project type was not. On the other hand there was a significant interaction between the project type and the contractor selection method which suggested that the effect of the contractor selection method differs between public and private projects. These significant differences occurred when selected competition and open competition were used, and there was no significant difference between the contract period of public and private projects when negotiation and two stage tendering are used. By considering a planned contrast the differences in contract periods between the contractor selection methods were considered; open competition did not significantly differ from selected competition, however negotiated and two stage tendering were significantly different to selected competition. Additionally a planned contrast was used to specifically address the main research question; is construction getting quicker? The polynomial contrast used suggested that there was a significant linear trend in contract period over the year groups, however the trend showed an increase in contract period rather than a decrease. The target of reducing construction periods by 25% as identified by Construction 2025 (BIS, 2013) does seem a difficult achievement based on these findings.

The first major limitation of this study is that by using the secondary data source of the BCIS data the projects are not randomly selected. However, all of the projects that were found between the years 1995 and 2014 for the building functions selected were included, unless they had data values missing, to attempt to eliminate the possible bias.

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Appendix A: Data in year group

Year

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1995	45	5.1	5.1	5.1
	1996	60	6.8	6.8	11.9
	1997	55	6.2	6.2	18.1
	1998	41	4.6	4.6	22.7
	1999	42	4.7	4.7	27.4
	2000	54	6.1	6.1	33.5
	2001	59	6.7	6.7	40.2
	2002	41	4.6	4.6	44.8
	2003	53	6.0	6.0	50.8
	2004	48	5.4	5.4	56.2
	2005	49	5.5	5.5	61.7
	2006	49	5.5	5.5	67.2
	2007	52	5.9	5.9	73.1
	2008	54	6.1	6.1	79.2
	2009	47	5.3	5.3	84.5
	2010	48	5.4	5.4	89.9
	2011	28	3.2	3.2	93.1
	2012	23	2.6	2.6	95.7
	2013	24	2.7	2.7	98.4
	2014	14	1.6	1.6	100.0
	Total	886	100.0	100.0	

Appendix B: BCIS data

Variable	Definition	Categories (if applicable)
Contract value	The anticipated cost of construction at the time of the anticipated start date.	-
Building function	The primary use of the building during occupation. The building functions have been grouped into similar building types.	Road vehicle buildings; Factories; Warehouse stores; Offices; Retail; Emergency services; Health centre clinics; Hospital buildings; Care homes; Animal welfare; Catering; Community centres/halls; Pavilions/clubhouses; Sports buildings; Swimming pools; Religious facilities; Laboratories; Libraries; Museums/exhibition spaces; Schools; Universities/colleges; Mixed housing and flats; Housing estates; One-off housing; Flats; Hotels and motels; Halls of residence/hostels; Sheltered housing; Sanitary blocks
Procurement	The process which best describes the way in which the project will be procured.	Traditional lump sum; Traditional lump sum with quants; Traditional lump sum without quants; Design and build; Management contracting; Construction management; Design, manage, construct; Other
Selection of contractor	The option which best describes the way the contractor will be selected.	Single stage tendering; Two stage tendering; Negotiated; Partnering; Other
Client organisation	The sector of the client organisation.	Public; Private
Quarter	The quarter of the year in which the contract value has been priced.	-
Location factor	Adjusts the contract value to UK mean location, or a region or county level, using BCIS location factors.	-

Appendix C: Condensed variables

Variable	Categories
Building function	**Public data:** Adult education facilities; Colleges; Laboratories and research facilities; Libraries; Nursery schools/creches; Primary schools; Schools for the handicapped; Secondary schools; Universities **Private data:** Factories and warehouses; Hotels and guest houses; Offices and mixed facilities; Religious and community buildings; Restaurants, cafes and public houses; Sports facilities; Supermarkets, shops and retail warehouses
Region	East Midlands; East of England; London; North East; North West; Northern Ireland; Scotland; South East; South West; Wales; West Midlands; Yorkshire and Humber
Selection of contractor	Negotiated; Open competition; Selected competition; Two stage tendering
Year	1995-1998; 1999-2002; 2003-2006; 2007-2010; 2011-2014

Appendix D: The codes used in the GLM to represent the independent variables

Sector	Selection of contractor	Year	Project was
0	1	1	Public project through selected completion built 1995-1998
0	1	2	Public project through selected completion built 1999-2002
0	1	3	Public project through selected completion built 2003-2006
0	1	4	Public project through selected completion built 2007-2010
0	1	5	Public project through selected completion built 2011-2014
0	2	1	Public project through open competition built 1995-1998
0	2	2	Public project through open competition built 1999-2002
0	2	3	Public project through open competition built 2003-2006
0	2	4	Public project through open competition built 2007-2010
0	2	5	Public project through open competition built 2011-2014
0	3	1	Public project negotiated and built 1995-1998
0	3	2	Public project negotiated and built 1999-2002
0	3	3	Public project negotiated and built 2003-2006
0	3	4	Public project negotiated and built 2007-2010
0	3	5	Public project negotiated and built 2011-2014
0	4	1	Public project through two stage tendering built 1995-1998
0	4	2	Public project through two stage tendering built 1999-2002
0	4	3	Public project through two stage tendering built 2003-2006
0	4	4	Public project through two stage tendering built 2007-2010
0	4	5	Public project through two stage tendering built 2011-2014
1	1	1	Private project through selected completion built 1995-1998
1	1	2	Private project through selected completion built 1999-2002
1	1	3	Private project through selected completion built 2003-2006
1	1	4	Private project through selected completion built 2007-2010
1	1	5	Private project through selected completion built 2011-2014
1	2	1	Private project through open competition built 1995-1998
1	2	2	Private project through open competition built 1999-2002
1	2	3	Private project through open competition built 2003-2006
1	2	4	Private project through open competition built 2007-2010
1	2	5	Private project through open competition built 2011-2014
1	3	1	Private project negotiated and built 1995-1998
1	3	2	Private project negotiated and built 1999-2002
1	3	3	Private project negotiated and built 2003-2006
1	3	4	Private project negotiated and built 2007-2010
1	3	5	Private project negotiated and built 2011-2014
1	4	1	Private project through two stage tendering built 1995-1998
1	4	2	Private project through two stage tendering built 1999-2002
1	4	3	Private project through two stage tendering built 2003-2006
1	4	4	Private project through two stage tendering built 2007-2010
1	4	5	Private project through two stage tendering built 2011-2014

LEGAL FRAMEWORK FOR EFFECTIVE IMPLEMENTATION OF ADR METHODS UNDER THE CONSTRUCTION INDUSTRY DEVELOPMENT ACT

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ABSTRACT

The recently enacted Construction Industry Development Act No. 33 of 2014 is for the development of the construction industry in Sri Lanka. The Act facilitates the resolution of disputes within the construction industry. There is ineffectiveness on implementation of ADR methods for the settlement of disputes. Thus, this study focuses on developing a legal framework for effective implementation of ADR methods for the settlement of disputes in accordance with the said Act.

The research was initiated with a literature survey. A survey approach was implemented whereby two rounds of questionnaires were distributed and semi-structured interviews were conducted among construction professionals with more than 10 years of experience. A pilot study was conducted as a preliminary measure to design the questionnaire round one. Questionnaire survey was conducted by Delphi technique with two rounds by targeting 36 and 30 professionals in round one and two respectively. Data was analysed by taking as a percentage of the total number of respondents for questionnaire round one. For questionnaire round two, first t-test was used to identify the significant problems and potential solutions and then MWR was used to rank them. The structured interviews were analysed using content analysis. The sampling technique was a judgemental sampling.

The survey results on questionnaires revealed the problematic areas related ADR methods used by the construction industry and at the said Act. The survey findings also presented potential solutions to overcome those problematic areas. In addition to the questionnaire survey, interviews were generated recommendations to the part IX - Settlement of disputes of the said Act. Through these results of the study legal framework for effective implementation of ADR methods under the Construction Industry Development Act No. 33 of 2014 was developed. This framework can be adopted to settle the dispute effectively in the Sri Lankan Construction Industry. By practicing this framework the projects can be continued without deadlock, whenever dispute is arisen.

Keywords: *Alternative Dispute Resolution; Construction Industry Development Act No.33 of 2014; Settlement of Disputes.*

1. INTRODUCTION

The construction industry is one of the crucial industries that be able to place any country on the fast track of development. Thus, construction industry is placing a vital role in the growth of economy (Central Bank of Sri Lanka, 2014). Construction projects are highly uncertain, complex in nature and it is difficult to decide every detail at the earlier stages (The College of Estate Management, 2014).

ICJ (2011, p.2) stated that the dispute is a "disagreement on a point of law or fact, a conflict of legal views or of interests between two persons". Whenever dispute comes, projects stops at a half and everybody loses money (Patterson, 2015). Therefore, the settlement of dispute is necessarily considerable to complete the projects successfully as to eliminate the delays of the completion of construction projects (Cheung *et al*., 2010).

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The cost, time consumption and risk of litigation in construction disputes tends to look for fresh and further efficient techniques to resolve the disputes outside the court premises (Elziny *et al*., 2014). Thus, alternative dispute resolution (ADR) methods have been introduced and practised in construction industry (Patterson, 2015). At SBD/02, ICTAD (2007) mentioned that, normally when any dispute arises, the conditions of contract in contract document is referred to check whether is there any methods to follow for the settlement of the disputes. Every arrangement to the potential for disagreement over issues arising from a contract should be considered (Bihancov, 2014). The developed countries already have construction Acts which facilitate the dispute resolution process by using the ADR methods. For an example, UK construction Act which is known as the Housing Grants, Construction and Regeneration Act (The National Archives, 2015). But, in Sri Lanka, there is no such an Act earlier. These kinds of issues are resolved by introduction of the Construction Industry Development Act No.33 of 2014, which is provided for the development of construction industry in Sri Lanka. In case of any disputes relating to construction works, if any provision is not included in the contract to settle the dispute, then the dispute is to be settled in accordance to the Act.

A couple of provisions is there in this Act which introduce a way of solving disputes associated with construction activities (Jayalath, 2014). The Act facilitates the resolution of disputes within the construction industry. Even though, this Act has three ADR methods to be followed in case of disputes, when the clauses are silent at the condition of contract in the contract document, there are some drawbacks in the selection of ADR methods at the newly enacted Act (Jayalath, 2014). In the Act, there is a way from conciliation, mediation and adjudication without a stopover at any arbitral tribunal that has being in practice over five decades (Jayalath, 2014). Arbitration is the single most preferred method of dispute resolution recognised internationally as providing a flexible and effective alternative to costly and time consuming litigation (Mwenda, 2003). Such an ADR method is not mentioned in this Act.

Accuracy, short response time, cost savings, increased awareness of the issues, accountability and dependency could be a reflection of success, as a dispute mechanism (Jayalath, 2014). Thus, the construction industry needs a cost effective and fast dispute resolution process (Jayalath, 2014). Hence, the research tends to develop a legal framework for effective implementation of ADR methods for the settlement of disputes according to the Construction Industry Development Act No.33 of 2014.

This paper initially provides a comprehensive literature review in order to mine the background of the ADR methods used by the construction industry and at the said Act. Then the findings of the questionnaire surveys and interviews have been presented. Finally, conclusions have been drawn from the findings.

2. RESEARCH METHOD

The research commenced with literature review which reviews the existing literature on ADR methods and said Act. Firstly, it was decided that a survey approach would be suitable for this research to address the research problem and to collect the data from the construction practitioners with more than ten years of experience. Sampling strategy for data collection was judgmental sampling. Pilot survey was conducted to six practitioners to collect input and to improve the questionnaire. Questionnaire survey was conducted by Delphi technique with two rounds. In questionnaire round 1, data was collected from 36 respondents and analysed by taking a percentage of the total number of respondents and the problematic areas and potential solutions which were obtained above 50% out of total respondents had been qualified to questionnaire round 2. For questionnaire round two, data was collected from 30 respondents and at first t-test on SPSS software to identify the significant problems and potential solution. Then, MWR was calculated to rank the significant problems and potential solution. The structured interviews were conducted to 28 professionals and analysed using content analysis. Finally, arrived at conclusions and recommendations.

3. LITERATURE REVIEW

3.1. CONSTRUCTION INDUSTRY DEVELOPMENT ACT NO.33 OF 2014

Construction Industry Development Act (2014) stated that the Construction Industry Development Act No.33 of 2014 is,

> An Act to provide for the development of the construction industry in Sri Lanka; to regulate, register, formalize and standardize the activities of the construction industry; to provide for the establishment of the national advisory council on construction; the establishment of the construction industry development authority; and the establishment of the construction industry development fund and the fund of the construction industry development authority; to provide measures for the improvement and wellbeing of the industry related professionals, manufacturers, suppliers, contractors and craftsmen; and for the settlement of disputes related to construction activities; to ensure public safety in the construction industry of Sri Lanka; and for matters connected therewith or incidental thereto. (p.1)

3.2. SETTLEMENT OF DISPUTES AS PER SAID LEGISLATION

A couple of provisions are there in this Act which introduces a way of solving disputes associated with construction activities (Jayalath, 2014). Construction Industry Development Act (2014) states in the Act that there are three ADR methods which could be followed in case of a dispute. They are conciliation, mediation and adjudication. However, Act introduced special Appeal Board to hear the appeal on decision or award of ADR methods.

If the parties in the contract faced any dispute between them in relation to contract, initially the dispute could be settled by conciliation or mediation. For the disputes which are unable to be resolved with conciliation or mediation, the adjudication could be the next choice. The parties who are not satisfied with the decision of the adjudicator, may appeal to the Appeals Board which has been introduced in this Act (Construction Industry Development Act, 2014). Likewise there is a certain process to be carried out to settle the dispute as per this Act.

3.3. INTERNATIONAL PRACTICES OF SETTLEMENT OF DISPUTES

The most of the countries already have construction Acts which facilitate the dispute resolution process by using the ADR methods. For example, UK construction Act which is known as the Housing Grants, Construction and Regeneration Act (The National Archives, 2015). Moreover the Building and Construction Industry Security of Payment Act of Singapore is one like (Building and Construction Authority, 2005). As per the official position, Singapore is still a developing country. In Singapore, mediation, adjudication and arbitration are in use to settle the disputes. The United Kingdom is a developed country and has the world's fifth largest economy. At UK, mediation, adjudication and arbitration are used to settle the disputes.

3.4. COMPARISON BETWEEN SRI LANKA, SINGAPORE AND UNITED KINGDOM PRACTICES ON ADR METHODS

In Sri Lanka, Debt Conciliation Board Act 1941 is available for conciliation. But, it is not suitable for the construction industry. UNCITRAL is recognizing the value of conciliation as a method of amicably settling disputes arising in the context of international commercial relations (United Nations Commission on International Trade Law, 1994).

In Sri Lanka, Mediation Board Act (No. 72 of 1988) and Mediation Boards (amendment) Act, No. 4 of 2011 provide legal recognition to the mediation. SMC empowers parties to take charge and gain positive outcomes in complex business environments through facilitating the mediation of disputes in a range of commercial areas (Singapore Mediation Centre, 2013). The Chartered Institute of Arbitrators (CIArb) is an institute of arbitrators and a professional membership body for potential and practicing mediators at UK. The guidelines are provided to conduct the mediation by the CTArb (CIArb, 2007).

In Sri Lanka, Adjudication is practiced as per the SBDs according to the form of contract of the projects. In Singapore and UK, adjudication is conducted as per Building and Construction Industry Security of Payment Act 2004 and Housing Grants, Construction and Regeneration Act 1996, respectively. Adjudication has the legal assent at UK through the Housing Grants, Construction and Regeneration Act.

In Sri Lanka, arbitration is practiced as per Arbitration Act No. 11 of 1995. Moreover, in Singapore and UK, arbitration is conducted as per International Arbitration Act (Original Enactment: Act 23 of 1994) revised on 2002 and Arbitration Act 1996 accordingly. There are no any huge deviations among the arbitration practices in these countries.

3.5. PROBLEMATIC AREAS OF ADR METHODS

Conciliation is rarely practiced and not popular when compared to the other ADR methods (Kassem, 2014). As well as, decision given by the conciliator is not bound between the parties (Kassem, 2014). Conciliators have no powers of enforcement (Billings and Watts, 2007). As well as the awareness of ADR methods and awareness in related legislation or standard conditions of contract is less (Abeynayake, 2014).

Mediation is not binding the parties with the decision, not provide any decision to settle, the dispute rarely practiced and not that much popular and the awareness of ADR methods and awareness in related legislation or standard conditions of contract is low (Jayalath, 2014). Mediator diversity and training, greatly affect whether disputants can get fair and unbiased outcomes (Valters, 2013). There is an informality for the mediator to perform his function and generally no legal obligations arise for the mediator from the solution (Office of Legal Affairs Codification Division, 1992). Depending on skills of Mediator outcome vary.

In adjudication, low level of satisfaction on proceedings and outcomes are there. Additionally, less formal than arbitration, strict rules of evidence are not applied (Bentley, 1992). Procedural rules may be imposed by nominating body. Adjudication may destroy the relationship between parties. The consequences of failure to comply with time constraints may be severe (Jayalath, 2014).

In arbitration, there is dissatisfaction with current arbitration practice within the construction industry because of its complexity and slowness (Albright and Stoddard, 2012). Therefore, low level of satisfaction is there on arbitration as an ADR method such as proceedings and outcomes. Time limits are not mentioned at the Arbitration Act (Jayalath, 2014). Involvement of Lawyers for the arbitration hearings is higher. The fee charged by the arbitrator in order to settle the dispute is higher these days (Albright and Stoddard, 2012).

3.6. POTENTIAL SOLUTIONS OF ADR METHODS

As solutions, increasing the practice of technically qualified construction professionals as arbitrators, adjudicators, etc. for settlement of construction disputes, speeding up the proceedings of ADR methods, giving more attention in drafting the correct dispute resolution clause, changing the attitude of construction professionals to encourage an ADR culture and moving away from traditional court practices, conducting awareness programs such as teaching and training in ADR methods and their procedure at the professional and academic institutes, establishing an institute for practicing, developing and regulating all ADR methods, introducing rules and guidelines for ADR methods used in the construction industry in Sri Lanka for mediation and conciliation, introducing time framework to the ADR methods for settlement of disputes, appointing of a lawyer and experts on the construction industry to the ADR tribunal and introducing rules for non-involvement of legal professionals in ADR practice (Abeynayake, 2014). A complete re-orientation of the traditional approach and attitude towards dispute resolution is needed for the stakeholders of the Sri Lankan construction industry (Lim, 1994). During operations and implementation of ADR methods, establish of effective procedures for selection, training, and oversight of conciliators, mediators, adjudicators and arbitrators is essential (Brown *et al*., 1996).

4. DATA ANALYSIS AND RESEARCH FINDINGS

Data was collected through pilot survey, two rounds of questionnaire survey and semi-structured interviews were conducted among construction professionals with more than ten years of experience.

4.1. PILOT SURVEY

The pilot questionnaire was prepared and distributed to 6 experts in construction industry and obtained suggestions, mainly for the problematic areas and potential solutions. In addition to literature review, respondents were suggested additional problematic areas and potential solutions. Moreover, some problematic areas were removed according to the comments. Problematic areas such as mediator is not provide any decision to settle the dispute, creative remedies are not possible and arbitration is an adversarial process were removed. “No time framework for settlement of disputes” was changed as “Time framework for settlement of disputes at the contract is not followed” for the reason that, the actual meaning of the problem was not represented on the previous phrase.

In conciliation, not enforceable by courts unless parties make separate agreement to enforce and o trained personnel to do Conciliation were added. Community should be advanced to consider others’ views were included in mediation. Under adjudication, time framework for settlement of disputes at the contract is not followed, temporary Binding, awareness of importance and outcome of Adjudication is low, lack of competent adjudicators at Sri Lanka and costly method added. Arbitration was included costly method, only few construction professionals are there and slow in enforcement of arbitral award. These are the newly added problematic areas through pilot survey.

A potential solution “Introduce time framework for ADR methods for settlement of disputes” has been removed from the questionnaire round one for the reason that, if the time framework is at the contract, it would not be suit to all type of disputes. The suggested potential solutions were honour the outcome of the ADR when it is not enforceable, guidelines to draft ADR clauses in contracts and appoint full time adjudicator for the complex projects. Finally, questionnaire round one was developed based on the results.

4.2. DELPHI ROUND ONE

A total of 38 questionnaires were distributed to where 36 respondents responded. Among these respondents (36), the problematic areas for each ADR methods were replied by different number of professionals. The number of practitioners replied for each ADR methods among respondents at Delphi Round one are 29 practitioners for conciliation, 34 practitioners for mediation and adjudication and 35 for arbitration.

The conclusive evidence that the 97% of the respondents in the sample have admitted the awareness of the Act. The usage of adjudication and arbitration are high in the Sri Lankan construction industry is identified through the survey. Thus, adjudication and arbitration are being practiced more in the construction industry. However, mediation is also being practiced in the industry up to some extent. But, the usage of conciliation is comparatively low. Through the survey, it is clear that the awareness of method and its procedure is high for arbitration. Second highest for adjudication. However, mediation knowledge also there for nearly 64% of construction practitioners who are having more than 10 years of experience. But, the awareness of conciliation is comparatively low among the construction professionals.

4.2.1. *PROBLEMATIC AREAS OF ADR METHODS*

Problematic Areas related to Conciliation

The problematic areas related to conciliation in Sri Lankan construction industry is identified in the percentage of respondents of conciliation. 'Conciliation is rarely practiced and low popularity' and 'Conciliation is not binding the parties with the decision and conciliators have no powers of enforcement' were accepted by 86.21% and 82.76% of respondents. Moreover, 'no time framework for settlement of disputes', 'not enforceable by court unless parties make separate agreement to enforce' and 'no trained personal to conciliation' were answered as problem by 75.86% of respondents. Due to mixed questionnaire, problems which were recognized as addition to the above are parties have discretion to withdraw from the process at any stage, process is practiced only in case of minor disputes, no encouragement from the authorities, no proper awareness, not included within standard forms of contracts and parties attitude about conciliation (Confidence about process).

Among these problems, 'parties have discretion to withdraw from the process at any stage' was rejected, because this is a feature and not a problem. Furthermore, 'parties attitude about conciliation (Confidence about process)' was removed for the reason that, the respondent mentioned that the parties who involve in the conciliation are not following the procedures with full involvement because they have the mentality that if it fails then they can refer it to adjudication or arbitration. Therefore, this can be categorised under no proper awareness of the method.

Problematic Areas related to Mediation

The problematic areas related to mediation in the Sri Lankan construction industry is identified in the percentage of respondents for mediation. 'Mediation is not binding the parties with the decision and Mediators have no powers of enforcement' and 'Depending on skills of Mediator, outcomes vary' are by far the most popular problems related to mediation with 85.29%. 'No time framework for settlement of disputes' and 'Mediation is rarely practiced and awareness of mediation is low' were accepted by 76.47% and 67.65% respectively. However, 'community should be advanced to consider others views' is much less significant problem with 44.12%. Due to mixed questionnaire, problems which were recognized as addition to the above are skill of mediators, parties have discretion to withdraw from the process at any stage, process is practised only in case of minor disputes, no trained personnel to do mediation, not included within standard forms of contracts and parties attitude about conciliation (Confidence about process).

Among these problems, 'community should be advanced to consider others views' was eliminated due to the acceptance by lesser than 50% of respondents. 'Parties have discretion to withdraw from the process at any stage' was eliminated, because it is a feature. In this process, parties' believe in achievement of decision is important. Thus, if the parties feel that they cannot obtain a decision in any stage of the process. Then, the parties have discretion to withdraw. 'Parties attitude about mediation (Confidence about process)' was rejected due to the same reason as mentioned under problematic areas related to conciliation.

Problematic Areas related to Adjudication

The problematic areas related to adjudication in Sri Lankan construction industry are identified in the percentage of respondents for adjudication. 'Time framework for settlement of disputes in the contract is not always followed' and 'Normally Adjudicator is not appointed at the initial stage' are by far the most popular problems related to adjudication with 79.41%. 'Temporary binding' and 'Lack of competent adjudicators at Sri Lanka' were accepted by 76.47% and 61.76% respectively. However, 'Awareness of importance and outcome of adjudication' and 'Costly method' were much less significant problem with 44.12% and 38.24% accordingly.Due to mixed questionnaire, problems which were recognized addition to the above are adjudicators rarely follow the events at site progressively until the dispute is notified and they are not keen in prevention of disputes, loosing party can resort to Arbitration and so rarely accepts the decision, preference to Arbitration over adjudication, standing DAB may be costly method, lack of procedural rules and decision of Adjudication is not honoured even temporarily.

Among these problems, ‘awareness of importance and outcome of adjudication’ and ‘costly method’ were eliminated due to less than 50%. ‘Adjudicators rarely follow the events at site progressively until the dispute is notified. They are not keen in prevention of disputes.’ was rejected because cannot mention as ‘they are not keen in prevention of disputes’ because if there is a standing adjudication they try to prevent the problem too. Thus, that phrase is removed. ‘Lack of procedural rules’ was eliminated, due to the reason that ICTAD Publication which is known as Guidelines for ICTAD enlisted construction adjudicators is contained procedure for enlistment, procedure for adjudication and principles of ethics.

Problematic Areas related to Arbitration

The problematic areas related to arbitration in Sri Lankan construction industry are identified in the percentage of respondents for arbitration. ‘Slowness of the method’ and ‘higher involvement of Lawyers for arbitration hearings whenever not necessary’ are by far the most popular problems related to adjudication with 88.57%. Moreover, ‘Slowness of enforcement of Arbitral Award’ and ‘costly method’ were accepted by 82.86%. However, ‘only few construction professional are there’, ‘No time framework for settlement of disputes’ and ‘Dissatisfaction with current arbitration practice within the construction industry because of complexity of the method’ were accepted as a problem by around 80%, 71.43% and 71.43% of respondents accordingly.Due to mixed questionnaire, problems which were recognized additionally are relevant technical professionals are rarely appointed as arbitrators as well as dominated by legal persons and lengthy proceedings follow similar to litigation in courts.

Among these problems, ‘Dissatisfaction with current arbitration practice within the construction industry because of complexity of the method’ was rejected because this is a feature of arbitration not a problem. Furthermore, ‘lengthy proceedings follow similar to litigation in courts’ was removed due to the same reason.

4.2.2. POTENTIAL SOLUTIONS

The potential solutions suggested to improve ADR were presented to respondents. They were asked to mark whether they identify the following as potential improvements in ADR methods to settle construction disputes efficiently. Table 1 summarises the responses received. The percentages identified with reference to solutions are shown in the table below.

Table 1: Potential Solutions

	Potential solutions	**%**
1	Increase the practice of technically qualified construction professionals as conciliators, mediators, adjudicators and arbitrators for settlement of construction disputes	100.00
2	Make the proceedings of ADR methods speeder	88.89
3	Change the attitude of construction professionals to encourage an ADR culture and to move away from traditional court practices	83.33
4	Conducting awareness programs	83.33
5	Appoint full time adjudicator for the huge and complex projects	80.56
6	More attention should be given in drafting of the correct dispute resolution clause	77.78
7	Introduce rules and guidelines for ADR methods used in the construction industry in Sri Lanka for mediation and conciliation	77.78
8	During operations and implementation of ADR methods, establish effective procedures for selection, training, and oversight of conciliators, mediators, adjudicators and arbitrators.	77.78
9	Guideline to draft ADR clauses in contracts	69.44
10	Establishment of an institute for practicing, developing and regulating all ADR methods	61.11
11	Honoring the outcome of the ADR, when it is not enforceable	58.33

Due to mixed questionnaire, potential solutions which were identified as addition to the above solutions identified through literature review and pilot survey are the proceedings shall continue uninterruptedly for required number of days until completion, enforce the agreed time frame by parties and arbitration panel strictly follow without any extension for submissions and postponements of hearing, introduce rules and guidelines for adjudication and guidelines shall be drafted in nominating adjudicators etc from the panel lists of appointing authority, shortcomings are exposed in the present system.

Among above potential solutions, following potential solutions were rejected or amended for the purpose of questionnaire round two. Those potential solutions were supported with the reason of rejection or amendment as below.

- Conducting awareness programs - It was changed as "Conducting awareness programs and Continuing Professional Development (CPD) programs regarding ADR methods" as to make it more detailed.
- Establishment of an institute for practicing, developing and regulating all ADR methods - There are institutes such as CIDA, ICPL Arbitration Centre and Sri Lanka National Arbitration Centre. CIDA is facilitating and regulating the ADR methods. As well as, CIDA is going to establish an institute for adjudication too. ICPL Arbitration Centre and Sri Lanka National Arbitration Centre are practicing, developing and regulating arbitration.
- Introduce rules and guidelines for Adjudication - ICTAD Publication No. ICTAD/ADV/01 - Guidelines for ICTAD enlisted construction adjudicators is a contained procedure for enlistment, procedure for adjudication and principles of ethics. Thus, this is rejected from potential solution.

Finally detailed questionnaire round two was developed based on the results of questionnaire survey round one.

4.3. DELPHI ROUND TWO

A total of 36 questionnaires were distributed to which 30 respondents responded. Among these respondents (30), the problematic areas for each ADR methods were replied by different number of professionals. The number of practitioners replied for each ADR methods among respondents at Delphi Round one are 25 for conciliation, 28 for mediation and adjudication and 29 for arbitration.

4.3.1. PROBLEMATIC AREAS OF ADR METHODS

The section one of questionnaire survey round two was designed to identify the level of each problematic areas in implementation of ADR methods such as conciliation, mediation, adjudication and arbitration in Sri Lankan construction industry and finally ranked using scale of 5 levels (Likert). For analysis, first t-test was used to identify the significant problematic areas. t-test was done through one sample t-test on SPSS software. Then, MWR was calculated to rank the significant problematic areas.

Benchmarking p value for this t test was 0.05. If the significance level which is the p value for a particular problematic area is less than 0.05, then that problem is significant. Null hypothesis is non-significant problematic area and alternative hypothesis is significant problematic area. In the problematic areas, if the t observed value is greater than the t-critical value, and they were considered as significant problematic areas, then the null hypothesis was rejected and the alternate hypothesis was accepted. A test value is 3 and confidence level is 95% ($p < 0.05$, $\alpha = 0.05$)

Problematic Areas related to Conciliation

The critical t-value is 1.711 from the t-table when degrees of freedom is 24 (25-1). Thus, the t-values of the problematic areas should be greater than the critical t-value. If so, null hypothesis to be rejected. Further, $t(24)$ = observed t-value. Significant problematic areas arrived through one sample t-test was ranked using MWR is shown in Table 2.

Table 2: Ranking of Significant Problematic Areas Related to Conciliation

Problematic areas related to Conciliation	MWR	Rank
Not included within standard forms of contracts	4.32	1
Conciliation is not binding the parties with the decision and conciliators have no powers of enforcement	4.24	2
Not enforceable by court unless parties make separate agreement to enforce	3.96	3
No proper awareness	3.88	4
No time framework for settlement of disputes	3.68	5
No encouragement from the authorities	3.64	6
Conciliation is rarely practiced and low popularity	3.64	6

Problematic Areas related to Mediation

The critical t-value is 1.703 from the t-table when degrees of freedom is 27 (28-1). Thus, the t-values of the problematic areas should be greater than the critical t-value. If so, null hypothesis to be rejected. Further, t (28) = observed t-value. Significant problematic areas arrived through one sample t-test was ranked using MWR is shown at Table 3.

Table 3: Ranking of Significant Problematic Areas Related to Mediation

Problematic areas related to Mediation	MWR	RANK
Mediation is not binding the parties with the decision & no powers of enforcement for mediators	4.43	1
Depending on skills of Mediator outcome vary	4.21	2
Skill of mediators	4.18	3
Not included within standard forms of contracts	4.14	4
No time framework for settlement of disputes	3.68	5
Mediation is rarely practiced and awareness of mediation is low	3.61	6
No trained personnel to do mediation	3.57	7

Problematic Areas related to Adjudication

The critical t-value is 1.703 from the t-table when degrees of freedom is 27 (28-1). Thus, the t-values of the problematic areas should be greater than the critical t-value. If so, null hypothesis to be rejected. Further, t (28) = observed t-value. Significant problematic areas arrived through one sample t-test was ranked using MWR is shown at Table 4.

Table 4: Ranking of Significant Problematic Areas Related to Adjudication

Problematic areas related to Adjudication	MWR	RANK
Adjudicators rarely follow the events at site progressively until the dispute is notified.	4.11	1
Loosing Party can resort to Arbitration and so rarely accepts the decision	4.07	2
Normally Adjudicator is not appointed at the initial stage	3.96	3
Preference to Arbitration over adjudication	3.89	4
Standing DAB may be costly method	3.86	5
Time framework for settlement of disputes at the contract is not followed	3.71	6

Problematic Areas related to Arbitration

The critical t-value is 1.701 from the t-table when degrees of freedom is 28 (29-1). Thus, the t-values of the problematic areas should be greater than the critical t-value. If so, null hypothesis to be rejected. Further, t (28) = observed t-value. Significant problematic areas arrived through one sample t-test was ranked using MWR is shown at Table 5.

Table 5: Ranking of Significant Problematic Areas Related to Arbitration

Problematic areas related to Arbitration	MWR	RANK
Relevant technical professionals are rarely appointed as Arbitrators but dominated by lawyers and retired judges	4.21	1
Costly method	4.03	2

Slowness of the method	3.97	3
Higher involvement of Lawyers for arbitration hearings whenever not necessary	3.86	4
Only few construction professionals are there	3.72	5
Slowness of enforcement of Arbitral Award	3.48	6

4.3.2. POTENTIAL SOLUTIONS

The potential solutions to improve ADR methods were presented to respondents. They were asked to mark on the level they are agreed on each potential improvements. Ranking was done with scale of 5 levels (Likert). For analysis, first t-test was used to identify the significant solutions. t-test was done through one sample t-test on SPSS software. Then, MWR was calculated to rank the significant potential solutions. The ranking was to prioritise the solutions that have to be taken in order to make ADR methods more effective and efficient.

Benchmarking p value for this t-test is 0.05. If the significance level for a particular potential solution is less than 0.05 that potential solution is significant. Null hypothesis is non-significant potential solution and alternative hypothesis is significant potential solution. In the potential solutions, if the t observed value is greater than the t-critical value, then they are to be considered as significant potential solutions, then the null hypothesis is to be rejected and the alternate hypothesis is to be accepted and vice versa. The critical t-value is 1.699 from the t-table when degrees of freedom is 29 (30-1). Further, a test value is 3, t (29) = observed t-value, and confidence level is 95% ($p < 0.05$, $\alpha = 0.05$). Significant potential solutions arrived through one sample t-test was ranked using MWR is shown at Table 6.

Table 6: Ranking of Significant Potential Solutions

Potential Solutions	MWR	RANK
Appointment of standing adjudicator for complex projects	4.47	1
Increase the practice of technically qualified construction professionals as conciliators, mediators and etc. for settlement of construction disputes	4.40	2
Guidelines shall be drafted in nominating adjudicators from the panel lists of appointing authority	4.33	3
Organise the publications of ADR methods in Sinhala and Tamil medium	4.30	4
Conducting awareness programs and CPD programs regarding ADR methods	3.97	5
The proceedings shall continue uninterruptedly for required number of days until completion	3.90	6
Introduce rules and guidelines for mediation and conciliation to use in the Sri Lankan construction industry	3.90	6
Provide attention in drafting of correct dispute resolution clause	3.83	8
During and before operations and implementation of ADR methods, establish effective procedures for selection, training, and oversight of conciliators, mediators and etc.	3.77	9
Make the proceedings of ADR methods speeder	3.73	10
Change the attitude of construction professionals to encourage an ADR culture	3.70	11
Enforce the agreed time frame by Parties and Arbitral tribunal strictly without any extension	3.70	11
Guideline to draft ADR clauses in contracts	3.60	13
When the decisions are not legally enforceable, Then made contractually binding	3.55	14

4.4. SEMI STRUCTURED INTERVIEW

Aim was to make recommendations to the part IX - settlement of dispute at the said Act. Views and knowledge of construction expertise with more than ten years of experience in the construction industry was referred and focused in conducting semi structured interviews. The semi structured interview guideline was prepared and conducted to 28 construction practitioners. 75% of professionals are unsatisfied on the selection of the ADR methods in the said Act. 79 % of professionals are unsatisfied on the part IX.

Recommendations to the Part IX - Settlement of Disputes at the Act

According to the results of the interviews, 9 professionals have told that the detailed procedures of the ADR methods have to be included in the said Act or otherwise the document to refer has to be mentioned. Moreover, 4 professionals have suggested to provide the legal assent to the adjudication. Similarly, 3 professionals have stated to include arbitration as an ADR method, before referring the dispute to the court. Due to time constraint in the construction projects, facilitate process in speedy manner by rules and guidelines was recommended by two professionals. Additionally, the other recommendations which were stated are to establish a committee in CIDA to decide on appointment of adjudicators or arbitrators, to introduce appeal system for decisions of mediators, conciliators etc. to the authority, to encourage to attend ADR awareness programme as pre requisite for registration, to penalise any party if they are absence from proceedings, to provide flexible rules and the guidelines, to introduce negotiation as first method to solve disputes, to conduct CPDs or related conferences to enhance knowledge of mediators, conciliators, arbitrators and adjudicators and to use New Zealand or Malaysia model as a guide to settlement of disputes.

5. CONCLUSION

Overall, the study has captured the level of effectiveness on settlement of disputes in the construction industry by means of problematic areas of ADR methods which are used by the construction industry and at the said Act. As well as, legal framework was proposed for settlement of disputes, using ADR methods through the Act with the help of potential solutions and the recommendations to the part IX of the said Act. The legal framework for settlement of disputes is through ADR methods according to the Construction Industry Development Act No.33 of 2014 is shown at Figure 1. The use of proposed framework for settlement of disputes could contribute to the development of construction industry.

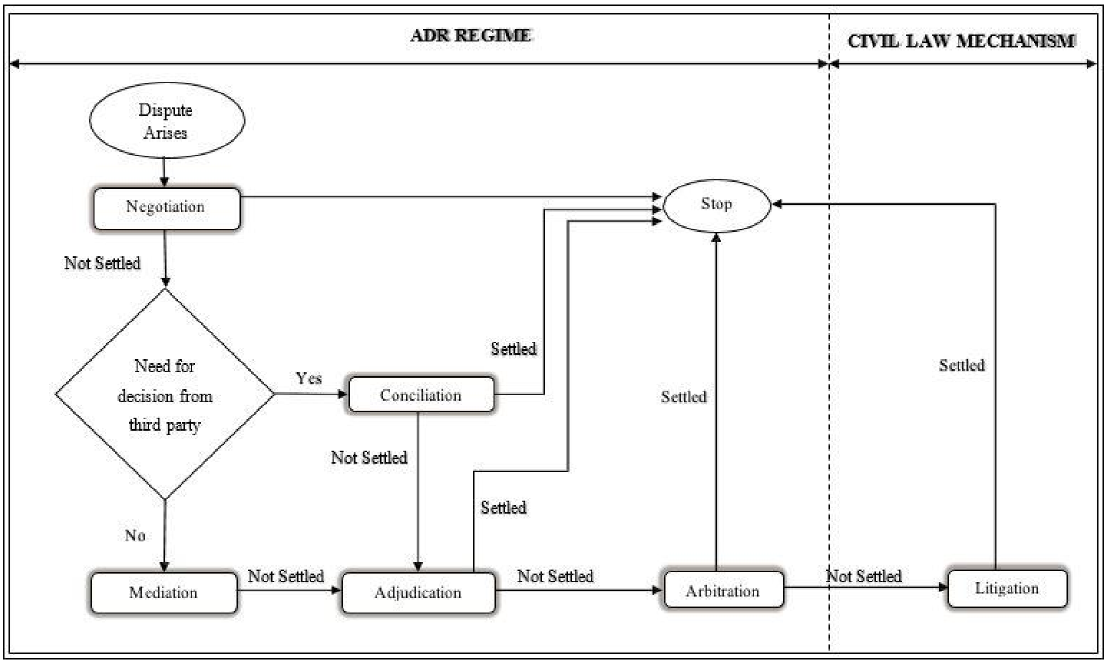

Figure 1: Legal Framework for Settlement of Disputes through ADR Methods according to the Construction Industry Development Act No.33 of 2014

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MANAGING OCCUPATIONAL STRESS OF PROFESSIONALS IN LARGE CONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

This research aims to take an insight at construction professional-specific occupational stress causing factors, and their impacts to the productivity. The occupational stress causing factors pertinent to construction professionals, consequences of occupational stress and occupational stress prevention strategies that could be implemented within the construction sites were studied and a questionnaire survey was carried out among construction professionals such as project managers, Engineers and Quantity surveyors to identify the significance of them. Ten stressors were identified as significant in causing occupational stress among constructional professionals. Further it was recognized the organization related factors have a significant variance of occupational stress among professionals. Thereafter 11 significant impacts for project managers, 9 significant impacts for Engineers and 11 significant impacts for Quantity surveyors were explored. Impact of occupational stress of construction professionals for low performance and productivity can be reduced and job satisfaction can be enhanced by implementing the occupational stress management strategies in construction sites.

Keywords: *Occupational Stress; Productivity, Large Construction Projects; Construction Professionals; Occupational Safety and Health*

1. INTRODUCTION

Continuous increasing in complexity of work and growing demand for higher productivity have become common features of the industry and thus, created a challenging environment towards achieving time, cost and quality targets of construction projects (Ibem *et al*., 2011; Jang *et al*., 2003). Under such circumstances, many professionals including project managers, engineers and quantity surveyors have to work under pressure (Thomas *et al*., 2005). Thus to a certain extent, stress has become a normal part of most of the professionals' work environment. Stress is a natural consequence of a change that can be either positive or negative (Strutton and Tran, 2014). Occupational stress is a pattern of responses in workplace that occurs when employees are offered with work demands which are not matched to their knowledge, skills or abilities, and which challenge their ability to cope with (Mohajan, 2012).

Generally, it is considered that occupational stress is harmful to physical and mental health of workers under various circumstances. As such, excessive stress interferes with their performance and productivity and thus efficiency of the overall project delivery (Ng *et al.*, 2005; Amankwah *et al.*, 2015). Therefore, occupational stress is a growing problem worldwide which results in significant costs for both of the employees and organizations and may experience in various behaviours (Strutton and Tran, 2014; Cotton and Hart, 2003). These behaviours includes; low motivation and morale, decrease in performance, high turnover and sick leave, accidents, low job satisfaction, low quality products and services, poor internal communication and conflicts etc. (Schabracq and Cooper, 2000). However, this problem has been overlooked at the industry level and hence professionals have to find ways of managing their stress at individual capacity to meet delivery of the projects within the time, cost and at the required quality (Leung, Ng *et al.*, 2004). Therefore, this particular research was mainly outlined and aimed to address the occupational stress causing factors and their impact, extend of the occupational stresses among professionals in large construction projects.

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2. TYPES OF STRESSES

Selye (1976), who often referred to as the "father of stress", was the first to distinguish stress as "good stress (eustress)" or positive stress and "bad stress (distress)" or negative stress. Positive stress is generally short term perceived and results motivation, better focus improve personnel coping abilities, feel exciting, improve performance etc., whereas negative stress can be short term (acute) or long terms (chronic) resulting anxiety unpleasantness, decreased performance and mental or physical problems (Leung *et al*., 2004). Among these, chronic stresses create bad health problems and thus it is required to manage its causing factors. When the stress caused as a result of occupational factor such as mismatch of the job requirement and the worker's capabilities, resources or need of the workers, is known as occupational stress (The National Institute of Occupational Safety and Health (NIOSH) cited Mohajan, 2012). Such "Stress" is not limited to any particular occupation or profession (Ng *et al*., 2005).

Statt (1994) has specially noted that construction work is the third most stressful profession after mining and police work. As cited by Oladinrin *et al*. (2014), Sutherland and Davidson (1993) found that 77% are senior managers and 23% are middle level managers among professionals who have experienced stress in the UK construction industry. Further, recent studies show that construction workers experienced much more stress at their workplace than at home, and thus created undesirable effects on their health and productivity at work (Wahab, 2010). Similarly, a negative correlation is mentioned between the occupational stress and the job satisfaction as well as organizational performance (Elovainio *et al.*, 2002; Cotton and Hart, 2003; Kazmi, 2007 cited Amankwah *et al*., 2015). While there is a reported increased in occupational accidents high absenteeism, alcoholism, and drug abuse have become major social problems due to occupational stress (Clarke and Cooper, 2004).

The common types of stressors related to the construction industry can be categorized into four main groups at the site level as work demand, work environment, job role and organizational related (Ibem *et al*., 2011). Unspecified employment requirement, extremes of formality, lack of locus of authority are organizational related stressors (Raitano and Kleiner, 2004). Additionally, Ng *et al*., (2005) mentioned inadequate room for innovation, unsatisfactory remuneration and ambiguity of job requirement as stressors. According to Cooper cited Ekundayo (2014), these causing factors have been categorized in a broader way by adding several levels including environment, individual and individual differences in addition to organizational level stressors. Uncertainties such as economic, political and technological are discussed under environmental related stressors.

3. SIGNS AND SYMPTOMS OF OCCUPATIONAL STRESS

According to literature findings, signs and symptoms of occupational stress are appeared as physical, psychological, behavioural consequences which include (Gupta, 2013; Ekundayo, 2014; Oladinrin, *et al*., 2014; Ademola (2005) and Melinda *et al*. (2010) cited Amankwah *et al*., 2015);

- Physical: cardio-bronchial pains, blood pressure, palpitations, weight loss from under-eating and sleeping at abnormal times, eating disorders, headaches, hair loss, breathlessness and hyperventilating, muscle ache, dryness of throat and mouth, sweaty palms, diarrhea, indigestion, stomach ulcers, etc.
- Psychological: feeling of useless, and hopeless, lack of concentration, tenseness, sleep disturbances, depression, distrust, anxiety, etc.
- Behavioral or emotional: impulsive behavior, eating more or less, easily distracted, speech problems, sleeping too much or too little, change in personality, irritable or aggressive, grinding of teeth, increasing smoking and drugs and alcohol, burnout, nervous habits, increased errors, absenteeism, lack of concentration, etc.

4. OCCUPATIONAL STRESS MANAGEMENT

Individuals' ability to mobilize and successfully or unsuccessfully deal with stress factors is defined as coping with stress, adjusting to stress or stress management self-mobilization (Stoica, 2010). Instead of taking medicine to reduce stress, there are many ways of diminishing its damaging effects through better control and management (Oladinrin *et al*., 2014). Moreover, organizations can orient their employees to regular maintaining of well-being and prevention of occupational stress (Treven and Potocan, 2005). Such prevention strategies at organizational level can be taken as primary, secondary and tertiary prevention methods (Ratino and Kleiner, 2004; Jordon *et al*., 2013):

- Primary prevention is the elimination or reduction of the factors that promote distress
- Secondary methods involve moderating the response of stress itself
- Tertiary prevention strategies are the attempts to minimize or cope with excessive distress from inadequately controlled stressors and inadequately controlled or moderated stress responses.

5. OBJECTIVES OF THE STUDY

Since stress at work is a well-known factor for low construction productivity, the research focuses to examine whether the various construction professionals can adequately cope with the stresses they are confronting. Thus, the research is designed to examine occupational stress causing factors and their impact, extend of the occupational stresses among professionals in large construction projects in Sri Lanka.

6. RESEARCH DESIGN

The research was structured to several phases. It begins with an extensive literature review to identify occupational stressors specific for the construction professionals, impact of occupational stress and occupational stress prevention strategies. Literature findings were used to formulate the questionnaire and it was validated though a pilot survey, focusing on the comprehensiveness, reliability, and conciseness. Three industry experts from each professional categories were participated for the pilot survey. Those experts were selected considering the experience in large construction projects and experience in both civil engineering and building sectors.

In the second phase, the detailed questionnaire was designed by incorporating the expert feedback given to the pilot questionnaire. The questionnaire was comprised with two separate sections namely; personnel information and subject information and a cover page. Further, it was included with both open ended and closed ended questions. Personnel information section covered the profession of the respondent, experience in large construction projects, age and gender of the respondents, marital status and opinion of the respondents for the occupational stress as a health and safety problem.

Three main questions to identify significant stressors, impact of such situation and stress prevention were included for the observations of the subject information. In the first question, forty one stressors were organized into ten headings namely; (1) work load and workplace related factors WL&WP, (2) work time related factors - WT, (3) organization related factors - O, (4) work related factors W, (5) career development and status related factors - CD, (6) interpersonal relationship related factors - IR, (7) preparation and training related factors, (8) Organizational function and culture related factors - OC, (9) participants related factors - P, and (10) other problems related factors - OP. In the second question, 17 number of potential health impacts which were identified through the literature survey were listed under three groups as physical response, psychological response, and behavioral or emotional response.

Respondents were asked to rank the extent of given problem using a 5 point Likert scale to measure the severity.

7. SAMPLE SELECTION

The target survey group was considered as the professionals who are working in large construction projects. Large construction projects were defined as;

“Construction projects which are complex in nature and multitasking, contact sum more than Rupees 600 million including both Building and Civil engineering construction projects” for the study.

Hence, large construction Organizations defined as the "Organizations which are undertaking large construction projects".

However, it was impossible to survey those large populations due to limited resources. The cluster sampling method was used for the study by selecting the registered large scale construction contractors (i.e. grade C1) in Colombo area. Further, it was aimed to select the most experienced professionals. A list of C1 grade contractors in Colombo area were taken from the ICTAD (Institute of Construction Training and Development) website. In view of that, 20 firms were listed as C1 contracting firms in Colombo area. Visiting the firms, details of large construction projects which were completed in last 10 years were obtained and 25 projects were selected for the study. Most experienced persons who have engaged in those projects from each professional category were invited for the survey. Hundred and six questionnaires were delivered using two methods; direct handover and via emails. Further on average 2-3 reminders had to be sent for the professionals who were communicated through emails. Reminders were given over the phone and visited to collect the completed questionnaires for other professionals.

8. RESULTS AND DISCUSSIONS

8.1. PROFILE OF THE SURVEY SAMPLE

84 questionnaires were received claiming 79% response rate from 106 questionnaires. Nine questionnaires were rejected due to their incompleteness. Tables 1 and 2 represent the composition of the survey , and site experience and age of the selected respondents respectively. Further, 36% of the sample was female while remaining 64% was male.

Table1: Composition of the Survey Sample

Profession	Distributed Questionnaires	Received Questionnaires	Response Rate	Selected Questionnaires
Project Managers	37	26	70.27%	25
Engineers	33	29	87.87%	25
Quantity Surveyors	36	30	83.33%	25

Table 2: Site Experience and Age of the Respondents

Description	Project Managers	Engineers	Quantity Surveyors
		Site Experience (years)	
< 5years	-	17	15
5-10 years	16	7	4
10 years <	8	1	6
		Age (years)	
25-35 years	14	21	19
35-45 years	7	3	6
over 45 years	4	1	-

Occupational Stresses among Professionals

Results reveal that 96% of the respondents have experienced occupational stress while 4% have not experienced occupational stress during their work experience. Further, 90% of respondents have indicated that occupational stress as a health and safety problem and hence it impacts the productivity whereas 10% responded have not considered it as a health and safety problem.

8.2. SIGNIFICANT STRESS CAUSING FACTORS

T-test (at 5 percent significance level) was conducted using Statistical Package for Social Sciences (SPSS) software to identify significant stressors from given 41 stressors in the questionnaire. To test the null hypothesis the following conditions were used:

H_0: $m=m_0$ against the alternate hypothesis

H_1: $m=m_1$, where 'm' is the population mean and m_0 is the sample mean.

Test value was taken as 3, according to the given scale. Thus the stressors which have obtained critical t-value 1.990 and less than 0.05 p value are identified as significant. According to results obtained from the t-test, 11 significant stressors were established from 41 given stressors under 10 headings in the questionnaire survey (Table 3).

Table 3: Significant Stressors

Stressor	Mean Rating	Std. Dev.	t-value	Sig.	Rank
Time pressures and deadlines (WL&WP)	3.85	0.711	10.397	0.000	1
Work overload (WL&WP)	3.83	0.795	9.007	0.000	2
Lack of control over pacing of work (WL&WP)	3.48	0.760	5.471	0.000	3
Long hours of work (W)	3.55	0.949	4.991	0.000	4
Different views from superiors (W)	3.43	0.808	4.571	0.000	5
Unpredictable hours of work (WT)	3.35	1.007	2.982	0.004	6
Inadequate recess (WT)	3.33	0.977	2.954	0.004	7
Exposure to heavy traffic jam (OP)	3.32	1.092	2.537	0.013	8
Inflexible work schedules (WT)	3.24	0.998	2.083	0.041	9
Lack of resources and staff shortages (OP)	3.28	1.192	2.035	0.045	10
Use of mobile phones while working (OP)	3.28	1.225	1.999	0.050	11

8.3. IMPACT OF OCCUPATIONAL STRESS

Occupational stress causes serious impact when it is taken as a negative stress. As highlighted by Ilbem *et al*. (2011) in his study, recent studies show that construction workers experienced more negative stress at their workplace, and this had been caused undesirable effects on their health and productivity at work. Occupational stress is a critical issue for the individuals and consequently result in loss of organizational productivity (Akrani, 2011 cited Amankwah *et al*., 2015). In this research, second objective was to examine the impact of occupational stress of professionals in large construction projects.

Two tailed t-test was conducted to identify the critical impacts faced by each professional category separately. The results are shown in Tables 4, 5 and 6.

Table 4: Response of Project Managers

Productivity Impacts	Mean	Std. dev.	t-value	Sig.	Rank
Fatigue (PR)	3.20	0.763	7.856	0.000	1
Tense more often (ER)	3.40	0.913	7.668	0.000	2
Aggressiveness (BR)	2.92	0.702	6.549	0.000	3
Neck and Back pains (PR)	3.20	1.041	5.765	0.000	4
Impact on family and personnel life (BR)	2.96	0.841	5.710	0.000	5
Less job satisfaction (CR)	2.80	0.764	5.237	0.000	6
Unable to Relax (ER)	3.12	1.201	4.661	0.000	7
Reduced attention (CR)	2.40	0.500	4.000	0.001	8
Headaches (PR)	2.64	0.907	3.527	0.002	9
Depression and Anxiety (ER)	2.40	0.764	2.619	0.015	10
Sick more often (PR)	2.36	0.810	2.221	0.036	11

Table 5: Response of Engineers

Productivity Impacts	Mean	Std. dev.	t-value	Sig.	Rank
Aggressiveness (BR)	2.84	0.850	4.938	0.000	1
Less job satisfaction (CR)	3.08	1.115	4.843	0.000	2
Unable to Relax (ER)	2.76	0.926	4.106	0.000	3
Tense more often (ER)	2.76	0.970	3.919	0.001	4
Depression and Anxiety (ER)	2.80	1.080	3.703	0.001	5
Feelings of powerlessness (ER)	2.68	1.069	3.180	0.004	6
Headaches (PR)	2.36	0.700	2.571	0.017	7
Fatigue (PR)	2.52	1.085	2.397	0.025	8
Neck and Back pains (PR)	2.52	1.194	2.177	0.040	9

Table 6: Response of Quantity Surveyors

Productivity Impacts	Mean	Std. dev.	t-value	Sig.	Rank
Depression and Anxiety (ER)	3.08	0.909	5.939	0.000	1
Tense more often (ER)	2.96	0.841	5.710	0.000	2
Unable to Relax (ER)	3.00	0.913	5.477	0.000	3
Aggressiveness (BR)	2.88	1.092	4.028	0.000	4
Less job satisfaction (CR)	2.68	0.945	3.597	0.001	5
Fatigue (PR)	2.68	1.069	3.180	0.004	6
Impact on family and personnel life (BR)	2.52	0.918	2.831	0.009	7
Neck and Back pains (PR)	2.72	1.275	2.823	0.009	8
Reduced attention (CR)	2.36	0.700	2.571	0.017	9
Making mistakes frequently (CR)	2.44	0.870	2.529	0.018	10
Feelings of powerlessness (ER)	2.40	0.816	2.449	0.022	11
Headaches (PR)	2.56	1.356	2.064	0.050	12

Results obtained from the t-test explored 11, 9 and 12 significant impacts for the PMs, Engineers and QSs respectively. Eight impacts such as Fatigue, Tense more often, Aggressiveness, Neck and back pain, less job satisfaction, Unable to relax, Headache, Depression and anxiety are common for all three professionals.

Fatigue is more often due to the heavy work load. Generally they have consciously work more than eight hours during a project to meet their targets. This problem has become more serious when they handle multiple projects.

Similarly, Tense more often and Aggressiveness are often linked with heavy work load. When the job demand is high; exceeding the person capacity, the above responses have become common among construction professionals.

Back and neck pain is occurred due to longer sitting hours with wrong posture. This problem is more often originated due to mismatch of the dimension of the chairs with person's body height to have better ergonomic seating facility. On the other hand, people are not serious about seating posture in most of the time.

Due to stressful working environment, most of them have felt less satisfaction towards their job. Thus, they are not fully committed to perform their work well.

Headache and even Depression and anxiety situation are identified mostly due to unable to relax with the workload. This has been further impacted on Family and personal life of them. In the local context, people always try to hide depression situations. Therefore, they are reluctant to obtain medical advice or drugs at early stages to control the situation due to fear in exposing the situation to others.

In addition, professionals neglect to highlight their health problems at work as well as they are still ready to work even if they are not feeling well. This is very common in developing countries (Chopra, 2009).

9. CONCLUSIONS

According to the previous researches, occupational stress leads to a decline in employees' job performance as excessive stress interferes with performance. This supports the assertion that excessive stress interferes with productivity. Stress must therefore be kept under control. Occupational stress has become an ignored term in the construction industry and the impact has been rarely studied due to the inherent characteristics of the industry. Construction projects are highly committed to the achievements of time, cost and quality targets. During last 10 years large construction projects were started by turning a new page in the Sri Lankan construction industry due to the construction boom. Therefore, it was identified that this is the most appropriate time frame to start assessment of occupational stress of professionals involved in construction industry.

Majority of the respondents (96%) have responded that they are experiencing stress at workplace while others (4%) said that they are not experiencing occupational stress. However, stress has become a big issue for the performance of the individuals due to less job satisfaction. Further 89.93% of respondents have presented that they are facing occupational stress as a health and safety issue, while 10.07% of the respondents stated that they do not face occupational stress as a health and safety problem.

This research study found 11 significant occupational stressors and especially organization related factors which have difference of occupational stress among different professions. Further, significant consequences were studied for different professionals separately as the results were shown in tables.

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OCCUPANT PRODUCTIVITY AND INDOOR ENVIRONMENT QUALITY LINKED TO GLOBAL SUSTAINABILITY ASSESSMENT SYSTEM

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ABSTRACT

Occupant productivity is gaining momentum in the field of sustainable built environment. Humans spend most of their time indoors, and the majority of the world's population lives in urban areas and work in an office environment. Different Indoor Environment Quality (IEQ) factors affect productivity in an office environment. This paper investigates Global Sustainability Assessment System (GSAS) rating system to identify criteria and submittals focusing different physical indoor environment quality factors that influence occupant productivity. It draws implicit links between the current state of sustainable research and indoor environment quality factors covered in the GSAS rating system. The study highlights that GSAS has focused one-third of its weightage to indoor environment quality factors. Most IEQ criteria like indoor air quality, thermal comfort, lighting and day lighting, Biophilia and views are well addressed in the GSAS. There is still room to focus on factors like office layout, look and feel, and location and amenities. This paper is a part of ongoing research endeavour to update GSAS to incorporate occupant productivity and well-being in rating system's focus to improve green buildings in the Middle East. The paper would help researchers and professionals who aim to understand the link between the GSAS rating system and indoor environment quality factors that affect productivity.

Keywords: *Green Building Rating System; Indoor Environment; Quality Occupant Productivity; Sustainability.*

1. INTRODUCTION

Humans spend most of their time indoors, and the majority of the world's population lives in urban areas and work in an office environment (ASHRAE, 1993). There has been a significant global shift in the economy from manufacturing sector towards service and knowledge-based sector, operating in indoor office environments (Haynes, 2008; World Green Building Council, 2014). Hence, it is becoming important to understand the indoor office environment and the effect it has on occupant well-being and performance. Office environment has a high level of influence on its occupants' well-being and performance (Leaman and Bordass, 1999; Frontczak *et al*., 2012 ; Roelofsen, 2002; Mawson, 2002; Van der Voordt, 2004). Past studies on sustainable buildings postulate that green design strategies and technologies enhance the indoor workplace environment. It enables to create an environment favouring occupants' comfort and performance in both newly built and retrofitted buildings (Romm and Browning, 1994). The majority of the building stock which will exist in 2050 has already been built (UNEP, 2009). Thus, there is a need to understand the quality of the indoor workplace environment, and its relation to

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occupant productivity and comfort. An extensive literature review was conducted to identify physical indoor environment quality factors that affect occupant productivity and comfort.

The study identifies eight physical components that affect occupant satisfaction and productivity in an office environment:

1. **Indoor Air Quality and Ventilation** (Vernon and Bedford, 1926; Wargocki *et al*., 2000; Fanger, 1988; Fisk *et al*., 2012)
2. **Thermal Comfort** (Fanger, 1970; De Dear *et al*., 1997; Tanabe *et al*., 2007; Djongyang *et al*., 2010)
3. **Lighting and Daylighting** (Hopkinson, *et al*. 1966; Alrubaih *et al*., 2013; Edwards, L. 2000)
4. **Noise and Acoustics** (Sundstrom *et al*., 1994; Banbury and Berry, 2005; Mui and Wong, 2006)
5. **Office Layout** (Brill *et al*., 1985; Laing *et al*., 1998; CABE, 2005; Haynes, 2009)
6. **Biophilia and Views** (Heerwagen and Orians, 1984; Grinde and Patil, 2009; Heerwagen, 2009; Bright, 2012)
7. **Look and Feel** (Mahnke, 1996; Kwallek *et al*., 1988; Ou *et al*., 2004; World Green Building Council, 2014)
8. **Location and Amenities** (Duffy *et al*., 1992; Gordon-Larsen *et al*., 2009; World Green Building Council, 2014)

This research paper investigates the Global Sustainability Assessment System (GSAS) rating system and its categories to identify criteria focusing the eight physical environmental factors identified above.

The comprehensive GSAS rating system measures and evaluates every project on eight key aspects or categories that have a direct impact on environmental stress mitigation (refer Figure 1). Each category is assigned a weight based on Analytical Hierarchy Process (AHP). The categories are then broken down into specific criteria that measure and define these individual issues. A score is then awarded to each criterion based on the level of compliance.

GSAS indicated that the impacts resulting from limited control and design of the indoor environment include are mainly the following:

- Climate Change
- Fossil Fuel Depletion
- Air Pollution
- Human Comfort and Health

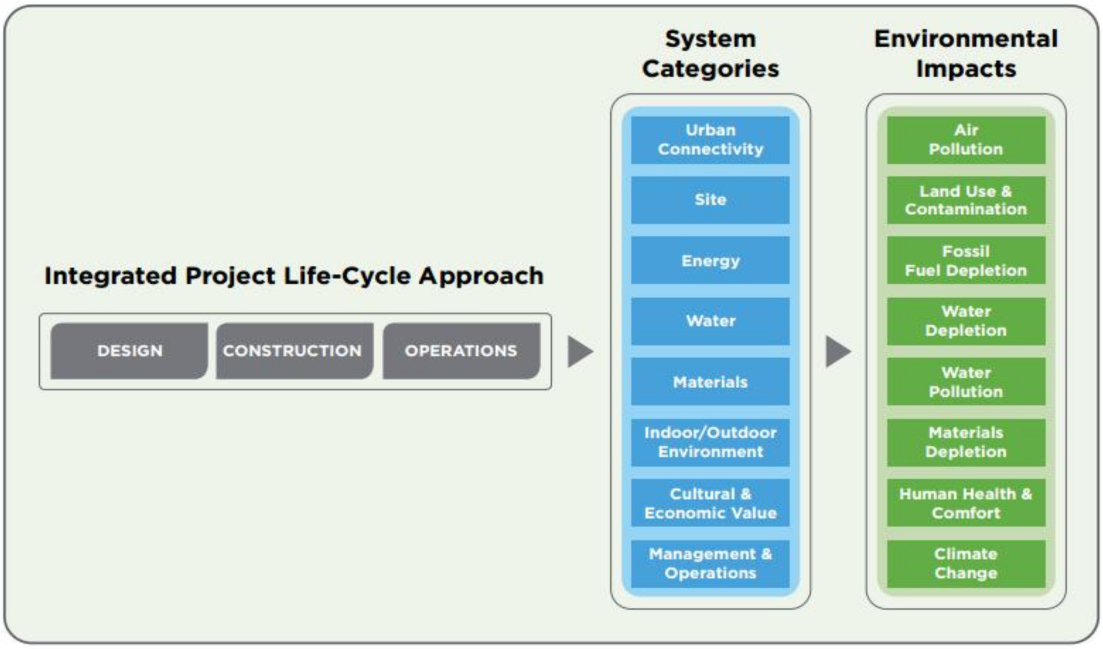

Figure 1: GSAS Categories and Environmental Impacts

The GSAS green building rating system divides its criteria and submittals into eight categories (refer Figure 2). The indoor environment has its category with 16% weightage. However, this document analyses all the categories in GSAS to identify criteria related to the identified eight aspects affecting occupant productivity.

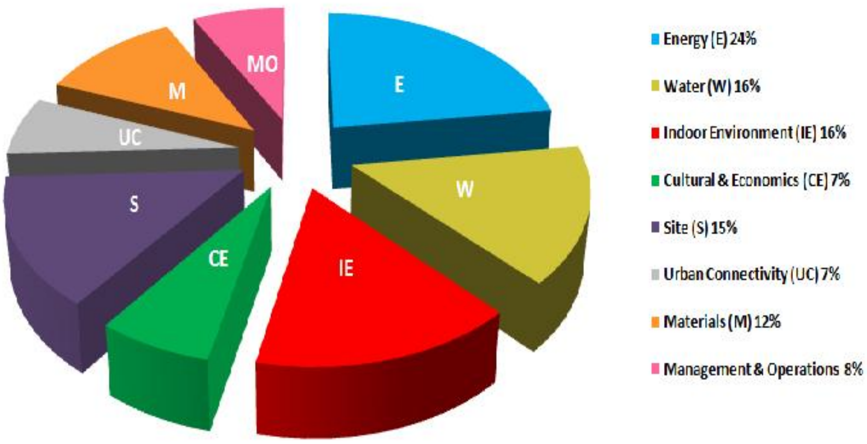

Figure 2: GSAS Categories and Weights V2.0

2. Research Methodology and Process

This study aims to identify the current gap in the GSAS rating system's focus towards employee productivity. The study was conducted by desktop analysis/study. The research process was divided into two steps:

1. The first step was literature review. It was done by looking at journal articles, conference articles and books to establish a firm base for the research findings. The keywords used were: occupant productivity, workplace satisfaction, indoor environment quality, occupant comfort. The authors used the University library's online search engine and Google Scholar, Science Direct and Elsevier for the literature search.

2. The second step of the study was to draw links between eight IEQ factors identified in the literature review and GSAS rating system. The analysis was done using desktop study to identify current gap in the GSAS rating system based on the literature review findings.

The rest of the study is divided into nine sections. First eight sections discuss each identified IEQ factor and GSAS criteria and submittals focusing that IEQ factor. The last section presents the conclusion of the study.

3 INDOOR AIR QUALITY

Indoor air quality is covered by two categories in the GSAS guidelines. In energy category, criterion (E.5) focuses on the nitrogen and sulphur gases in the indoor environment. The criterion defines two submittals with 2.05% weightage of the overall scoring. The indoor environment category has four criteria focusing indoor air quality. These criteria focus on ventilation design (IE.2, IE.3) of the building and indoor air pollutant source (IE9, IE.10) in the buildings. These four criteria have 16 submittals with 7.12% weightage of the overall scoring. Overall indoor air quality has 15 points with 9.17% weightage of the overall scoring.

Table 1: Details of Indoor Air Quality

Category	Criterion	Submittals	Max Score	Weightage
Energy	E.5 - NOx, SOx, and Particulate Matter	Energy Calculator (one for all 5 criteria below)	3	2.05%
		Horizontal work plan area calculations		
Indoor Environment	IE.2 - Natural Ventilation	Natural Ventilation Calculator	3	1.13%
		Occupancy calculations		
		Floor plans highlighting all occupied spaces		
		Elevations highlighting operable parts of windows, or drawings for controlled direct air supply system		
	IE.3 - Mechanical Ventilation	Calculations for fresh outdoor air delivery	3	2.33%
		Equipment Schedule		
		Report showing comparison between Fresh air calculations based on minimum required outside air for each zone as per ASHRAE 62.1-2010 recommendations, and Fresh air as per design		
		Report showing equipment efficiency compared to ASHRAE 90.1-2007		
	IE.9 - Low-Emitting Materials	Low-Emitting Materials Calculator	3	1.83%
		Material Safety Data Sheet listing VOC content for all indoor materials and finishes		
	IE.10 - Indoor Chemical and Pollutant Source Control	Floor plans to demonstrate the locations of contaminant sources in the project	3	1.83%
		Wall sections or other drawings to demonstrate how source of contamination spaces are sealed and isolated		
		Mechanical drawings showing dedicated exhaust system for those spaces		
		Doors specifications illustrating self-closing doors are provided for those spaces		
		HVAC specifications and equipment schedules to demonstrate the scope of filtration systems		
		Floor plans showing permanent entryway system provided at main entrances		

4. THERMAL COMFORT

Thermal comfort is an important aspect of indoor environment quality. GSAS system has one dedicated criterion for thermal comfort in the indoor environment category. The criterion outlines six submittals with 1.57% weight of the total score. Energy category has energy demand performance (E.1) criterion that focuses on the energy efficiency of the building for thermal comfort. This criterion has nine submittals with 7% weightage of the overall scoring. The site category has heat island effect (S.7) criterion focusing on the heat island effect generated by the neighbouring building. Heat island effect also influences the thermal comfort of the occupants. This criterion has six submittals with 0.78% weightage of the overall scoring. Overall, thermal comfort aspect has nine points and 9.35% weightage of the total scoring.

Table 2: Details of Thermal Comfort

Category	Criterion	Submittals	Max Score	Weightage
Indoor Environment	IE.1 Thermal Comfort	System operation specifications	3	1.57%
		Floor plans highlighting spaces under assessment		
		Glazing data sheet		
		HVAC drawings showing nominal air supply for spaces under assessment		
		Equipment Schedule		
		Diffuser data sheet		
Energy	E.1 Energy Demand Performance	Energy Calculator (one for all five criteria below)	3	7%
		Architectural drawings.		
		Relevant MEP drawings.		
		Area, volume and envelope calculations		
		Roof and Walls U-value calculations		
		Glazing data sheet		
		SEER Calculations		
		Lighting calculations for the whole building		
		Fan efficiency calculations or data sheet		
Site	S.7 Heat Island Effect	Heat Island Effect Calculator	3	0.78%
		Site plan including neighbouring buildings within the 200 m radius, illustrating required coordinates and Selector Indicator calculations		
		Landscape plan highlighting different types of site finishes		
		Roof floor plans illustrating coordinates		
		Construction material specifications for building envelope and site finishes		
		Simulation results for irregular shape buildings		

5. LIGHTING AND DAY LIGHTING

Lighting and day lighting is covered by indoor environment category. There are three criteria focusing lighting and day lighting aspect of the indoor environment. These are illumination levels (IE.4), daylight (IE.5) and glare control (IE.6). They have 15 submittals with nine points and 4.57% weightage of the total score.

Table 3: Details of Lighting and Day Lighting

Category	Criterion	Submittals	Max Score	Weightage
Indoor Environment	IE.4 Illumination Levels	Illumination Levels Calculator	3	1.37%
		Electrical drawings highlighting spaces being measured		
		Lighting simulation results for all typical spaces		
		Lighting manufacturer's data sheet		
	IE.5 Daylight	Daylight Input Calculator	3	1.83%
		Daylight Scoring Calculator		
		Daylight Simulation results		
		Drawings identifying measuring point locations		
		Boundary conditions for daylight simulation		
	IE.6 Glare Control	Glare Control Input Calculator	3	1.37%
		Glare Control Scoring Calculator		
		Simulation boundary condition template		
		DGI simulation result		
		Relevant drawings including elevations, plans and site map with surrounding buildings		
		Diagram identifying the measuring point location		

6. NOISE AND ACOUSTICS

Three GSAS categories cover noise and acoustics aspect. Urban connection category has an acoustic condition (UC.6) criterion that highlights submittals focusing urban level acoustic conditions around the site. Noise pollution (S.9) criterion under site category identifies submittals focusing neighbouring noise pollution sources and design mitigation strategies. Acoustic quality (IE.8) criterion under indoor environment category identifies seven submittals focusing noise sources, acoustic quality of material used in the building and acoustic analysis in and around the building. Noise and acoustic factor has nine points and 2.21% weightage of the total score.

Table 4: Details of Noise and Acoustics

Category	Criterion	Submittals	Max Score	Weightage
Urban Connection	UC.6 Acoustic Conditions	Acoustic Condition Calculator	3	0.26%
		Traffic report for each road		
		In case an airport exists in proximity to the site, provide site DNL if current DNL contours are available, or a report		
		Drawings or diagrams showing the distance between the site and any major road or airport		
Site	S.9 Noise Pollution	Noise Pollution Calculator	3	0.58%
		Site plan including neighbouring buildings within the 500 m radius, specifying building types		
		Report for hourly sound pressure level measurements at the 4 test positions on an operational day		
		Plans and elevations for outdoor HVAC equipment location		

		HVAC equipment manufacturer sound data		
Indoor Environment	IE.8 Acoustic Quality	Acoustic Quality Calculator	3	1.37%
		Floor plan and elevation highlighting space under assessment (worst case selection)		
		Site plan showing road under assessment		
		Report for road traffic input data and measurements		
		Building material specifications illustrating absorption coefficients		
		HVAC drawings		
		Noise source sound power levels		

7. OFFICE LAYOUT

There is no criterion focusing office layout in the GSAS commercial building guidelines.

8. BIOPHILIA AND VIEWS

The GSAS system has views (IE.7) criterion under indoor environment category that highlights five submittals focusing outside views from the indoor environment of a building. The criterion has 1.37% weightage of the total score. Biophilia has two elements, the biophilia features outside the building and the features inside the building. GSAS building guidelines system indirectly addresses the biophilia features outside the building in the site category. The habitat preservation (S.3) and vegetation (S.4) criteria outline eight submittals highlighting strategies for preserving local ecosystem and vegetation and landscape design for the site. These criteria have six points with 1.68% weightage of the total score. GSAS system does not recommend any indoor biophilia design strategy. Overall, biophilia and views aspect has nine points with 3.05% weightage of the total score.

Table 5: Biophilia and Views

Category	Criterion	Submittals	Max Score	Weightage
Indoor Environment	IE.7 Views	Views Input Calculator	3	1.37%
		Views Scoring Calculator		
		Floor plans showing all occupied areas, and areas within 7 meters of the perimeter		
		Building elevations highlighting window area		
		Interior partitions specifications, if any		
Site	S.3 Habitat Preservation	Ecologist Site Assessment Report and preservation plan	3	0.65%
		Drawing identifying habitats pre and post-development		
		List of endangered plant and animal species		
		Strategies for preserving ecosystem interaction within the site and adjacent areas		
	S.4 Vegetation	Vegetation Calculator	3	1.03%
		Landscape plan highlighting total landscape area		
		Landscape plan highlighting lawn area		
		Landscape material data sheet		

9. LOCATION AND AMENITIES

Location and amenities aspect is partially covered in the GSAS building guidelines system. Urban connection category has three criteria that focus on the location and transportation aspect of the building site. Proximity to infrastructure (UC.1), public transportation (UC.3) and private transport criteria (UC.4) outline nine submittals highlighting the transportation options and facilities for the building occupants. The research indicates that amenities can help increase occupant productivity and recommends employers to provide few amenities on site or around the site. Proximities to amenities (UC.7) only focus on locating nearby amenities. It does not provide extra points for incorporating amenities in the design of the commercial buildings. It would be helpful to introduce a criterion or submittal that encourages employers/owners to include amenities like gym, childcare inside or near the site in case these facilities are not available. Location and amenities aspect has 12 points with 3.43% weightage of the total score.

Table 6: Details Location and Amentities

Category	Criterion	Submittals	Max Score	Weightage
Urban Connection	UC.1 Proximity to Infrastructure	Proximity to Infrastructure Calculator	3	1.22%
		Site map showing all available connection for existing infrastructure		
	UC.3 Public Transportation	Public Transportation Calculator	3	1.15%
		Authorized public transportation site plan, showing bus/rail stops within 240, 320, 400 and 480m from site		
		Transportation plan for shuttle services, connecting occupants to public transportation if provided		
	UC.4 Private Transportation	Private Transportation Calculator	3	0.38%
		Building floor plans highlighting all provided facilities		
		Transportation plan for shuttle services or alternative, if provided		
		Occupancy calculations		
	UC.7 Proximity to Amenities	Proximity to Amenities Calculator	3	0.68%
		Sitemap, using interactive map such as Google maps, showing locations and types of amenities within 480, 720, and 960 m from the site		

10. LOOK AND FEEL

Look and feel aspect of the indoor environment is indirectly covered in the heritage and cultural identity (CE.1) criterion in the cultural and economic value category in the GSAS system. The criterion defines a submittal to outline design strategies to incorporate design features that address the heritage and cultural identity of Qatar. The criterion addresses the Qatar's cultural identity in design. However, it does not recommend any strategy to incorporate potential occupant's perspectives and opinion about interior design's look and feel. The look and feel aspect has three points and 3.12% weightage of the total score.

Table 7: Look and Feel

Category	Criterion	Submittals	Max Score	Weightage
Cultural and Economic value	CE.1 Heritage and Cultural Identity	Concept brief outlining design strategies that meet the criteria along with supporting design drawings or renderings	3	3.12%

11. CONCLUSION

This research study has analysed the current GSAS green building rating system and its categories along with various indoor environment quality factors that affect occupant productivity. The study establishes the implicit links between eight indoor environment quality factors and GSAS building rating system. Indoor air quality and thermal comfort have the highest weightage allotment among the eight IEQ factors. Indoor environment quality and thermal comfort have high impact on occupant comfort and productivity and they are well addressed in the GSAS. The medium impact IEQ factors like lighting and day lighting, noise and acoustics, and Biophilia and view have been taken into account carefully as well. However, the study indicates that office layout and location and amenities can be addressed more appropriately. GSAS can include criteria on office design to reduce disruption and distraction caused due to inefficient office layout in the office buildings. Overall, the analysis presents that GSAS guidelines have 34.90% weightage towards both indoor and outdoor environment aspects that influence occupant productivity. GSAS rating system has a well-balanced approach towards occupant comfort and productivity. The study findings would help architects, engineer designing building under GSAS to also include office layout strategies to increase occupant productivity in their buildings. This study can also be used a model study to investigate other international green building rating system and their focus on occupant comfort and productivity.

Table 8: Details of Analysis

IEQ Aspect	Category	Criteria	Submittals	Total score	Weightage
Indoor Air Quality	2	5	15	15	9.17%
Thermal Comfort	3	3	21	9	9.35%
Lighting and Day Lighting	1	3	15	9	4.57%
Noise and Acoustics	3	3	16	9	2.21%
Office Layout	Nil	Nil	Nil	Nil	Nil
Biophilia and Views	2	3	13	9	3.05%
Location and Amenities	1	4	11	12	3.43%
Look and Feel	1	1	1	3	3.12%
Total			92	66	34.90%

12. ACKNOWLEDGEMENT

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OPTIMISATION OF PROJECT PERFORMANCE IN POST-DISASTER BUILDING RECONSTRUCTION PROJECTS IN SRI LANKA

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ABSTRACT

Natural catastrophes occur frequently around the world and cause severe undesirable impacts on human lives and properties of the communities. The restoration of a human life style after such massive event, consume some significant time and cost, comparatively to the conventional day-to-day constructions. Recovery and rehabilitation of the affected nature have to be completed at extreme cost and within strict time limitations, in order to achieve the project goals up to highest possible level of satisfaction. Whereas, numerous issues and challenges, affecting the reconstruction projects, leading to failures and inefficient outcomes at the project completion stage. Time, cost and quality parameters will always be the highlighted aspects in the process of determination of project performance level in reconstruction projects. Thus, the lack of strategies to enhance the degree of performance status, is addressed as the research gap of the study.

Case study was selected as the most appropriate approach for the study. Six interviews were conducted among Project Engineers and Managers and Client's Representatives. Further, document reviews also conducted in the case study. Consequently, code-based content analysis was used to capture the substantial factors as well as the probable elements that can be implemented to optimise project performance in post-disaster reconstruction projects in Sri Lanka. Thus, conclusions are drawn and recommendations are suggested.

The outcomes of the analysis were able to identify critical issues of post-disaster reconstruction projects in Sri Lanka, and probable attributes which can be implemented for a proper trade-off in time, cost and quality perspectives. The findings would be much effective for developing strategies to implement to achieve the best performance level in reconstruction projects.

Keywords: *Cost Performance; Post-disaster Reconstruction; Project Performance Optimisation; Quality Performance; Time Performance.*

1. INTRODUCTION

Catastrophes, both natural and human-caused, have been arising with aggregate frequency and influence in recent decades in many countries around the world (Schilderman, 2004). Societies are necessary to be equipped for natural and human-made disasters because they can strike anywhere, regardless of location, culture or history.

Moreover, Moe and Pathranarakul (2006) explained that, disasters cause a significant influence to the entire world. Further, authors have clearly highlighted that, the occurrences of natural disasters have increased sharply worldwide causing loss, disruption and damage to lives, built and social assets, and economy. Natural hazards endure to cause thousands of deaths and billions of dollars economic loses each year around the world.

According to Pathiraja and Tombesi (2009), disasters can affect the community through physical losses and economic losses and to overcome those losses post-disaster reconstructions are performed. Whereas,

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post-disaster reconstruction (PDR) and rehabilitation is a complex issue with several dimensions and those projects often deals with uncertainties. Meanwhile post-disaster reconstruction can be considered as a process with potential for creating a resilient built environment or for generating further vulnerabilities to the disaster affected communities and it is part of a sequence of three identifiable post disaster periods: emergency, restoration and reconstruction (Chang *et al.*, 2012). Therefore, the success of post-disaster reconstruction is a matter of delivering and constructing houses and towns, and how much it reaches the project goals.

However, the critical consideration in post-disaster reconstruction is that how a country's construction industry is able to engross and put to efficient rebuilding by using all the aids and resources available. Relief, recovery, rehabilitation and reconstruction are the main activities in rebuilding the affected nation where the government and non-government organizations are the major stakeholders (Freeman, 2007). Therefore, the challenge of recovering from natural disasters will create an unpredicted future with the burning necessity of effective post disaster responses strategies. Hence, post disaster reconstruction situation can be seen as one of new opportunities for reconciliation, investment and growth, sustainable resource utilization, human capital formation, employment generation and human development (Pathiraja and Tombesi, 2009).

Nowadays, it has been discovered that there are numerical challenges and barriers in post disaster reconstruction projects (Ahmed, 2011). There the time, cost and quality constraints have become major challenges that are difficult to overcome (Baroudi and Rapp, 2010). Hence, disaster reconstruction is all about certifying the properties are reassembled and it requires a substantial sum of funding for an adequate accomplishment. Another concern that can be identified is lack of time, since post disaster re-establishment work have to be done within a limited time period as the restorations are the "basics" of the affected communities. Furthermore, it is clear that inadequacy of qualified people may affect the reconstruction process duration and quality of the work done (Chang *et al.*, 2011).

Meanwhile optimisation is finding an alternative with the most cost effective or maximum feasible performance under given limitations, by making the best use of desired factors and minimizing undesired ones (Huimin and Peng, 2013). Furthermore, optimisation means trying to attain the highest or maximum result or outcome without regard to cost or expense (Alex, 1999). Therefore, optimizing project performance in post-disaster reconstructions is significant as those are facing many challenges as well as resources restrictions.

On the other hand, post-disaster reconstruction performance measurement is defined as the process of evaluating performance relative to a defined goal in post-disaster management and it provides a sense of where the reconstruction process lies and more importantly, where it happens (Khosrowshahi, 1997). Khosrowshahi (1997) further stated that, performance measurement can guide steady advancement towards established goals and identify shortfalls or stagnation and the significance of measuring performance.

Moreover, it is a widely accepted view that, performance measures of a project are based on time, cost and quality. Hence, Atkinson (1999) noted that these three components of project performance as the 'iron triangle'. As a result of frequent challenges faced in post-disaster reconstruction projects in Sri Lanka, the performance level of constructions is at a lower level (Pathiraja and Tombesi, 2009). The current situation in Sri Lankan post-disaster reconstruction projects is more severe due to numerous challenges faced by the industry. The construction industry in Sri Lanka is developing in order to manage post-disaster reconstruction work especially through the experiences of enormous destruction in Tsunami disaster in 2004. Although, government and non-government organisations contribute for post disaster due to the unavailability of standard performance measures, the direction of post disaster reconstruction projects, performance optimisation have been a significant challenge.

Further, lack of research has been conducted in order to address the gap of finding the way of optimising projects performance in post-disaster reconstruction projects in Sri Lanka. Therefore this research is focused to fill the research gap through developing a framework to optimize projects performance in post-disaster reconstructions. The scope of the research is limited to post-disaster building reconstruction projects and those projects were done due to natural disasters occurred such as landslides, tsunami etc.

Consequently, the research question is "how to optimize project performance in post-disaster reconstruction projects in Sri Lanka?"

2. LITERATURE REVIEW

2.1. DISASTER RECOVERY AND POST-DISASTER RECONSTRUCTION

Generally, disasters are known for its vast impacts on human lives, economy and environment (Moe and Pathranarakul, 2006). Disasters lead to terminate the developmental projects since the fund allocations should be transferred to the new outcomes for relief, reaction and rehabilitation work other than interrupting the usual life of affected groups. Post-disaster recovery and reconstruction is identified as developing a set of strategies to support a community in rebuilding after a disaster occurs (Newport and Jawahar, 2003). Recovery planning can also be thought of as building the outline for reconstruction of the community after a disaster. There are a number of activities that communities can engage in to address post-disaster recovery.

The most common goal in disaster recovery process is to restore buildings, infrastructure, business and activities of the government to the ordinary pattern that existed (Newport and Jawahar, 2003). Hence, post-disaster reconstruction can be indicated as a process of creating a resistant built environment for generating future vulnerabilities, to the disaster affected communities. It is a process of developing new buildings or refurbish the damaged constructions in order to replace the affected ones.

Major stages of post-disaster reconstruction projects can be identified as 'definition, design and implementation' (Attalla *et al.*, 2004). Yet, these projects always deal with uncertainties, complication and challenges as it has been done within the disaster-affected areas in most of the times. Therefore, PDR is a part of a long-period process including emergency, re-establishment, reconstruction and betterment construction.

2.2. TIME, COST AND QUALITY PERFORMANCE

Atkinson (1999) identified the three criteria of time, cost and quality as 'iron triangle'. The author further proposed that when other definitions of project management are developed, the 'iron triangle' is always used as time, cost and quality. The Iron Triangle was initially considered as a framework to empower project managers to assess and balance the challenging demands of time, cost and quality of the projects (Torbica and Stroh, 2001). According to Stojcetovic *et al.* (2014) this triangle was named as 'Iron triangle' because, the margins can reduce or extend, whereas the structure is unbreakable. Changes can be done in to one aspect; however other two also should be balanced and adjusted accordingly.

Cho *et al.* (2009) have defined that project performance management reviewing the efficiency of the project by analysing the practices and procedures. The duration, cost and the quality are the basic criteria of high project performance level, which is identified and discussed by each and every academic and experts. In addition to those basic criteria, Cooke-Davis (2002) has identified that project psychosocial consequences that refer to the fulfillment of interactions and relationships with project team is also a cause to project success.

"Time" denotes the duration of the project from the inception to completion of the project. It is programmed to facilitate the building to be occupied by a date specified by client in accordance with his future plans. Time management is very critical and the project cost is highly depended on the estimated time duration (Kim and Garza, 2005). When the duration of a project is compacted it is essential to increase labour and more productive tools which increase the cost.

"Cost" is another significant aspect that determines the project performance (Cooke-Davies, 2002). Cost can be defined as the expenses incurred for labour, material, plant, financing, services etc. including the overheads and profit. It is very difficult for an organization to keep increasing the quality of projects and seeking to reduce their costs as the cost and the quality are inter-related aspects.

"Quality" is another principle that is highlighted by academics and researchers. However, assessing quality is relatively subjective. Stojcetovic *et al*. (2014) have defined that quality as the degree to which a set of essential characteristics satisfy the requirements of client or stakeholders.

Trade-off is necessary among the three targets of cost, time and quality in a construction project. The requirement of a project is to complete it within the specified time period, adhering to the budget and reaching the quality standards which are identified in the specifications.

2.3. ISSUES AND CHALLENGES THAT AFFECT PROJECT PERFORMANCE IN PDR PROJECTS

Various experts and researchers have been involved in defining cross cutting challenges that are faced by different post-disaster reconstruction stakeholders. Ismail *et al*. (2014), have identified delay, resourcing etc. as the major challenges. Further Comerio (1997) and Shaw (2006) have identified that, reconstruction financing and environmental sustainability are some other issues in post-disaster reconstruction projects.

1. Delay
2. Resource Challenging
3. Financing Issues
4. Lack of Coordination
5. Unstable Policies
6. Quality of Work
7. Cost Overruns
8. Shortage of Technical Staff
9. Inflation of Prices
10. Weak Regulation and Control
11. Unpredictable Weather Conditions
12. Risk and Uncertainty
13. Lack of Proper Training
14. Lack of Project Management Experiences
15. Non-Performance of Subcontractors
16. Design Changes
17. Contract Interpretation Disagreements
18. Conflicts between Parties

2.4. PROJECT PERFORMANCE OPTIMISATION IN POST-DISASTER RECONSTRUCTION PROJECTS

'Optimisation' is defined by Khosrowshahi (1997) as finding a substitute which reaches the performance to the maximum level with most cost effective within the given limitations, by making the best use of preferred aspects and minimizing undesired aspects. Maximization means trying to achieve the utmost or highest consequence despite of concerning cost or expenses whereas optimisation is restricted by limitations of time and cost.

Due to various limitations, the level of project performance in PDR projects is at a very low level (Baroudi and Rapp, 2010). According to Yi and Yang (2014), the methods of financing the reconstruction projects is a critical factor as there will be a strong pressure due to limited funds. Barenstein and Pittet cited in Thanurjan and Seneviratne (2009) identified that post-disaster reconstruction projects are one of the least effective sectors in the implementation stage.

Optimising the project performance is a concept of not merely increasing the level of performance, but providing splendid standards in all aspects of project performance. In simple terms performance is reaching project goals successfully and keeps the client's satisfaction to the maximum level in time, cost and quality aspects (Nkado and Meyer, 2001). The level of performance is highly depended on the activities of each stakeholder, resource allocation, construction management etc.

2.5. CURRENT STATUS OF PROJECT PERFORMANCE OF PDR PROJECTS IN SRI LANKA

Empirical evidence revealed that the Sri Lankan cities face number of challenges in achieving a disaster resilient built environment. Some of the challenges identified are, lack of regulatory frameworks to regulate disaster resilient development, such as resilient building codes, planning regulations and risk maps; unplanned cities and urbanisation; old building stocks and at risk infrastructure; unauthorised structures; institutional arrangements; inadequate capacities of municipal councils; lack of funding; inadequacy of qualified human resources; and corruption and unlawful activities. Sri Lanka encountered a big challenge in reconstruction, as it had not earlier faced a disaster of the level of tsunami (Karunasena and Rameezdeen, 2010).

Post-disaster housing reconstruction is considered by many experts as one of the least successful sectors in terms of implementation (Barenstein and Pittet, 2007). Further, lack of effective information and knowledge dissemination can be identified as one of the major reasons behind the unsatisfactory performance levels of current disaster management practices (Haigh and Sutton, 2012). According to Banerjee cited in Haigh and Sutton (2012), lack of prior knowledge and proper point of reference have made most of the recovery plans guessing games, eventually failing without adding appropriate values to the recovery attempts.

3. RESEARCH METHODOLOGY

A research design is the logical sequence that connects the empirical data to a study, initial research questions and, ultimately to its conclusions (Yin, 2013). A research design is not just the work plan where a thing more than that with the purpose is to avoid the situation in which the evidence does not address the initial research questions.

Case study approach included two phases design called exploratory design where by collecting and analysing qualitative data at first and based on that collection and analysis of quantitative data is done to test or generalize the initial qualitative findings. Since this study was aimed to investigate the strategies used to optimise the projects performance in post-disaster reconstruction projects, multiple case study design was selected to obtain the realistic data and final conclusions.

Since this research depends on experts' knowledge and numerical data so as to carry out an effective data collection within the available time, and budget several limitations were undergone. Number of post-disaster reconstruction projects is limited and finding stakeholders who involved in them were hard to discover. In qualitative approach, interviews are most commonly used data collection technique. To collect the data on overall project performance, the critical factors identified were used in interviews. In order to cater for emerging questions in the interview, semi structured interviews were selected. Yin (2013) explained that, in-depth interviews were conducted to gather essential details from the experts while clarifying the doubts, asking further questions. Interviews were carried out with qualified and experienced representative such as Project Engineers, Project Manager and client's representatives.

Content analysis involved codifying qualitative information in to pre-defined categories while gathering data, to obtain patterns in the presentation and reporting of information. Yet, it is an analytic approach which undertakes similar cognitions in a same concept in a systematic and replicable manner. Therefore, as the qualitative data analysis software available, NVIVO (version 10) was used, manufactured by Qualitative Solutions and Research (QSR) International (Pvt) Ltd. for content analysis which enclosed graphical presentation of interpreting relationships.

4. RESEARCH FINDINGS AND DISCUSSION

As the initial step, in finding the strategies to optimise project performance in PDR projects, the interviewees were asked about the critical factors that affect the cost performance of post-disaster reconstruction projects. After that probable ways to optimise the performance level were identified through the semi-structured interviews. Figure 1 shows the critical factors affecting cost performance.

Nodes

Name	Sources	References
Critical factors affecting Cost performance	6	39
Changes in the scope of the project	2	5
Design Changes occured in construction stage	3	6
Inadequate experiences of the contractor	1	1
Incorrect planning and scheduling by contractors	3	5
Issues in material procurement	1	1
Poor site management	2	2
Price escalation	4	8
Shortage of workers	1	1
Underestimation	2	4
Unforeseen Ground conditions	2	6

Figure 1: Critical Factors Affecting Cost Performance in PDR Projects in Sri Lanka

As the next step in finding the methods to optimise project performance level, the respondents were questioned about the critical factors that affect the time performance of post-disaster reconstruction projects, with their involvement in these projects. Thus, it was identified that what kind of components have an influence on time performance.

Nodes

Name	Sources	References
Critical factors affecting Time performance	6	29
Average delay in regular payments	2	4
Delays due to no chain of command	1	1
Delays occured due to site preparation	1	1
Delays occured in fund allocation	2	2
Delays occured in site selection	2	2
Faults in the design	1	2
Insufficient site supervision	1	1
Insufficient skilled labour force	1	1
Low speed in decision making	1	1
Material Shortage	2	2
Unavailability of resources	3	4
Unforeseeable weather conditions	2	3
Variations occured during the construction period	3	5

Figure 2: Critical Factors Affecting Time Performance in PDR Projects

The interviewees were asked about the critical factors, which affect quality performance of the post-disaster reconstruction projects in Sri Lanka in accordance with experiences gained in the industry. Thus, some aspects were identified through the data collection as factors which are having a negative impact on the quality performance.

Nodes

Name	Sources	References
Critical factors affecting Quality performance	6	76
Changes in specification during the construction	4	8
Lack of quality assurance systems	5	12
Limited fund allocation	4	13
Design changes	3	11
Using low quality materials	1	3
Design errors	3	6
Less coordination of the construction team	2	7
Searching for ideal solutions instead of practical solutions	2	5
Insufficient experiences of the contractor	2	5
Insufficient qualified work force	2	6

Figure 3: Critical Factors Affecting Quality Performance in PDR Projects

All the respondents highlighted the issues that affect the project performance in PDR projects as critical factors that highly affecting time, cost and quality factors. As the next step, the interviewees were asked to expose the suggestions and probable attributes in order to optimise the project performance level.

- A broadly defined project team organisation structure (hierarchy) with a clear outline of duties, responsibilities, authority, and communication channels etc. For each and every individual of the project team.
- Preparation of comprehensive financial management plan and strict implementation ensure the availability of funds, before commencing the project or sections of the project.
- Preparation of comprehensive site organisation plan, optimizing the efficient usage of site space.
- Recruitment and appointment of competent professionals for the project team by analysing their level of knowledge, experience, skills and attitudes.
- Proper consultation on project definitions and requirements in order to minimize design errors and variation.
- Sequential development of the design with relevant professionals, in order to minimize design errors
- Strict evaluation on the capacity, performance and qualifications of the Contractor before awarding the Contract
- Establishment of firm site security and supervision structure.
- Comprehensive project time line or plan development with identification of resource requirements in each stage, in order to minimize lack of resources on time.
- Consideration of weather patterns as much as possible in planning stage and allow sufficient buffer time period for such unforeseen conditions
- Liaison between the parties regarding the project requirements in the designing stage in order to minimize design changes and emphasize on the importance of not changing the design thereafter and consequences, if it had to be changed.
- Incorporation of quality control procedure within Contractor and client as well.
- Introduction of severe penalties and damages for deliberate poor quality work.
- Increased defect liability period and high quality supervision procedure.
- Introduction of strict specification and standards for the construction materials and construction methods, in order to eliminate poor quality materials and workmanship
- Development of comprehensive cost plan for the work items and establishment of cost control procedure and cost analysis methods to avoid unnecessary cost overruns and wastage.

- Reduce time incurred to follow up office procedures and enhance the performance of government organisations

This research attends to determine probable attributes and suggestions that can be integrated into project performance optimisation of post-disaster reconstruction projects. Accordingly, there were several attributes highlighted in the interviews which would be better to suggest for time, cost and quality improvements.

5. CONCLUSIONS

Undertaking reconstruction projects after a major disaster can be identified as challenging task in Sri Lankan context. Furthermore, the importance of managing all stakeholders involved in the project for effective and efficient recovery of an affected community. It is emphasized and highlighted the significance of reconstruction planning as well as the accurate ways of executing the activities in the construction project. The research indicates the importance of reconstruction process referring to high-cost and long-term commitments required. The complexity of post disaster reconstruction, in related to various dimensions as risks and uncertainty lead the whole project in to unsuccessful.

The numerous critical factors affecting the time, cost and quality performance levels were identified in the research through expert interviews. Those aspects are within six main subsections such as, issues occurred in the planning stage, issues in related authorities and professional bodies, unforeseeable conditions, issues in the site, issues due to economic instability and issues of the contractor and suppliers. Ultimately, the probable project ways of enhancing and optimising the degree of time, cost and quality perspectives in post-disaster reconstruction projects in Sri Lanka were identified through the research.

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POTENTIAL TO IMPLEMENT BIM PROJECT WITH SRI LANKAN PROFESSIONALS

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ABSTRACT

Building Information Modelling (BIM) was found by construction industry, to increase the productivity of construction, while other industries gain more productivity by automating the processes and using software. BIM opened a new era to the construction industry, in which stakeholders in the industry deals with concepts in three dimensional virtual environments, leaving behind the time which used two dimensional concepts on papers. Even though other countries are gaining the benefit of BIM, Sri Lanka is still in the infant stage when it comes to BIM. If BIM is to be used for a construction project in Sri Lanka, a major barrier would be finding suitable persons as the participants to the project team. Therefore, this research is aimed to identify the best BIM team in Sri Lanka, for successful completion of a project using BIM.

With the aim of identifying the best BIM team in Sri Lanka, first a literature review was conducted to identify the tasks to be carried out in a BIM project. Having identified the tasks to be performed such as advising the client on purpose of using BIM, the required skills to perform each task were also identified. Thereafter, the conventional design team in the current construction industry in Sri Lanka was identified, and tasks to be performed by the BIM team were mapped to the conventional design team, to create hypothetical ideal BIM team.

Thereafter the hypothetical BIM team was analysed through a qualitative research approach to formulate the ideal BIM team.

Keywords: *Building Information Modelling; Construction Industry; Professional Team; Sri Lanka.*

1. INTRODUCTION

Building Information Modelling which is often represented by the acronym BIM is used, as a tool, a technology and a process, in architecture, engineering and construction (AEC) industry in many countries, for producing better products in AEC industry. When it comes to Sri Lankan AEC industry, the number of AEC projects completed utilizing BIM in any means, is zero. Therefore, Sri Lanka, not only the AEC professionals but also government, employers and facility managers, should be acknowledged about the advantages that are gained by other countries in using BIM, what are that advantages Sri Lanka could have, and how to implement BIM for Sri Lanka AEC projects. In that context, many literatures have been produced in Sri Lanka, regarding technological and cost aspects of implementing BIM is Sri Lanka, but only a few writings have been done in Sri Lanka, about the people who work in BIM. That is why, this research is focused on the people who work with BIM, more precisely the skills needed for professionals to work with BIM.

A huge advancement in terms of productivity has been gained by the industries like health, manufacturing, distribution, and finance, through automated processes, tools, and software, over the last 30 years, but not in the AEC industry (Reddy, 2012). One such advancement happened in AEC industry is Building Information Modelling (BIM) (Eastman, Teicholz, Sacks and Liston, 2011). Now BIM has become a tool which is used not only for designing and documenting a project, but also as a means of a facilitator to boost the communication between the parties in a project (Krygiel and Nies, 2008).

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1.1. AIM AND OBJECTIVES

The aim of the study was to identify the best BIM team for successful completion of a project in Sri Lanka. The followings were the objectives which should be fulfilled, in order to reach the above aim,

- identify the process of a BIM project
- identify the tasks and responsibilities of the members in the BIM team
- determine the required skills to perform the task and fulfil the responsibilities
- check the required skills with the capabilities of the professionals in the AEC industry of Sri Lanka
- map the positions in a BIM team with the professionals in the AEC industry of Sri Lanka

2. HOW BIM IS USED?

Building Information Modelling (BIM) has been described in many different ways in many different places. BIM is the evolution which made it possible to trade in three dimensional and virtualized buildings which contain a vast amount of knowledge, leaving the age behind, in which professionals traded with owners, consultants and constructors, using two dimensional concepts and ideas on papers (Hardin, 2009).

BIM is described as a tool, a platform, and an environment. If it is described as a tool, BIM will be a task-specific software tool which is built to generate and manage building data, throughout its total lifetime, that is, starting from conceptual design stage to operation and end of life (Deutsch, 2011). And also software systems that include BIM design applications and other relevant application that use BIM data are called as BIM systems. Sometimes the systems may be connected over a local area network (LAN) or the internet (Eastman *et al*., 2011).

For the purpose of this research, BIM is defined as the total process consists of BIM tools, BIM platforms and BIM environments, which are utilized to deliver a construction project. The process that uses the information created by BIM for planning, scheduling, analysis, cost estimating and other uses is called as the BIM process (Eastman *et al*., 2011). A digital database that includes all the information of objects of a particular building is defined as a BIM model or a BIM data model. It may include, and shall not be limited to, information such as its geometry, its planning, its construction and operations (Eastman *et al*., 2011).

2.1. UTILIZING BIM IN CONSTRUCTION

In the construction industry, BIM has the power, to generate models, to produce drawings, to produce specifications, to prepare cost estimations, to do clash detection and error detection, to perform energy analysis, render models, to prepare schedules, and to visualize models (Eastman *et al*., 2011). In BIM to make the work success, it is important to get information from all the parties involved in the project, so an integrated and combined approach is necessary (Mallik and Irving, 2012).

With the evolvement of BIM, construction industry works towards becoming automated, which force the professionals to adopt sophisticated services incorporated 3D, 4D, 5D, 6D and xD (Smith, 2014). The basic level of BIM is 3D BIM, in which 3D virtual model is taken as the sole source of information about the building. All the specification details and dimension details are included in the 3D model (Czmoch and Pekala, 2014). In BIM, 4D modelling is used for project time allocation that means for project scheduling and construction sequence scheduling (Ding, Zhou, and Akinci, 2014). 5D BIM modelling is also utilized for projects. 5D BIM gives cost aspects regarding the project. 6D BIM is for sustainability and 7D BIM is for operations (Deutsch, 2011). All of these tools can be used for BIM projects.

2.2. *WHAT IS TO BE DONE IN BIM?*

BIM is said as a process and software, identifying it as just software is wrong (Hardin, 2009). In that process, various tasks to be done in throughout the total project life time (Deutsch, 2011). For a construction project to be designed and managed successfully using BIM, activities needed in each stage should be fulfilled (RIBA, 2012)

BIM overlay to the RIBA Plan of Work 2013 is shown in the Table 1.

Table 1: BIM Overlay to the RIBA Plan of Work 2013

RIBA Work Stage	Core BIM Activities
0 Strategic Definition	▪ NA
1 Preparation and Brief	▪ Client is advised on purpose of using BIM, addressing the benefits of BIM ▪ Level of BIM usage (4D-Time, 5D-Cost, 6D-FM) is agreed and defined ▪ Long term responsibilities, including model ownership, are defined ▪ Inputs and outputs to BIM are defined ▪ Scope of BIM surveys and investigation reports are identified ▪ Data drop 1 is performed
2 Concept Design	▪ Pre-start meeting for BIM is held ▪ For strategic analysis and options appraisal, the initial model is shared among the members if the design team ▪ Environmental performance and area analysis is done using BIM data ▪ Main model elements such as prefabricated components are identified ▪ For all major elements, concept level parametric objects are created ▪ Access to BIM data is granted to the design team ▪ The extend of Performance specified work is agreed ▪ Data drop 2 is performed
3 Developed Design	▪ To perform design co-ordination and detailed analysis, data sharing and integration is facilitated. Data links between models are also enabled ▪ Generic design components and bespoke design components are integrated and/or developed ▪ Using BIM data, environmental performance and area analysis id done ▪ For design co-ordination and technical analysis, data sharing is facilitated and also specification data is added ▪ BIM model data is exported in to planning application to prepare schedules ▪ 4D and 5D BIM are assessed if required ▪ Data drop 3 is performed
4 Technical Design	▪ To perform building control analysis data is exported from BIM ▪ To conclude design co-ordination and to perform detailed analysis with subcontractors, data sharing is facilitated ▪ Detailed modelling, integration and analysis ▪ Clash detection is performed ▪ For all the major elements of the model, production level parametric objects are created ▪ Specification details are embedded in to the model ▪ Final review of the model is performed and the parties sign off from the model ▪ Access to the BIM model is given to the contractor(s) ▪ Model information of sub-contractor performance specified work is integrated into the BIM model data ▪ Construction sequence of the project, which is incorporated to 4D BIM, is reviewed with the contractor ▪ Data drop 4 is performed

5 **Construction**	▪ Clash detection is performed ▪ For Soft landings, the timing of happening and the scope to be covered is agreed ▪ BIM record model data for 'End of construction' is released with co-ordination of other parties ▪ Construction administration is done using 4D and 5D BIM data ▪ Data drop 5 is performed
6 **Handover and Close out**	▪ When an asset change is made, BIM model data for FM is issued ▪ Parametric object information that is contained within the BIM model data is studied ▪ Data drop 6 is performed
7 **In Use**	▪ NA

Considering the current practise of professionals in the conventional system, a hypothesis was built to make the analysis easy. Data collection was carried out based on the hypothesis.

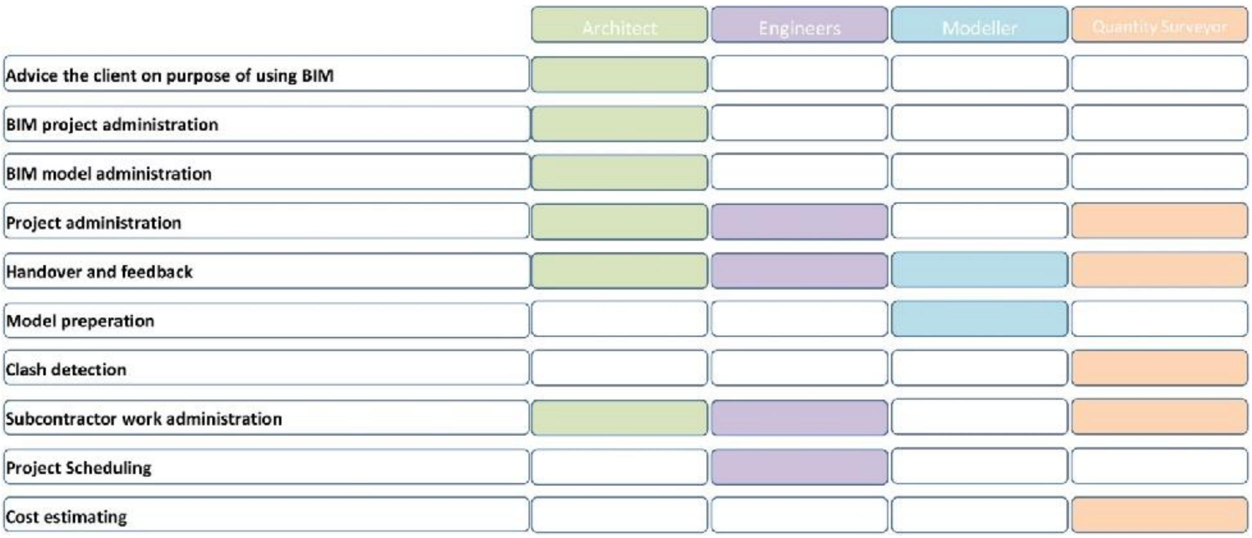

Figure 1: Hypotheses of BIM Team

3. RESEARCH METHODOLOGY

For the research, mainly there were two research approaches that could be adopted; quantitative and qualitative (Creswell, 1994).The suitable approach to address this hypothesis was a qualitative approach. Since in the Sri Lankan construction industry nothing related to BIM is practised, (Rogers, Chong, Preece, Lim, and Jayasena, 2015) it was difficult to get quantitative data to test the hypothesis.

Commonly used research designs for qualitative research are case study, oral history, interviews, and observation (Kumar, 2011). As it was observed in the literature review, many work related to BIM had been done based on case studies. However, for this research, it was impossible to do a case study due to the unavailability of cases, which utilized BIM. As a result of the nature of the research; which is about a very new aspect to Sri Lanka, oral history method is not practical.

In the data collection, the skills in the professionals in the Sri Lankan construction industry were collected, through structured interviews. The next step of the research was to analyse the collected data. Describing the data analysis under the research methodology is a bit problematic for a qualitative research than for a quantitative research (Rudestam and Newton, 2007). The data collected in qualitative research is huge. There are techniques used in qualitative researches to reduce the amount of data to be presented and analysed. Using methods such as coding, and data matrix, the amount of data to be presented and analysed, was reduced. For coding QSR NVivo 11 Starter software was used.

4. RESEARCH FINDINGS AND ANALYSIS

For data collection, eleven (11) respondents with various backgrounds were selected. While selecting respondents their ability to provide opinion based on their experience and the ability to provide sufficient information to conduct the analysis were the major concerns.

4.1. THE ARCHITECT

The architect who is selected for the BIM team will have to do the following tasks; advising the client on purpose of using BIM, BIM model administration, project administration, subcontractor work administration and handover and feedback. In the hypothesis built up, BIM project administration was under the architect's work scope, however based on the analysis of data collected, that task was included under the engineer's work scope. There are two alternatives for the selection of an architect as shown in Table 2.

Table 2: Selection of Recommended Architect

Recommended Architect	T1	T3
An architect with prior experience as a lead architect in similar kind of projects	✓	✓
An architect with prior experience as project architect for more than five years	×	✓

When both the requirements are considered, an architect with prior experience as a lead architect in similar kind of projects is the most suitable person. The selected architect should have the required BIM based skills related to his tasks.

4.2. THE ENGINEER

The engineer who is selected for the BIM team will have to do the following tasks; project scheduling, BIM project administration, subcontractor work administration, project administration and hand over and feedback. In the hypothesis built up, BIM project administration (T2) was under the architect's work scope, however based on the analysis of data collected, that task was included under the engineer's work scope. There are three alternatives for the selection of an engineer as shown in Table 3.

Table 3: Selection of Recommended Engineer

Recommended Engineer	T9	T2
An engineer with prior experience as project manager	✓	✓
An engineer with prior experience as planning engineer	✓	×
An engineer with prior experience in similar kind of projects for more than ten years	✓	×

When all the requirements are considered, an engineer with prior experience as project manager is the most suitable person. The selected engineer should have the required BIM based skills related to his tasks.

4.3. THE QUANTITY SURVEYOR

The QS who is selected for the BIM team will have to do the following tasks; cost estimating, clash detection, subcontractor work administration, project administration and handover and feedback. There are three alternatives for the selection of an engineer as shown in Table 4.

Table 4: Selection of Recommended Quantity Surveyor

Recommended Quantity Surveyor	T10	T7
A quantity surveyor with prior experience in more than five similar kind of projects	✓	✓
An engineer with prior experience in more than five similar kind of projects	×	✓

When all the requirements are considered, a quantity surveyor with prior experience in more than five similar kind of projects is the most suitable person. The selected quantity surveyor should have the required BIM based skills related to his tasks.

4.4. *THE MODELLER*

If a 3D modeller is appointed for the BIM team, he will have to prepare models for the architect's and engineer's designs. There are two alternatives for the selection of a modeller for the BIM team as shown in Table 5.

Table 5: Selection of Recommended Modeller

Modeller	T6
An architect + 3D modeller	✓
An architect with 3D modelling skills	✓

For the project, for model preparation, an architect can be appointed to designing and a modeller can be appointed to prepare the model, or an architect with 3D modelling skills can be appointed to do both the designing and preparing the model.

4.5. *3D MODELLING IN SRI LANKA*

Frequently used software for creation of 3D models of buildings were Google SketchUp, Autodesk 3Ds Max and Autodesk Maya. Such software is only capable of creating 3D model to visualize the idea. They are not much help for designing process. Usage of 3D modelling software specially developed for construction modelling has being popular since few years. Autodesk AutoCAD can also be used for 3D modelling for construction. But it takes time. Most popular software for 3D modelling for construction is Autodesk Revit. 3D modellers and professionals who use Autodesk Revit for modelling is increasing.

4.6. *3D MODELLING COURSES IN SRI LANKA*

All the courses are based on Autodesk Revit Architecture software. Most courses provide similar skills. All the courses include the following features; creating and modifying building components; floor, roof, ceiling, curtain wall, stair, railing, etc., adding annotations, dimensions and details, rendering views and creating walkthroughs, using massing tools, adding site features. In addition to them, some courses include features such as creating and modifying schedules, creating structural elements, sheets and title blocks, and using dimensions, alignments and constraints.

4.7. *SRI LANKAN PROFESSIONALS AND 3D MODELLING*

Sri Lankan professionals have had a light touch to BIM in their work to make their work easy. They do not implement projects based on BIM, they only use BIM software individually to complete their tasks. Even though Sri Lankan construction industry is not using BIM tools much, for structural engineering, Sri Lankan professionals are aware of such tools. That shows the attitude of Sri Lankan professionals towards new trends. Due to this reason, implanting BIM in Sri Lanka would not be a very hard task.

5. DISCUSSIONS AND CONCLUDING OBSERVATIONS

From the findings of the study, it can be concluded, a project can be completed successfully by implementing BIM, formulating a team from the participants in the current construction industry in Sri Lanka. In a BIM project there are special tasks to be carried out, which are not in the conventional construction process. Even though the participants in the Sri Lankan construction industry had never done those tasks, they could easily do those tasks correctly, with the help of a little training of working with BIM.

The conclusion for the selection of the participants for the BIM team is as follows. The team members in the conventional design team and their tasks were identified in the literature review. They have to perform the same tasks using BIM tools, in a project carried on using BIM. For that the participants in the BIM team need to have the knowledge to use BIM tools in their work.

Apart from those tasks in conventional construction projects, the participants in the BIM team have to perform special tasks unique to a BIM project. Those tasks with respect to the participants of the team are as below.

The Architect

The architect's special tasks include advising the client on purpose of using BIM, BIM model administration, project administration, subcontractor work administration, and handover and feedback. Alternatively, if the architect is going to prepare the model of the design himself, architect has to do model preparation as well.

To do those tasks the architect needs to have the following BIM related skills; understanding of BIM process, understanding of ownership privileges, understanding of model sharing, view a BIM model, preparing correspondence and submittals using BIM data, knowledge about the data to be inserted to the model, import and export BIM model data between software, extracting quantities, areas, volumes from a BIM model, and preparing, reviewing and updating project schedule using BIM model data. If the architect is going to prepare the model he needs the following skills; knowledge about the data to be inserted in to the model, drafting components and design with parametric modelling.

Architect's strengths include visualization ability, ability to convince the client and coordinating people. Architect's weaknesses include lacking in extensive knowledge about all the parts of the building, no competency in planning, lacking in technical knowledge and prioritizing architectural design. Considering all the facts an architect with prior experience as a lead architect in similar kind of project is selected.

The Engineer

The engineer's special tasks include project scheduling, BIM project administration, subcontractor work administration, project administration, and Hand over and feedback. Alternatively, if the engineer is going to prepare the model of the design himself, engineer has to do model preparation as well.

To do those tasks the engineer needs to have the following BIM related skills; understanding of BIM process, understanding of ownership privileges, import and export BIM model data between software, preparing, reviewing and updating project schedule using BIM model data, generating BIM sequence animation and schedule animation, extracting quantities, areas, volumes (quantity taking off) from a BIM model, preparing correspondence and submittals using BIM data, view a BIM model, understanding of model sharing.

Engineer's strengths include understanding of all the aspects of the building such as design, schedule and cost, extensive knowledge about all the parts of the building, planning. Engineer's weaknesses include prioritizing structural design. Considering all the facts an engineer with prior experience as a project manager is selected.

The Quantity Surveyor

The quantity surveyor's special tasks include cost estimating, clash detection, subcontractor work administration, project administration, and handover and feedback.

To do those tasks the QS needs to have the following BIM related skills; understanding of BIM process, understanding of ownership privileges, extracting quantities, areas, volumes (quantity take off) from a BIM model, view a BIM model, import and export BIM model data between software, perform clash detection, understanding of model sharing, prepare correspondence and submittals using BIM data.

Quantity surveyor's strengths include extensive knowledge about all the parts of the building, detailed knowledge about cost, independent choice, planning. Quantity surveyor's weaknesses include lacking in understanding of designing process. Considering all the fact a QS with prior experience in more than five similar kind of projects is selected.

The Modeller

The modeller prepares BIM models for architect's and engineer's designs, if either the architect or the engineer does not prepare the model for their designs themselves. Modeller's tasks include for model preparation, and handover and feedback.

To do those tasks the modeller needs to have the following BIM related skills; understanding of BIM process, understanding of ownership privileges, understanding of model sharing, knowledge about the data to be inserted to the model, drafting components and design with parametric modelling, view a BIM model, import and export BIM model data between software, preparing correspondence and submittals using BIM data.

How to Implement BIM Successfully?

From the conclusion of the study, main recommendation that can be made is, if a client needs to, or likes to do a project using BIM, do not need to worry about formulating a reasonable BIM team within Sri Lanka. It does not require to hire people from outside. However, none of the participants to the BIM team, from Sri Lanka has not done a BIM project, they need an expert input. Giving an expert input to the team will be an added advantage, which will increase the success rate of the project. A foreign input can be taken to give the necessary exposure to BIM.

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RE-DIRECTING CONSERVATION RISKS TO DISASTER RISKS IN CONSERVING WORLD HERITAGE SITES IN MALAYSIA

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ABSTRACT

Although a host of researches have fished-out attributes collectively defining Conservation Risks (CR's) at World Heritage Sites (WHS's) in Malaysia, these attributes are reported to threatening WHS's thereby posing as potential Disaster Risks (DR's) to the WHS's. These fished-out CR attributes however somewhat fall within the confines of 'hazards' (as conceived by some researches and policy documents on DR's) leaving out the other two variables (vulnerability and capacity) which alongside hazards, collectively define DR's. This study as such, intends to explore the studies on CR in Malaysia with a view to aligning these studies to a DR approach in conserving WHS's in Malaysia. Literature is sourced and reviewed by means of document analysis. Interpreted inferences drawn will be used presenting results. Findings reveal that attributes CR while bearing semblance to attributes of DR however predominantly qualify to being hazards both originating from nature and human induced. It is recommended that adopting the full concept of DR to WHS involves exploring the other two variables (vulnerability and capacity) which alongside DR attributes qualified to being hazards will collectively define DR at WHS's both in Malaysia and beyond.

***Keywords**: Conservation Risk; Disaster Risk; Malaysia; World Heritage Sites.*

1. INTRODUCTION

Discussions that were topical during the World Heritage Convention held at Kyoto in 2012 were on increasing instances of hazards which culminate to disasters thereby subjecting World Heritage Sites (WHS) to great risks. Several reports on such topical issue were presented and deliberated upon by stakeholders at the Convention. The floods, earthquake and fire that occurred at WHS's in Japan, Thailand, Haiti, India, New Zealand and Nepal among other countries left devastating effects (Jigyasu, 2012; Okamura *et al.*, 2015). The magnitude of such devastations discussed in The Convention were pinned to inefficient and/or neglect of Disaster Risk Management Plans in conservation of the WHS's. Resolutions reached in The Convention was that since WHS's are at risk of being affected by hazards that eventually turn out to become disasters, Disaster Risk Reduction (DRR) strategies should be highly prioritised by state parties to The Convention.

Globally, several efforts have been put forth to combating disasters by means of DRR. The United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2007) captures the 'Strategy for Reducing Risks from Disasters at World Heritage Properties' which was adapted from the Hyogo Framework for Action (HFA, 2005). Although HFA served as a global platform for DRR from 2005 until 2015, the Sendai Framework for DRR (2015-2030) has replaced the HFA. The goal of these global platforms for DRR is the substantial reduction of Disaster Risks (DR) by means of optimising the impact of hazards, vulnerability, capacity and resilience of lives, livelihoods and assets within communities in all countries. To achieve these goals which reduce DR, these global platforms spell out priorities for action to DRR. The first priority for action in SFA (2015) is the 'understanding of DR in all its dimensions'.

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Having ratified the SFA, understanding DR within the field of heritage conservation among other fields by Malaysia will show the country's full commitment to the resolution of the World Heritage Convention of which it is a State Party.

Most often than not, risks at WHS's are taken to be within the context of Conservation Risks (CR's). There exists several researches on CR's to WHS's in Malaysia (Kamal *et al.*, 2007; Lee, 2009; Woon and Mui, 2010; King, 2012; Wan Isma'il, 2013; Mat Radzuan, 2016). Although these studies may differ in their attributes to CR, they however unanimously report the threats and/or negative effects the attributes collectively defining CR's bear to WHS's. Therefore, it may be deduced that the attributes collectively defining CR's to WHS's in Malaysia by extension pose as potential DR's.

While applauding the efforts of the researches that have extensively reported the attributes collectively defining CR's (particularly in Malaysia) at WHS's, they somewhat fall within the confines of 'hazards' as conceived by a host of authors on DR's (Anderson and Woodrow, 1989; Parker, 2000; Chen *et al.*, 2003; Reddy, 2010; UNISDR,2015). However, DR have been claimed to being a collective function of not only hazards but also vulnerability and capacity (Chen *et al.*, 2003; Vatsa, 2004; Venton, 2008;Reddy, 2010). Researches on the attributes of CR's at WHS's (particularly in Malaysia) as such contain a vacuum in the other two attributes of DR (vulnerability and capacity) which together with hazards collectively define DR. This study as such, intends to explore the studies on CR in Malaysia with a view to aligning these studies to a DR approach in conserving WHS's in Malaysia.

2. RESEARCH APPROACH

Addressing a problem in any research involves the selection of a suitable research approach (Jayaweera*et al.*, 2015). The aim of this research is to be fulfilled by means of document analysis. Justification for selecting such approach lies in the assertions of Prior (2003) and Owen (2014) that: in most social scientific work, document analysis is placed at the margins of consideration. Authors that have recently used document analysis include: Jayasinghe and Fernando, (2015); Jayaweera *et al.*, (2015).

Document analysis is useful when conducting a study to present ideas whose purpose is to make an issue better understood (Duignan, 2008; MohdAriffin, 2015). This assertion is in line with the goal of this study because this study intends to present findings that may yield better understanding of CR's as they pass for DR's to WHS's. Several documents on CR, DR and other subject matter of this research are sourced and reviewed. Interpretation of the review is by means of drawing inferences to suit the aim of this study.

3. CONSERVATION RISKS

Risks in the field if conservation whether to WHS's or to any heritage item are most often than not contextualised to being Conservation Risks (CR's). Although CR is broad in nature, two approaches have been selected to discussing them. While the first approach presents CR in general, the second approach presents CR relative to WHS's in Malaysia. The subsequent sub-sections discusses these approaches.

3.1. CONSERVATION RISKS IN GENERAL

Although researches in CR have been ongoing for decades, attributes collectively defining CR have been presented by different researchers in different contexts. While some authors merely 'identified' attributes collectively defining CR's, other authors went a step further to classify and/or categorise them. The subsequent sub-sections present these contexts.

3.1.1. CONSERVATION RISKS BY IDENTIFIED ATTRIBUTES

Forsyth (2007) identified attributes of CR's at WHS's to include: conflict in site values; access to disabled; lack of resources; lack of statutory control; lack of management policies; neighbourhood development; traffic; pollution; and skill gap. The work of Orbasli (2008) attributes the following as collectively forming CR's to WHS's: earthquake; high winds; freak storms; flooding; fire; deliberate vandalism; solar radiation; fluctuations in temperature, pollution, climate change, tourism flow, and population density. According to Dolff-Bonekamper (2008), political circumstances and disputes/

conflicts serve as a major source of CR. It is worthy to note that these identified attributes alongside others collectively defining CR's are WHS specific.

3.1.2. Classified Conservation Risks

The work of Waller (1994) classifies CR based on 'frequency of occurrence' into three types that range from 'Type 1' which are 'rare and catastrophic', to Type 2'which are 'sporadic and intermediate' in severity and finally 'Type 3', which are 'constant and gradual'. The relation between these somewhat arbitrarily defined types of CR is shown schematically in Table 1.

Table 1: Conservation Risks by Frequency of Occurrence

	Constant	Sporadic	Rare
Catastrophic			…1…
Severe		…2…	
Gradual	…3…		

Source: Waller (1994)

Another study classified CR's based on 'agents of deterioration'. Under this category, Michalski (1990) itemised nine CR's. Attempting to improve these, Waller (1994) and Waller (1995) did not only add the tenth CR but further categorised all of them based on the classification of CR's by 'frequency' (against the backdrop). This classification and further categorisation of CR is shown in Table 2.

Table 2: Classification and Categorisation of Conservation Risks

S/No.	Agent Type	Risk Type by Frequency of Occurrence	Examples
1	Physical forces	1	Earthquake
		2	Mishandling
		3	Poor support and vibration
2	Fire	1	Fire
3	Water	1	Flood
		2	Roof and plumbing leaks
		3	Rising damp
4	Pests	2	Infestation
5	Contaminants	3	Gases and vapours
6	Criminals	1	Theft of elements or parts
7	Pollutants	2	Industrial waste
8	Light and radiation	3	Fading of colour
9	Relative humidity and temperature	2	HVAC malfunction
10	Custodial neglect	1	Abandonment

Source: Waller (1995)

The work of Reyers and Mansfield (2001) and that of Reyers (2003) categorise CR based on: client/owner risk; consultant related risk; external bodies risk; Health and Safety risk; and risks associated to design constraints. The classification of CR from these studies can be said to be based on the parties involved in conservation work. Research conducted by Silva and Henriques (2015) presented CR based on “agent of degradation’ where they classified the agents into: biological, chemical and mechanical agents. All these classification of CR indicates the efforts put forth by authors to studying CR’s. Similarly, the classification also portrays the variability of CR’s.

3.2. CONSERVATION RISKS TO WORLD HERITAGE SITES IN MALAYSIA

According to Mohd-Isa *et al.* (2011), Melaka and George Town historical cities were inscribed as WHS’s by UNESCO in 2008. Justification for such inscription according to Idid and Ossen (2013) is that both cities possess Outstanding Universal Value (OUV) from the point of view of history, architecture, culture and spiritual practices. Ever since the inscription of these two historic cities as WHS’s, there exists considerable studies in the WHS’s. Some works include: Idrus *et al.*, 2010; Harun, 2011; Wan Isma’il, 2013; Sa’id *et al.*, 2013; Idid and Ossen, 2013; Hasbollah, 2014; Hasbollah and Baldry, 2014; Mansir and Kasim, 2015. These studies alongside others is a clear manifestation of the growing interest to studying WHS’s in Malaysia.

The enactment of National Heritage Act 645 (2005) alongside other legislations and statutory bodies (Federal, State and Local councils) in Melaka and George Town WHS’s are statutorily meant to tackle all issues on conservation. This involves combating CR’s among other issues. While commending their efforts, researches have not only identified CR’s at the WHS’s but also claim that CR’s threatens WHS’s in Malaysia. For instance, Shamsuddin and Sulaiman (2002) and also Said *et al.* (2013) reported worrying trends that threaten the survival of WHS’s to include: the disruption of the urban pattern; disappearing townscape; changing activity pattern; visual monotony and obsolescence; and gentrification.

Jenkins and King (2003) attribute CR’s at WHS’s to derive from relocation of property owners. The work of Kamal *et al.* (2007) and Woon and Mui (2010) identify large-scale urban development, neglect, and the high cost of maintenance to continuously threaten WHS’s. Another study by King (2012) attributes CR’s to WHS’s to: pressures for new high-rise development in the core and buffer zones; modernisation; and traffic. Similarly, the work of Wan Isma’il (2013) also touched on how workshops, factories, noise, smelly and dirty environment, illegal and unsympathetic renovations put WHS’s under risk. Furthermore, Said *et al.* (2013) enumerate that WHS’s are under intensified threats which include: design of new township development; intensive and uncontrolled development pressures; insufficient legislations and enforcement; changing lifestyles and consumption patterns of city dwellers; expectation of new tourists; public awareness; environmental degradation; non-transparent local initiatives; poor provision of grants and technical advice; insufficient law and enforcement and de-population of inner city.

According to Ahmat *et al.* (2015), CR’s in Malaysia could be as a result of: lack of funds; the desire for modernisation; diminishing residents due to increasing rejection of traditional values and identity; economic demand through tourism; attitude of conservation administrators. Although these studies are sourced from different authors, some of the attributes of CR enumerated by the different authors bear semblance. These studies alongside others clearly confirm that CR’s not only exists at WHS’s in Malaysia but they also threaten WHS’s.

4. DISASTER RISKS

Over the years, disasters in different parts of the world have left devastating effects to humans, property and communities. Depending on the context of a particular disaster, DR has evolved through numerous definitions by a host of authors. According to Vatsa (2004), DR refers to the chance of injury, damage, or loss. Reddy (2010) equally posits that DR refers to the product of some probability of occurrence of an event and expected loss generating thereof. From these definition, it becomes clear that DR can be said to be built around effects (usually negative) that originating from the occurrence of a probable event.

Being a global platform for DR, the International Strategy for Disaster Reduction (ISDR) has proffered interpretation of DR to being a function of hazard, exposure and vulnerability normally expressed as a probability of loss of life, injury or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time (ISDR, 2002; ISDR, 2005; ISDR, 2007; UNISDR, 2015). Adapting this interpretation, a host of authors (Anderson and Woodrow, 1989; Chen *et al.*, 2003; Vatsa, 2004; Venton, 2008; Reddy, 2010) all claim that DR is a function of three key variables which are:

hazard; vulnerability to that hazard; and capacity to anticipate, resist, cope with and recover from a hazards occurrence.

5. Re-directing Conservation Risks to Disaster Risks at World Heritage Sites in Malaysia

The subsequent sub-sections will begin by presenting some DR's at WHS's. It must be noted that these reported risks will particularly cover some countries in Asia. Furthermore, comparison will be drawn between CR's to DR's.

5.1. Reports on Disaster Risks at World Heritage Sites

Several reports and researches have established the attributes that relate to DR. Natural disaster attributes relating to DR as culled from Cummins (2012); Abungu (2012) and Okamura *et al.* (2015) include: Hurricane; Volcano; Earthquake; and Tsunami. Human induced disaster attributes relating to DR as culled from Abungu (2012); Nishibayashi (2012); Bokova (2012); Jigyasu (2012); Badman, (2012) and Okamura *et al.* (2015) include: pressures for development; conflicts; lack of funds; lack of coordination between stakeholders; lack of appropriate capacity; climate change; rapid urbanization; mass tourism; economic development; lack of management strategies; political and economic considerations; lack of consultation; suspicion of other parties; population pressure; unsympathetic and contradictory developments; and fire.

Reports have shown that some of these afore-presented attributes relating to DR have in the past individually or collectively culminated to disasters in WHS's. For instance, Jigyasu (2012) reported that floods, earthquake and fire among others resulted to devastating disasters affecting WHS at Japan, Thailand, India and New Zealand among other countries. Similarly, the earthquake that struck Nepal caused a great deal of loss to its WHS (Okamura *et al.*, 2015). These reports show that the factors claimed to cause disasters are among both afore-presented natural and human induced attributes relating to DR's.

5.2. Comparing Conservation Risks to Disaster Risks

Previous sections in this study presented the attributes relating to DR and also the attributes to CR's. Table 2 depicts some comparison drawn between them on the basis of the CR's authors that identified the DR attributes (listed in Table 3) in their study.

Table 3: Comparing Disaster Risk Attributes to Conservation Risk Attributes

S/No	Disaster Risk Attributes	Conservation Risks in General	Conservation Risks to World Heritage Sites in Malaysia
1	Earthquake	Michalski, 1990; Waller, 1995; Orbasli, 2008	
2	Pressures for development	Forsyth, 2007	
3	Conflicts	Forsyth, 2007; Dolff-Bonekamper (2008)	
4	Lack of funds	Forsyth, 2007	Said *et al.*, 2013; Ahmat*et al.*, 2015
5	Lack of appropriate capacity		Jigyasu, 2012; Said *et al.*, 2013
6	Climate change	Orbasli, 2008	
7	Rapid urbanization		Shamsuddin and Sulaiman, 2002;Kamal *et al.*, 2007; Woon and Mui, 2010; King, 2012; Said *et al.*, 2013
8	Mass tourism	Orbasli, 2008	Said *et al.*, 2013; Ahmat*et al.*, 2015
9	Economic development		Shamsuddin and Sulaiman, 2002;Kamal *et al.*, 2007; Woon and Mui, 2010; King, 2012; Said *et al.*, 2013

S/No	Disaster Risk Attributes	Conservation Risks in General	Conservation Risks to World Heritage Sites in Malaysia
10	Lack of management strategies	Forsyth, 2007	Said *et al.*, 2013; Ahmat*et al.*, 2015.
11	Political and economic considerations	Dolff-Bonekamper (2008)	Kamal *et al.*, 2007;Woon and Mui, 2010; King, 2012
12	Lack of consultation	Reyers and Mansfield, 2001; Reyers, 2003	
13	Suspicion of other parties	Reyers and Mansfield, 2001; Reyers, 2003	Jigyasu, 2012
14	Population pressure	Orbasli, 2008	Said *et al.*, 2013
15	Unsympathetic and contradictory developments		Said *et al.*, 2013; Wan Isma'il, 2013
16	Fire	Michalski, 1990; Waller, 1995; Orbasli, 2008	

Out of all nineteen attributes relating to DR (refer Section 5.1) none of the researches reviewed on CR's report on the following: hurricane; volcano; and tsunami (hence sixteen are captured). Although the DR attributes somewhat compare to the CR attributes identified by the authors (depicted in Table 2), these attributes somewhat fall within the category of 'hazards' as conceived by a host of authors on DR's (Anderson and Woodrow, 1989; Parker, 2000; Chen *et al.*, 2003; Reddy, 2010; UNISDR,2015).

5.3. ALIGNING CONSERVATION RISKS AT WORLD HERITAGE SITES IN MALAYSIA TO DISASTER RISKS

Although the attributes of CR's in WHS's somewhat fall within the confines of 'hazards', DR is reported to not only be a function of hazard but also that of vulnerability and capacity. The migration of CR's to DR's as such involves exploring the other two variables (vulnerability and capacity) which alongside hazards collectively define DR's at WHS's both in Malaysia and beyond. To achieve this, Table 4 showcases the extensive work authors have undertook to classify the three variables collectively defining DR's.

Table 4: Classification of the Variables Collectively Defining Disaster Risk.

Variables	Variable classification	Authors
Hazards	Origin (Natural and human induced)	Anderson and Woodrow, 1989; Parker, 2000; Chen *et al.*, 2003; Reddy, 2010; UNISDR, 2015.
	Magnitude	
	Frequency	
	Aerial extent	
	Duration	
	Speed of onset	
	Spatial dispersion	
	Temporal spacing	
Vulnerability	Physical/material	Anderson and Woodrow, 1989; Chen *et al.*, 2003; Vatsa, 2004; ADPC, 2006; IFRC, 2007; Venton, 2008; Reddy, 2010. UNISDR, 2015.
	Economic	
	Social	
	Economical	
	Institutional	
	Educational	
	Environmental	
	Attitudinal/motivational	
Capacity	Physical/material	ADPC, 2006; IFRC, 2007; Reddy, 2010; Gaillard, 2010; Eiser *et al.*, 2012; UNISDR, 2015.
	Institutional	
	Social	
	Economic	
	Attitudinal/motivational	

While these classifications may serve as a stepping stone thereby assisting in aligning CR's to DR's, it must be borne in mind that attributes defining the interplay between these three key variables must be defined within the context of DR's at a particular WHS.

6. Conclusion

The attributes of CR's at WHS's in Malaysia although bearing semblance to attributes of DR do not fall under the attributes identified (amongst other factors) to culminate to disasters at WHS's in Japan, Thailand, India and Nepal amongst other countries in Asia. However, these attributes of CR's at WHS's in Malaysia together with those attributes identified to cause disasters all somewhat fall within the confines of 'hazards'. Similar to the hazards that culminated to disasters in the afore-reported WHS's, attributes of CR's qualified to being 'hazards' may cause potential DR's in conserving WHS's in Malaysia.

Comprehensive coverage of DR's however involves classifying of attributes of CR's qualifying to being hazards based on the classification in Table 3. Furthermore, an integration of these attributes of CR's (which qualify as hazards) with a full exploration of 'vulnerability' and 'capacity' specific to the WHS's in Malaysia will be necessary. Doing such will fall in line with the integrated-approach to studying CR's usually propagated statutorily (ICOMOS, 2010a; ICOMOS, 2010b; ICOMOS, 2011; ICOMOS, 2012). This study although being part of an ongoing Ph.D. will in future explore 'vulnerability' and 'capacity' (based on classifications of Table 3) of the WHS's in Malaysia. Subsequently, a model to assess DR's at WHS's in Malaysia will be proposed.

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RE-THINKING POST-CONTRACT COST CONTROLLING TECHNIQUES IN THE NIGERIAN CONSTRUCTION INDUSTRY

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ABSTRACT

The challenges of cost and time overruns, construction disputes and client dissatisfaction have plagued the construction industry in Nigeria. This may be as a result of the approaches used in monitoring construction costs. The execution phase of a construction project relies on post-contract cost controlling techniques, such as cash flow monitoring, interim valuations, final account preparation, monitoring activities, site meetings and documentation of activities on site. These techniques are imperative for project success. The purpose of this paper is to assess the various techniques used in post-contract cost control in Nigeria, in terms of their effectiveness. The data was gathered from one hundred and thirty five (135) cost and project managers in Nigeria. The Kendall's coefficient of concordance was used to test the post-contract cost controlling techniques identified, through an extensive literature review along with one sample run test.

The findings reveal that monitoring material cost was the most effective and important technique with a Kendall's W score of 1.33 and 11.44 respectively. Cash flow monitoring had the lowest score of 7.85 for effectiveness, while variation management had the lowest score of 6.88 for importance. The effectiveness of the techniques was further evaluated using one sample run test. The findings show that sixteen out of the eighteen techniques were not effective from an overall point of view. The cost controlling techniques used in the Nigerian construction industry are deficient and generally ineffective. Therefore, there is a need to research alternative post-contract cost controlling techniques for the construction industry in Nigeria.

Keywords: *Construction Industry; Cost; Cost Controlling Techniques; Nigeria; Post-contract.*

1. INTRODUCTION

Cost management is the bedrock of a successful project. Project cost controlling activities are based on the output of project planning, tender evaluation and estimates (Rad, 2002; Samphaongoen, 2010). The entire process of cost management has the aim of ensuring that there is cost accountability and management. Therefore, cost controlling is vital for any construction project around the world. Shehu *et al*. (2014) noted that the major factors associated with project delays are the contractor's influence and financial management. Cost overruns are very common wherever project delays occur (Jainendrakumar, 2015; Olawale and Sun, 2013). The major factors identified for cost and time overruns are risk factors with regard to financial and political influence, the cost of construction materials, design changes, inaccurate estimations of time and cost, project complexity, lack of training on the part of the project manager, difficulty in collecting cost data and the cost of conducting cost control (Dada and Jagboro, 2007; Eshofonie, 2008; Liang, 2005; Olawale and Sun, 2013). Project cost and time overruns have been studied by many authors over the decades, but research has not focused on the pertinent techniques used by cost and project managers during the construction process. The techniques used by cost and project managers for cost control during construction are very important in determining if the project will complete on time and within budget.

The Nigerian construction industry has suffered a low growth rate and contribution to the gross domestic product of the country (AfDB *et al*., 2013; NBS, 2012). Within the last five (5) years, the construction industry in Nigeria has not grown as expected. The challenges faced by most construction industries around the world in terms of cost and time overruns are not peculiar to the Nigerian construction industry.

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The inaccuracies of construction cost estimates are affected by political, economic and geographical issues, security, time and legal factors (Oyedele, 2015). These factors have influenced the accuracy of construction estimates in Nigeria, hence cost and time overruns are prevalent. The contractor selection process is also cost based, which is associated with project delays and cost overruns (Olaniran, 2015). Post-contract cost controlling techniques in the Nigerian construction industry have not been a major research area. However, contractors' performance has been the major focus (Bala *et al*., 2009; Chukwudi and Tobechukwu, 2014; Fagbenle *et al*., 2011; Inuwa *et al*., 2014a; Inuwa *et al.*, 2014b; Odediran *et al*., 2012). The lack of in-depth analysis of the effectiveness and importance of the post-contract cost control techniques in the Nigerian construction industry is apparent. The techniques employed by contractors in Nigeria may be an influence on the performance of contractors.

2. POST-CONTRACT COST CONTROLLING TECHNIQUES IN THE NIGERIAN CONSTRUCTION INDUSTRY

According to Jagun (2006) Quantity Surveyors are the cost managers of construction projects in Nigeria. Hence, Quantity Surveyors are trained in the art and science of cost management for building, industrial, civil engineering, mechanical and electrical aspects of construction. According to Ashworth (2010) the Quantity Surveyor is heavily involved in the cost control processes. This stage starts from the planning to the issuing of certificates. The most critical phase of a project is always the execution phase. Based on exiting literature, the post contract cost controlling techniques used in the Nigerian construction industry were extrapolated for this study. The major techniques identified for post-contract cost control in Nigeria are listed in the table below with their description.

Table 1: Post-Contract Cost Controlling Techniques in Nigeria

S/N	Post-Contract Cost Controlling Technique	Description	Reference
1	Cash flow	Flows of cash for day to day activities for relevant activities on site. Allows the contractor to calculate the profit and other expenditure.	(Ashworth, 2010; Sanni and Durodola, 2012; Sanni and Hashim, 2013)
2	Taking corrective action	Errors and omissions identified during the construction process are corrected.	(Ashworth, 2010; Sanni and Durodola, 2012)
3	Monitoring overheads	Monitoring specific activities which may lead to more expenses. Some of these activities are identified in preliminary items of work.	(Ashworth, 2010; Sanni and Durodola, 2012)
4	Monitoring labour cost	The cost of labour and other rates are monitored.	(Ashworth, 2010); Sanni and Durodola, 2012)
5	Monitoring material cost	The material costs are monitored, effect of demand and supply and the exchange rate.	(Ashworth, 2010; Sanni and Durodola, 2012)
6	Monitoring Equipment cost	Hiring cost of equipment and plants are regularly considered.	(Ashworth, 2010; Sanni and Durodola, 2012)
7	Managing variations	Variation management is essential. There are always alterations and changes during the course of construction.	(Olawale and Sun, 2010; Ashworth, 2010; Sanni and Durodola, 2012)
8	Monitoring completed units	This process involves monitoring the progress of work.	(CII, 2000; Ashworth, 2010)
9	Unit rate	Single rate cost estimating method used during and before construction. Cost estimating of	(Olawale and Sun, 2010; Ashworth, 2010)

S/N	Post-Contract Cost Controlling Technique	Description	Reference
		the various building elements are calculated using this method.	
10	Interim valuations	Interim certificates may be issued for payment. Allows the client to make payment based on work done gradually.	(Ashworth, 2010)
11	Incremental Milestone	This is a technique for earned value analysis. It is used to measure completed work and outline the cost and during further calculations.	(CII, 2000; Leu and Lin, 2008)
12	Establishing baselines	Cost baselines are established to evaluate the planned cost against the actual cost.	(Ankur and Pathak, 2014; Leu and Lin, 2008; Czarnigowska, 2008)
13	Identifying indicators of cost overruns	Certain indicators which may lead to cost overruns may be identified. These may be inflation, economic changes or stakeholders' involvement.	(Ashworth, 2010; Olawale and Sun, 2010; Sanni and Durodola 2012)
14	Financial statement and summarizing profit and loss	Financial statements and other financial documents such as the profit and loss summary are used in identifying and evaluating the expenditure and calculating the final profit.	(Sanni and Durodola, 2012; Ashworth, 2010)
15	Site meetings and post project reviews	Final site meeting is documented to evaluate the performance of the project, in this instance, cost, expenditure and profit are evaluated.	(Puvanasvaran *et al.*, 2010); Berger, 1997; Chukwubuikem *et al.*, 2013)
16	Historical data	Data from previous similar projects are used during construction cost control.	(Sanni and Durodola, 2012)
17	Cost Forecasting	A technique used to evaluate the cost needed to complete the project, this may be carried out using earned value analysis.	(Sanni and Durodola, 2012; Czarnigowska, 2008).
18	Using established budget and targets	Bills of quantities are used during construction activities for managing construction cost.	(Sanni and Durodola, 2012; Ashworth, 2010)

The eighteen post-contract cost controlling techniques identified in the table above will be used for this investigation. The effectiveness of the techniques will be assessed.

3. PROBLEM STATEMENT

The problem of cost and time overruns has affected a number of construction companies in Nigeria (Bala *et al.*, 2009). Also, there has not been an adequate study into the post-contract cost control techniques used in the construction industry. Most emerging small and medium scale construction organizations in Nigeria have not been competing well, in recent years, with the larger construction firms. Hence, liquidation of construction companies and loss of jobs in the construction sector has been prevalent, although it may be difficult to pinpoint the challenges exactly that most small and medium scale construction firms are experiencing in terms of post-contract cost controlling techniques at the moment.

There is a need to investigate and ascertain the role of post-contract cost controlling techniques in terms of effectiveness.

4. HYPOTHESES

The following hypotheses was used to evaluate the eighteen identified post-contract cost controlling techniques in Nigeria.

- H0: Post-contract cost controlling techniques identified are not effective for cost control activities in the Nigerian construction industry.
- H1: Post-contract cost controlling techniques identified are effective for cost control activities in the Nigerian construction industry.

The next section addresses the data collection, and testing techniques.

5. METHODOLOGY

A theoretical sampling technique was used to define the sample population and the number of respondents. Walliman (2006) noted that theoretical sampling**,** which is a form of non-probabilistic sampling, targets the population with adequate knowledge and experience. The targeted population were chosen based on experience and knowledge level. Cost and project managers in Lagos, Nigeria were selected because of their influence in construction projects. The respondents had a minimum of fifteen and maximum of thirty eight years of experience in the construction industry. Subsequently, the population size was selected based on a quarter of construction companies in Lagos. There are over one thousand construction companies according to the Lagos State Ministry of Housing (Sanni and Durodola, 2012). Therefore, two hundred and fifty (250) questionnaires were distributed to construction companies in Nigeria, however, one hundred and thirty five (135) questionnaires were obtained. The questionnaire was designed based on the five point (5) Likert scale format. The format is displayed as thus:

Table 2: Likert Scale Format for Data Collection

1	**2**	**3**	**4**	**5**
Not relevant	Not effective	Moderately effective	Effective	Highly effective

The questionnaire was used to elicit information from cost and project managers who were the only two categories of respondents in this survey. The theoretical sampling technique was used to target cost and project managers with at least fifteen years' experience in the construction industry. SPSS 22 was used to test the data for effectiveness.

5.1. KENDALL'S COEFFICIENT OF CONCORDANCE

The study also utilized Kendall's coefficient of concordance to assess the agreement between the respondents and also to rank the effectiveness based on the Kendall's W score. Kendall's coefficient of concordance is used to measure the agreement of judgement of a set of variables (Legendre, 2005). Mehta and Patel (2012) noted that Kendall's W test is a scaled Friedman's test with the formula:

$$W = \frac{Tf}{N(K-1)} \qquad \text{Eq: 01}$$

The test produces the p values which are the asymptotic p value. If the p value is less than 0.05 this is acceptable, also the Kendall's coefficient of concordance W should also be less than 0.05 for acceptable values (Mehta and Patel, 2012). The ranking produced by Kendall's W coefficient of concordance is a form of measure of association (Mehta and Patel, 2012). The author further noted that Kendall's W is a measure of the degree to which the *K* applicants agree with the *N* judge. This measures the level of effectiveness or importance for the various post-contract cost controlling techniques which are used by small and medium scale construction firms in Lagos, Nigeria.

5.2. HYPOTHESIS TESTING (ONE SAMPLE RUN TEST)

The hypothesis involved accepting or rejecting the null hypothesis based on one sample run test. The one sample run test addressed the randomness of data in an observed sequence. According to Singh *et al*. (2013, p.9) "a *run test is used for examining whether or not a set of observations constitutes a random sample from an infinite population. The test for randomness is of major importance because the assumption of randomness underlies statistical inference"*. The test for randomness in the Likert scale non-parametric data observed the occurrence of the responses as a measure of the hypothesis. The hypothesis test also utilized the significance value, which should be less than 0.05. The hypothesis test aimed to address the effectiveness of post-contract cost controlling techniques individually and juxtapose it with the findings of the Kendall's coefficient of concordance. Therefore, the tests addressed the core aims but the hypothesis looked at the overall impact of post-contract cost controlling techniques in the Nigerian construction industry.

The Kendall's coefficient of concordance and the one sample run test for randomness were carried out using SPSS22. The findings of the Kendall's coefficient of concordance and the one sample run test for randomness are presented in the next section.

6. FINDINGS

The result of Kendall's coefficient of concordance test from SPSS 22 is displayed in the table below. The results ranked monitoring material cost as the most effective technique with a score of 11.55. Interim valuation is the second most effective technique with a score of 11.05. The established working budget, which is the bill of quantities, is ranked third with a score of 10.90. The findings also revealed that variation management is not effective for the construction industry in Nigeria. This technique had the lowest score of 8.16. Cash flow monitoring, which is usually used by contractors, had the second lowest score of 8.17.

Table 3: Kendall's Coefficient of Concordance for the Identified Post-Contract Cost Controlling Techniques

Post-contract cost controlling technique	Mean	Rank
Monitoring Material cost	11.55	1
Interim valuations	11.05	2
Using established working budget	10.90	3
Taking corrective action	10.39	4
Monitoring Overheads	10.22	5
Monitoring Equipment cost	10.08	6
Using Historical Data	10.07	7
Monitoring Labour cost	9.94	8
Similar projects	9.41	9
Monitoring completed Units	9.39	10
Incremental Milestone	8.85	11
Identifying cost overruns	8.75	12
Forecasting at completion	8.63	13
Cost Ratio	8.57	14
Profit and loss summary	8.52	15
Unit rate	8.40	16
Cash flow	8.17	17
Variation Management	8.16	18

The Kendall's W score for agreement is given as 0.046. This implies that there is a low level of agreement between the respondents. In this instance, the respondents have given diverging views about the various techniques. Therefore, it is important to assess the techniques, based on their individual significance and randomness.

6.1. FINDINGS FROM THE ONE SAMPLE RUN TEST

As can be seen in Table 4 below, the findings revealed that the null hypothesis for each of the post-contract cost controlling techniques is retained. There are only two techniques which take corrective action and use the established working budget with a significance of 0.021 and 0.045 respectively, which rejects the null hypothesis. This implies that the post-contract cost controlling techniques identified are not effective for the Nigerian construction industry.

Table 4: Null Hypothesis Test for the Post-Contract Cost Controlling Techniques Identified

S/N	Null Hypothesis	Sig.	Decision
1	Cash flow is not effective	0.372	Retain null hypothesis
2	Using historical data is not effective	0.478	Retain null hypothesis
3	Using similar projects is not effective	0.918	Retain null hypothesis
4	Taking corrective action is not effective	0.021	Reject null hypothesis
5	Monitoring labour cost is not effective	0.0831	Retain null hypothesis
6	Monitoring material cost is not effective	0.143	Retain null hypothesis
7	Monitoring equipment cost is not effective	0.672	Retain null hypothesis
8	Monitoring overhead cost is not effective	0.084	Retain null hypothesis
9	Variation management is not effective	0.277	Retain null hypothesis
10	Cost ratio is not effective	0.850	Retain null hypothesis
11	Incremental milestone is not effective	0.601	Retain null hypothesis
12	Monitoring completed units is not effective	0.091	Retain null hypothesis
13	Identifying cost overruns is not effective	0.759	Retain null hypothesis
14	Forecasting at completion is not effective	0.163	Retain null hypothesis
15	Using a unit is not effective	0.091	Retain null hypothesis
16	Profit and loss summary is not effective	0.140	Retain null hypothesis
17	Interim valuations are not effective	0.907	Retain null hypothesis
18	Using an established working budget is not effective	0.045	Reject null hypothesis

88.89% of the techniques identified are not effective for post-contract cost controlling in Nigeria. Therefore, the null hypothesis H0, stating that "*post-contract cost controlling techniques identified are not effective for cost control activities in the Nigerian construction industry,*" will be retained.

7. DISCUSSION

The findings of the Kendall's coefficient of concordance reveals that monitoring material cost is the most effective cost controlling technique in the Nigerian construction industry. This finding has been corroborated by Sanni and Durodola (2012) in the assessment of cost control practices in the metropolis of Lagos, Nigeria. Although monitoring material cost was ranked second to using established working budgets in the author's findings, the impact of material cost monitoring, such as monitoring the cost of cement in Nigeria, is enormous. Most complex construction projects in the country require a lot of building material importation from Europe and Asia. Building materials such as windows, doors, ceramics, tiles, sanitary and plumbing appliances, have been imported into Nigeria over the years (Oruwari *et al*., 2002; Ugochukwu *et al*., 2014). The effect of inflation, fluctuating foreign exchanges, the rising cost of importation and custom duties have led to a many cost overruns in the Nigerian construction industry. Ugochukwu *et al*. (2014) conducted a survey which was based on the perception and patronage of imported building materials in Nigeria. The findings revealed that most building material sellers and contractors usually patronize "BUA" imported cement compared to the local "Dangote cement". Dangote cement is very popular in Nigeria, however, the prices of this cement brand fluctuate quarterly. This also influences the overall costs of construction projects in Nigeria.

Cash flow is viewed as a very important post-contract cost controlling technique but in the Kendall's coefficient of concordance test, the findings revealed that cash flow is the second least effective post-contract cost controlling technique in Nigeria. Sanni and Hashim (2013) stated that cash flow is the most effective technique for cost controlling. However, the tests conducted in this study have disclosed otherwise. Variation management was ranked as the least effective. This may be as a result of contract documentation and adequate preparation. Also, the quantity surveyor's experience matters in variation management; this has been corroborated by the findings of Sanni and Hashim (2013) in their assessment of construction cost control practices in Nigeria.

These factors have also influenced contractors and quantity surveyors' approaches towards the interim valuations and preparation of working budgets for tender. The null hypothesis was retained for sixteen out of the eighteen techniques, showing that the process of post-contract cost controlling in Nigeria is ineffective. However, the results showed that taking corrective action and conducting interim valuations are effective, yet these are only two techniques out of the eighteen techniques in the study. Therefore, the post-contract cost controlling techniques used in Nigeria are not effective, based on the findings of this study.

There is a need to explore the alternative means of controlling post-contract cost. However, the cost planning phase of construction in Nigeria needs to address certain aspects, which deal with contingency funds, profit and overheads. The addition of contingencies to the cost plans or budget is a management function. In most construction companies, profit and overheads are twenty (20) to thirty five (35) percent. The contingency funds are between five (5) to ten (10) percent of the total contract estimate. These figures have to be reviewed to allow for the changes in the construction industry, which may result from cost fluctuation for building materials.

8. CONCLUSION

Post-contract cost controlling techniques identified in the literature have been ranked and tested for effectiveness, and monitoring material cost is the most effective technique. This is as a result of the immense pressure to import high quality materials, which are not readily available in Nigeria. Cash flow and variation management are the least effective techniques. This may be as a result of the challenges posed by the regularly fluctuating material cost. It would be cost effective if more quality building materials were manufactured inside Nigeria. This would reduce the dependence on foreign building materials for construction projects. Notwithstanding this, the economic situation in Nigeria also has an overall impact on construction projects. However, it is evident that activities which involve monitoring the rise and fall of construction material costs in Nigeria are necessary. Further hypothesis tests have also shown that most present post-contract cost controlling techniques are ineffective, and in fact, only two techniques were found to be effective at all. Therefore, there is a need to implement new practical approaches for conducting post-contract cost control. Modern cost management methods such as target costing, kaizen costing, value engineering and earned value analysis may be incorporated with the present post-contract cost controlling techniques in the Nigerian construction industry, thereby reducing the challenges of cost and time overruns.

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REVIEW OF STRATEGIES TO IMPROVE WORKPLACE SAFETY THROUGH ETHICAL CLIMATES

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ABSTRACT

Occupational Health and Safety (OHS) is an important aspect in every type of organisations. Healthy workers are an important asset to the organisation and safety issues causes various losses to the organisation. Therefore, it is vital to formulate strategies to improve the occupational health and safety in every type of organisations.

It has been found out that 80% of the workplace accidents are due to employee behaviours. Moreover, according to past researches, ethical climate of the organisation affects the individual employee behaviours. Ethical climate refers to the shared perceptions of organisational members regarding what is considered correct behaviour in the organisation and how the organisation deals with ethical issues. Ethical climate guides the employees to determine what is considered right and wrong behaviour at work. Therefore, it is much clear that there is a strong link between ethical climates and the workplace safety.

Thus, this study discusses how the ethical climates affect the employees' work place safety behaviours and ultimately on the occupational health and safety. The literature review shows that among the nine types of ethical climates, principal-local climates and benevolent- local climates have the highest positive effect on workplace safety behaviours. Therefore, the organisations should encourage these types of ethical climates in their organisations and can enhance the safety performance by aligning their safety initiatives with ethical climates.

Keywords: *Occupational Health and Safety; Ethical Climates; Employee Safety Behaviours.*

1. INTRODUCTION

Healthy workers are productive workers with high morale and better productivity (Pasha and Liesivuori, 2003). Workers have a right to a safe workplace. In every country the law requires employers to provide their employees with safe and healthful workplaces. However, according to Rantanen *et al*. (2004 cited Trute and Hiebert-Murphy, 2013). 2.4 billion working people in the developing countries often have to endure employment conditions, which do not meet even basic Occupational Safety and Health (OSH) standards.

The 'root cause' of the accident is a human error on part of a person involved directly in the dynamic flow of events (Rasmussen, 1998). As it was recorded, 70-80% of the industrial accidents were due to 'human error'. As human errors can be eliminated though behaviours, behaviours have always had a role in safety. For instance, Guldenmund (2000) viewed that, when designing and evaluating safety processes, attention needs to be in three basic domains; namely, environment (such as equipment, tools, machines, housekeeping, engineering, management systems); person (employees' knowledge, skills, abilities, intelligence, motives, and personality); behaviour (employees complying, recognizing, communicating, and actively caring). Behaviours are regarded the primary, and sometimes only, tools for survival, remaining today as the last tool when all else fails (Galloway, 2012). Galloway (2012) further explains that, when proper tools or systems were lacking, workers should behave in a manner for self-preservation. Thus, improving the safety behaviours of workers can be a reassuring way to eliminate human error, and enhance safety in an organizational level.

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As argued by many researchers, the organization and its subunit have the most important influences on the safety behaviour of the individual employee (e.g., Katz-Navon *et al*., 2005; Neal *et al*., 2000). Moreover, taking the right action in an organization when faced with a decision that influences other people is related to the work climate of the organization. This work climate determine what constitutes ethical behaviour at work (Victor and Cullen, 1988).

According to Parboteeah and Kapp (2008) there is an important but neglected link between workplace safety and ethics. However, only two studies have examined that link. Among that one study, McKendall *et al*. (2002) examined, how various aspects of an ethics program (ethical codes, communication about ethics, ethics training, and incorporation of ethics into human resources practices) were linked to Occupational Safety and Health Act (OSH Act) violations. And the finding was ethical compliance programs may actually be used to deflect attention from illegal activities rather than promote legitimate activities. In the second study by Parboteeah and Kapp (2008) which is the first one to demonstrate the utility of the ethical climate concept in explaining work place safety, confirmed that workplace safety can be enhanced through organisational ethical climate rather than solely on the typical contingent reward approach based on use of reward and punishment to encourage safety behaviours.

Accordingly, this paper aims at reviewing the strategies to improve workplace safety through ethical climates. This paper is based on the comprehensive literature review of an on-going MPhil research. Iqbal (2003) explains that literature review is required to identify any gap in the knowledge and a successful researcher claims a gap in the existing knowledge with evidence. Thus, findings of comprehensive literature review presented the overview of ethical climates, occupational health and safety issues, link between ethical climates and workplace safety and strategies to improve workplace safety through ethical climates. Finally, the paper elaborates future way of this research. Mainly, referring journal articles, books, published and unpublished bibliographies, conference proceedings, industry reports and documents took literature evidence. During the literature survey, key terms such as ethical climates, apparel industry, occupational health and safety, and ethical behaviour were used for the review.

2. LITERATURE REVIEW

2.1. OCCUPATIONAL HEALTH AND SAFETY

Occupational safety and health (OSH) is generally defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment (Alli, 2008). Simply, the goals of occupational safety and health aims at fostering a safe and healthy working environment.

According to International Labour Organisation (ILO) and the World Health Organisation (WHO) Occupational health should aim at: the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities; and, to summarise, the adaptation of work to man and of each man to his job (Amarasinghe, 2013). Therefore, it is clear that work and health is always interrelated. Health of the worker affects the work performance. Healthy worker is an asset to the work place because his work is productive, and efficient and less errors. An unhealthy worker should be referred for treatment, rest or at least to relax for a short time. Time spent for other activities except for the production, such as seeking treatment or resting in the sick room, is a cost to the organisation. At the same time work affects the health of a person in two ways, mostly in a positive manner, because of the earnings the workers will have a better access to nutrition, education. Accordingly, researchers, have found that the workers life expectancy is significantly longer than a non-working population, which is called the "Healthy workers effect". However, if the work place is not a safe place to work, the workers might end up with occupational accidents or if the workplace is not healthy the worker might end up with occupational diseases.

Workplace accidents occur for many reasons including accidents result from the behaviours of people, the hazards in the work environment (Figure 1). It has been found that unsafe actions, more so than unsafe conditions are the root cause of the vast majority of occupational injuries and accidents (Mcquiston, 2012). Moreover Mcquiston (2012) further explained that approximately 80 out of every 100 accidents are directly attributable to the person involved in the incident. In fact, unsafe work behaviour causes four times as many accidents as unsafe work conditions.

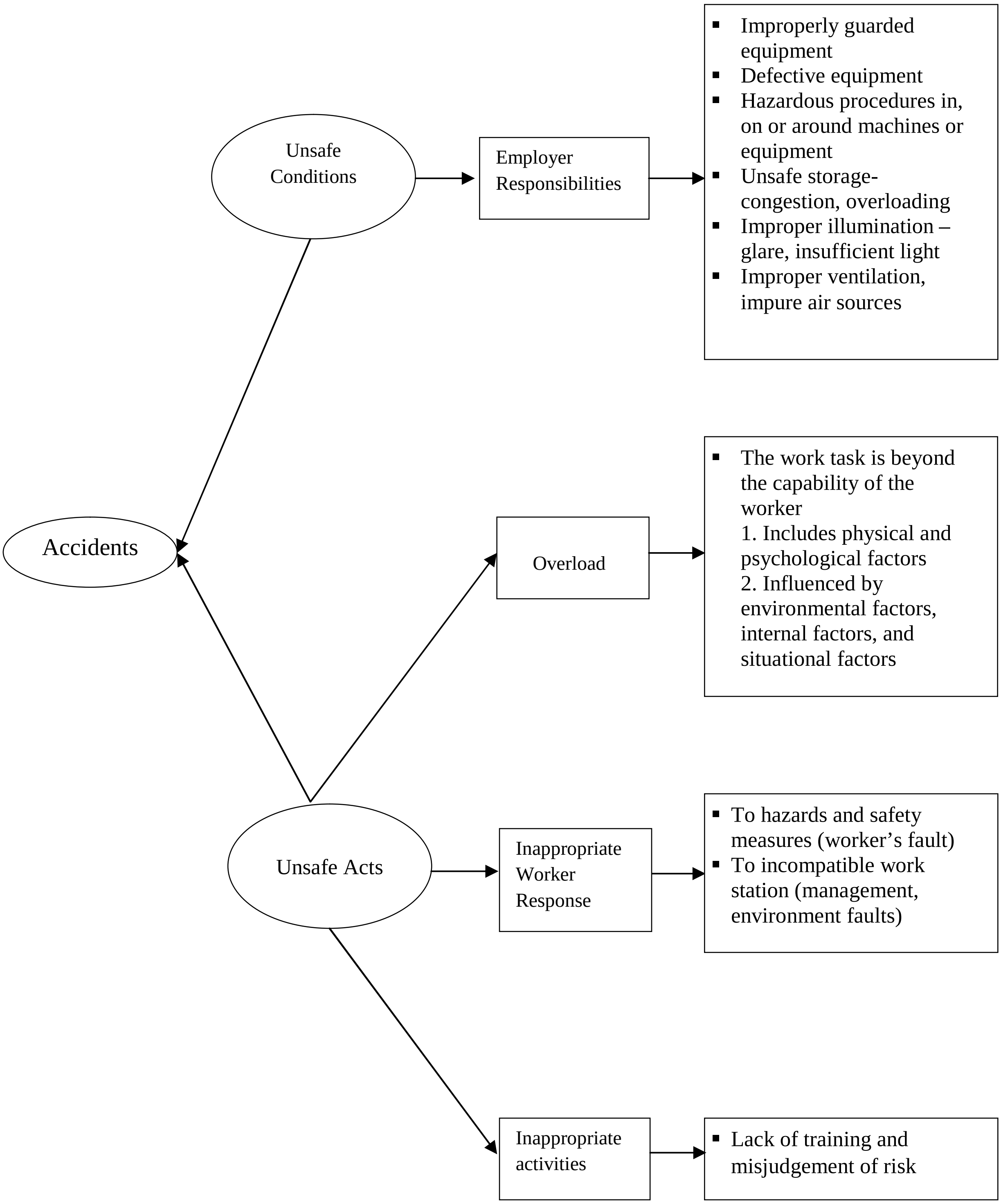

Figure 1: Causes for Occupational Accidents

Unsafe condition is a condition in the work place that is likely to cause property damage or injury. According to the World Health Organization (WHO), working conditions, for the majority of the three billion workers worldwide, do not meet the minimum standards and guidelines set by the WHO and the

International Labour Organization (ILO) for occupational health, safety and social protection. Throughout the world, poor occupational health and safety leads to two million work-related deaths, 271 million injuries and 160 million occupational diseases per year (Eijkemans, 2003). The majority of the world's workforce does not have access to occupational health services; only 10-15 % of the total global workforce has access to some kind of occupational health services. The main problem of the absence of occupational health services is the continuous presence of hazards in the workplace, such as noise, toxic chemicals, and dangerous machinery, leading to a huge burden of death, disability and disease.

On the other hand, unsafe act is a performance of a task or other activity that is conducted in a manner that may threaten the health and/or safety of workers (Hosseinian and Torghabeh, 2012). Behind every unsafe behaviour or unsafe act, there is a reason that those people engage in those acts. According to Henrich there are three major reasons behind the unsafe acts of the employees namely, overload, inappropriate response and inappropriate activities (Brauer, 2016).

However, all workplaces should be safe to work for all workers. Occupational safety and health should not be restricted to the industry as this is a cross cutting issue for all working sectors (Amarasinghe, 2013). It is the duty of the employer to provide all equipment which is intended to be worn or held by a person at work which him against one or more risks to his health and safety (Branson, 2015). Moreover, Amarasinghe (2013) explained that there is an equal responsibility lies with the employees as they are obligated to use the supplied personal protective equipment as per the Factories Ordinance and the Workmen's Ordinance of Sri Lanka.

However, it has been noted that many organisations have made substantial efforts to ensure that facilities and equipment are designed for safe operation, and that appropriate safety management systems are in place. However, all too often, employees are still having accidents. The reason behind these accident is the human errors (Sellers and Eyre, 2000). One of the important way of preventing the human errors is management of behaviours (Dekker, 2002). A lot of times, that has to do with the management system - the way people are measured and rewarded, the culture of the organization that leads unsafe behaviour to be exist (Cooper, 2001). Managers have to look at the causes of accidents as being a combination of a management system and a culture or environment that leads to human error (Ganguly, 2011). In this context ethical climate of the organisations can be used as an effective tool as to manage the behaviours hence improve the occupational safety and health practices.

2.2. ETHICAL CLIMATES

It is important to note that many types of climates exist within the organizational framework: climates for safety compliance, community service, and innovation are just a few that have been researched (Moore and Moore, 2014). Among those, the ethical climate concept has derived from the idea of organisational climate which refers to the way people perceive the environment of their workplace (Coetzer, 2015). According to Victor and Cullen (1988), organisational climate types can be categorized into two broad classifications. The first category relates to the aggregated perceptions towards structure and procedure forms for the use of rewards and control. The second concerns the aggregated perceptions of the existence of organisational norms supporting certain values.

According to Victor and Cullen (1988) climate types under the second classification have an ethical basis. Based on this premise combined with Schneider's (1975) conceptualisation of multiple climates in an organisation, Victor and Cullen (1988) hold that there should be a climate that guides organisational members to determine what is considered right and wrong behaviour at work, which they name ethical climate.

Therefore, according to (Cullen *et al*., 2001) ethical climate refers to the shared perceptions of organisational members regarding what is considered correct behaviour in the organisation and how the organisation deals with ethical issues. Moreover, Lombardo (2013) defines organisational ethical climate as the moral atmosphere of the work environment and the level of ethics practiced within a company. To clearly define the ethical climate of an organisation, Victor and Cullen (1988) employed theories derived from philosophy, psychology, and sociology. A two-dimensional model is then devised to describe possible various ethical climate types in organisations.

The first dimension called ethical criterion. This dimension refers to the considerations that individuals take into account when making ethical decisions. The basis of this dimension is the three basic ethical theories, namely, (1) egoism, (2) benevolence or utilitarian, and (3) principled or deontology. That is, whether the decisions associated with their own self-interest (egoism), the interests of as many people as possible (utilitarian), or the adherence to certain principles of right or wrong (deontology) respectively.

The second dimension called locus of analysis. It concerns the referent from which individuals receive their cues regarding what is considered ethically appropriate in decision making (Peterson, 2002). This dimension is derived from sociological theories of roles and references group as proposed by Merton (1957). Merton suggests the distinction between a local and a cosmopolitan referent that might help shape the behaviours and attitudes of role incumbents in social system. The sources of role definitions for the local incumbents are contained within the social system. For the cosmopolitan role incumbents, the referents of role definition are in social system external to the system in which the actor is embedded.

Gouldner (1957) apply these conceptions in organisational contexts. The local referent refers to the organisation itself (e.g., the organisation's standards and policies). The cosmopolitan referent is pertains to the organisation, such as the community or religious values (Martin and Cullen, 2006). Victor and Cullen (1988) extend the work of Gouldner (1957) to include another referent called individual. This referent is located within the individuals themselves (i.e. their own personal ethics). They develop a typology comprising nine theoretical ethical climate types as shown in Table 1.

Table 1: Theoretical Ethical Climates Types

Locus of Analysis / **Ethical Criteria**	**Individual**	**Local**	**Cosmopolitan**
Egoism	Self interest	Company interest	Efficiency
Benevolence	Friendship	Team play	Social responsibility
Principle	Personal Morality	Rules and procedures	The law or professional codes

Source: Victor and Cullen (1987)

This typology clarifies the interaction of the two ethical climate dimensions in an organizational context. In the context of the egoism criterion, the loci of analysis identify the particular "self" in whose interests one is expected to act (Victor and Cullen, 1988) with no consideration of other constituents' interests. Therefore, in the self-interest (egoism-individual) climate, the egoism criteria (the maximisation of self-interest) are used for the needs of one's own self, such as personal gain. In the company interest climate (egoism-local), the considerations are for the organisation's interest such as corporate profit. Finally, in the efficiency climate (egoism-cosmopolitan), considers society's best interest, for example, the efficiency of the social system.

In the context of benevolence criteria, the loci of analysis both identify for organisational members "who we are" and set the boundaries for "our concerns" (Victor and Cullen, 1988). In the team play (benevolence-local), the criteria are applied for the organisational collective. In the social responsibility climate (benevolence-cosmopolitan) the criteria are considered for other constituents outside the organisation, for example, caring for the interests of society as a whole suggests a concern for social responsibility.

In the context of the principle criterion, the loci of analysis define sources of principles expected to be used in the organisation (Victor and Cullen, 1988). In the personal morality (principle-individual) climate, organisational members are expected to be guided by their own personal ethics. In the rules, standard operating procedures climate, the source of principles comes from the organisation itself, such as organisational policies and codes of conduct. In the laws or professional codes climate the source of principles is outside the organisations, for instance, legal system, professional codes and religious values.

2.3. OCCUPATIONAL HEALTH AND SAFETY AND ETHICAL CLIMATES

As discussed in the previous section ethical climates represent a subset of the array of work climates and refer to the institutionalized organizational practices and procedures that define what is considered right or wrong within the organization.

As argued by many researchers, the organisation and its sub unit have the most important influences on the safety behaviour of the individual employee (e.g., Katz-Navon *et al*., 2005; Neal *et al*., 2000). According to Parboteeah and Cullen (2012) by investigating the local level, one can more accurately tease out the effects of the plant level climate on occupational health and safety. Additionally, plant level climate reflects a condition that is within the organizations ability to change. In contrast, other loci of analysis such as the individual or the cosmopolitan are not considered, because they do not necessarily reflect the strongest influence of ethical climate on safety behaviours.

It is argued that there are compelling reasons to expect a strong link between local ethical climates and workplace safety. Schneider (1990) defines climates as ‘‘incumbents perceptions of the events, practices and procedures and the kinds of behaviours that get rewarded, supported and expected in a setting.’’ Since ethical climates are concerned with issues that relate to workers overall welfare and well-being, it can be believed that the ethical climate within any plant will provide guidance as to the appropriate safety enhancing behaviour. Climate perceptions provide guidance to employees with respect to the types of role behaviours that will be rewarded and supported in the organization (Zohar and Luria, 2004). Therefore, the following section discusses the links between occupational health and safety and three ethical climates namely, egoist-local climates, Benevolent-local climates and Principled-local climates.

Egoist-local Climates

As discussed earlier the egoist dimension is generally based upon the maximization of self-interest (Cullen *et al*., 2003). Therefore, it is believed that in the egoist climate the decision-maker is likely to choose alternatives that benefit himself/herself the most while ignoring the needs of others (Martin and Cullen, 2006). Moreover, in the context of the local locus of analysis, decisions are made based on profitability or efficiency considerations at the expense of the individual well-being (Victor and Cullen, 1987; Victor and Cullen, 1988).

It is argued that an egoist-local climate will be associated with increased incidences of injuries in a plant. In an egoist-local climate, employees perceive ‘‘that self-interest guides behaviour, even to the possible detriment of others’’ (Martin and Cullen, 2006). If employees perceive that the organization is promoting the material well-being of the company at the expense of the well-being of the individual employees, they are less likely to be concerned about safety. In fact, they are more likely to be careless about the impact of their actions on others. Furthermore, safety programs are costly and can expect that the organization may not necessarily devote the resources to safety if they are focused on efficiency.

Consequently, it is likely that the egoist climates place pressures on employees for production and profitability. Therefore, can expect that in such egoist-local climates, there are higher incidences of injuries because of the exclusive emphasis on the productivity and profitability of the business.

In contrast, safety-compliance behaviours are seldom acknowledged in such climates. Safety-compliance behaviour seems inconsistent with an egoist-local climate, as it may not necessarily contribute to organizational efficiency and profitability. In fact, it more likely that employees will behave in self-interested manner and be less motivated to comply with safety standards and, more motivated to achieve production goals. Furthermore, it is also likely that as employees see others behave in self-interested fashion, they will be less likely to see the importance of safety and thus less motivated to comply (Zohar, 2002).

An egoist-local climate is also unlikely to promote the cohesiveness and active caring that has been shown to be so crucial to making employees feel more responsible for the safety of others (Simard and Marchand, 1997; Zacharatos *et al*., 2005). Exclusive focus on profitability and efficiency is likely to discourage employees from voluntarily participating in activities that enhance the safety of their colleagues.

The expectation is that individuals are not concerned with the well-being of others (Victor and Cullen, 1988). Under such conditions, it is seems unlikely that the workers would be motivated to voluntarily participate in safety programs. This lack of caring for the individual is likely to be manifested in lower motivation to participate in safety enhancing behaviours. Therefore, if egoist-local climate exists in an organisation, the organisation should identify and address the factors that influence the individual's determination of what is in their self-interest to include the personal benefits from maintaining a safe work environment.

Benevolent-local Climates

Benevolence is primarily based on concern for others (Victor and Cullen, 1987; Victor and Cullen, 1988). Within such a climate, the decision-maker is likely to make those decisions that result in maximum collective gains even at the expense of individual needs (Cullen *et al*., 2003). In the benevolent-local climate, the focus is on the well-being of those in the organisation. Therefore, a person perceiving a benevolent climate is most likely to be concerned about others in the plant and will make those decisions that provide the greatest good for the greatest number of people (Martin and Cullen, 2006).

Given the above, a benevolent-local climate is inherently concerned with concern for the welfare and greatest good for the greatest number of people (Parboteeah *et al*., 2005), of which safety is a likely an important component. It is therefore expected that workers respond to a benevolent climate by being more aware and concerned about safety issues. It is further argued that if workers perceive others to be showing concern for their own safety, they are also more likely to be aware of safety issues and to be motivated to enhance their own safety (Barling *et al*., 2002).

According to social exchange theory (Blau, 2009) when employees perceive that their organization values and supports them, an implied obligation develops on their part for future mutuality that will benefit the organization. Due to the high level of concern for safety and the collective well-being fostered by a benevolent climate, and the sense of mutual obligation surrounding safety (Hofmann and Morgeson,1999) workers are more likely to go beyond mere compliance and are more voluntarily motivated to participate in activities that promote safety within the organization. Thus, researches have suggested that organisations need to devise systems and structures to build an environment where employees genuinely care about each other's wellbeing.

Principled-local Climates

Victor and Cullen (1988) ethical criterion of principle embodies the application or interpretation of rules, laws, and standards in the normative expectations in a social unit. In general, when faced with an ethical dilemma, organizational or group norms suggest that the decision-maker resort to decisions that are based on adherence to rules and codes (Martin and Cullen, 2006). The expected sources of principles for such moral reasoning can be internal to an individual with a principled-individual climate, or external such as with a local ethical code (principled-local) or a broader code such as the Bible or state and federal laws (principled-cosmopolitan) (Victor and Cullen, 1988).

Principled climates are manifested through the application of organizational rules and codes of conduct (Martin and Cullen, 2006). As such, it is expected that in stronger principled climates, employees will be more motivated to comply with established safety requirements (Ismail, 2015). Therefore it can expect that principled climates to be positively related to safety behaviours as the inherent emphasis on security encourages employees to be more motivated to behave safely.

Additionally, it is expected that workers will be more motivated to participate voluntarily in safety programs in principled climates based on progressive personal and organizational policies and procedures that solicit employee participation in safety (Parker *et al*., 2001). In contrast, weaker principled climates may not place as much emphasis on safety and may not motivate voluntary participation on the part of the employees. Hence, managers are encouraged to establish and maintain a principled-local climate and foster adherence to company rules and procedures while simultaneously maintaining safety policies and procedures.

3. SUMMARY

Work place safety or occupational health and safety is an important aspect in any type of organisation. Therefore, there should be strategies to enhance workplace safety in the organisations. Moreover, literature identified that employee behaviour is a crucial factor in maintaining a safety environment. Various researchers have identified various methods to enhance the safety behaviours in the organisations and ethical climates can affect in employee behaviours. Thus, this paper reveals the strategies to enhance workplace safety through aligning safety initiatives with ethical climates. Figure 2 summarises the literature review of this study.

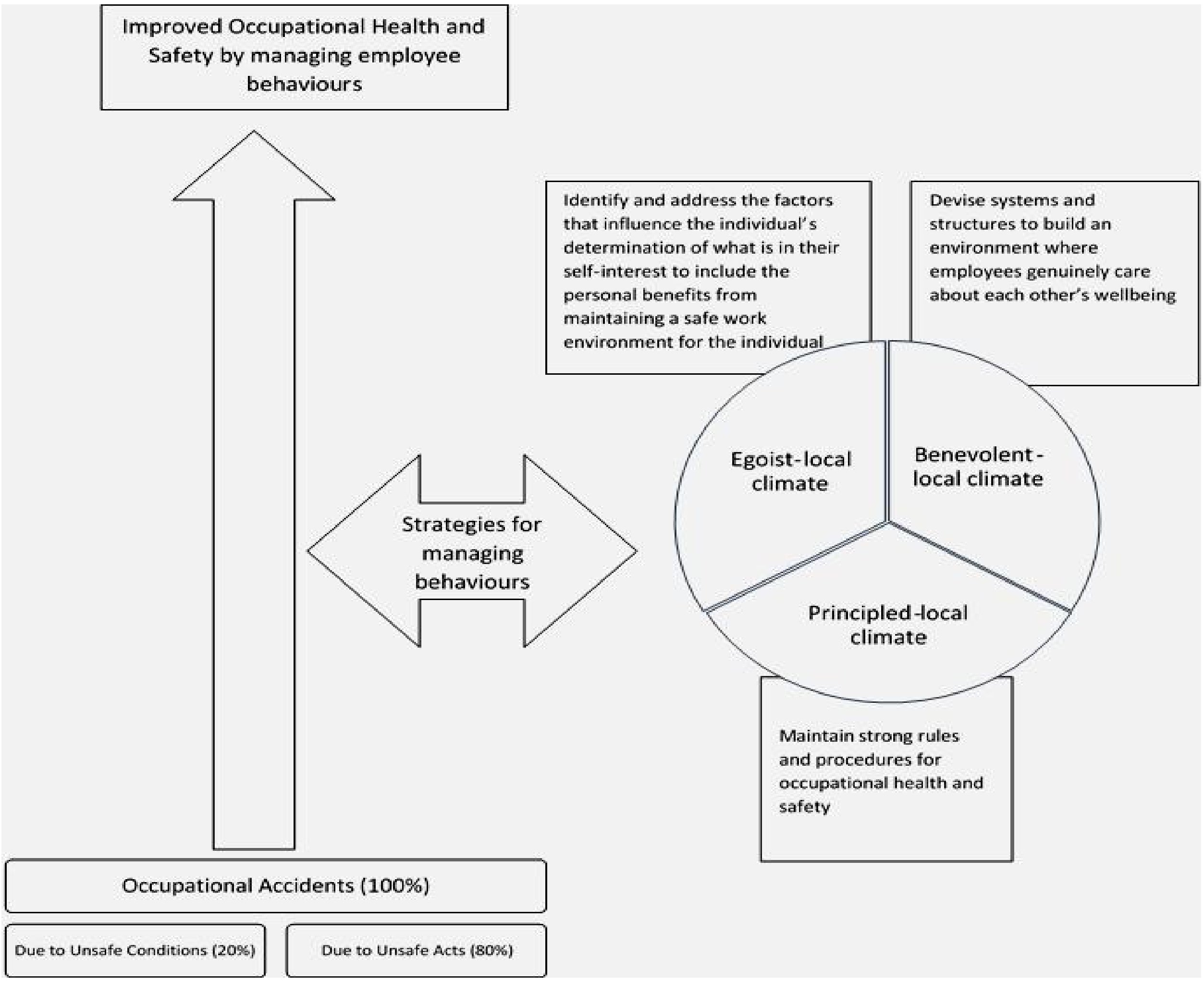

Figure 2: Summary of the Literature

It has been noted that the ethical climate exists within one organisation can defer from another organisation. The organisations with egoist-local climate can enhance the safety of the employees through identifying strategies to address personal benefits of the employees by maintaining a safety behaviours. The employees within the benevolent-local climates are inherently associated with the safety behaviours. Therefore the organisations with benevolent-local climate should devise the systems and structures to enhance caring of each other in the organisation. Moreover, it was revealed that as principled-local climates are positively affect on the employee safety behaviours, it is beneficial if organisations can transfer their organisational ethical climate into principled-local climate. Moreover, organisations with principled-local climate should maintain strong rules and procedures for occupational health and safety.

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REVIEW ON LEAN CONSTRUCTION AND TPS APPROXIMATION WITH BIM

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ABSTRACT

Lean construction is a substantial feature of construction including both pre-construction and post-construction activities which leads a project towards a successive or catastrophe end result. Nowadays, most of projects frequently face uncertainty and it causes to produce continuous waste throughout the construction process making negative outcomes of quality, cost, time and scope. Synergy of TPS (Toyota Production System) philosophy and BIM (Building Information Modelling) methodology is the key to diminish the above-mentioned project hazards which creates an opportunity to stimulate the construction process by avoiding negativity for a better lean future. Hence, aim of the paper focuses on determining most effective potentials that could be derived from the Toyota way philosophy to incorporate to BIM to benefit the lean construction industry.

A qualitative approach has been used considering the nature of the research, comprises of primary and secondary data collection which totally ran across information grabbed from online publications concerning the reliability of sources.

Evidences revealed that TPS-BIM model has agreeably accepted by construction field and the features of this model need to be more precised and refined to achieve more accomplishments in conditions of leanness. It was revealed that even if the method of synchronizing TPS capabilities on BIM tools by balancing nature of human dynamics along with technological endeavours, TPS-BIM integrated elements need more amendments and verifications to perform with its superlatives. Moreover, lean principles derived from TPS contain adequate capabilities to up heave BIM potentials to maximize the benefits in construction with all the positivity throughout the process.

Keywords: *Building Information Modelling (BIM); Lean Construction; Toyota Production System (TPS).*

1. INTRODUCTION

In the present context, which heading to a digit imminent; draws parallels in between technology and humanity as a respond to necessities gathered around. Building Information Modelling (BIM) can be identified as an incipient approach which guides to achieve better lean construction through principles by eliminating negative aspects behind. Though the BIM procedure is already in practice elsewhere in the field with positive responses, still it has potential to explore to deepen the existing knowledge through theoretical understanding and sometimes with collaborations. One such possibility is integration and resembling of Toyota Production System (TPS) philosophy along with BIM. TPS is the well-known example for the best practice of lean concepts to improve production cycle. Hence, this paper pursued to study the improvements that could be made by the philosophy of above mentioned TPS on BIM to achieve and succeed better lean construction.

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2. BACKGROUND

Productivity in the construction field is challenged all over the world and in contemporary situation. There is a competitive pressure is steadily increasing among product manufacturing companies which demand increased quality, added functionality, lower prices and speed of innovation; so companies must develop more desirable products ahead of their competitors before new technology emerges or market conditions change (Welo, 2015). So, it is questionable, how new product development practices can be improved to sustain competiveness (Welo, 2015). With this recent necessity, construction field use to practice the concept of 'lean' in order to achieve maximum output with minimal waste based on the core idea of lean concept (Marhani *et al.*,2012). In another way lean can take to mean as generating more assessment for customers with fewer resources. Lean construction defines the connection in between lean thinking and construction including fast time adjustments, low wastage and contemporary market address. Collaboration of these ideas stand for 'lean thinking' which shaped around the main theme of value.

BIM is a great technological achievement in recent years from architecture, engineering and construction industry which designates building designing process integrated with a comprehensible system of computer models which link between separate sets of drawings (Boton *et al*., 2013). Although the features of BIM model is more like 3D geometrical, it reaches assured advance extend with its integration of other building analysis applications such as cost estimating, energy simulation, day light, computational fluid dynamics, space planning and building code checking within the model (Kumanayake and Bandara, 2009).

The term 'lean' was taken into act by Toyota's business in 1980's (Marhani *et al*., 2012). It is competent throughout many centuries with its thoughtful proficiencies which can be identified mainly under five principles of technological invention of Building Information Modelling; commonly known as BIM agreeably blend with this 'lean' concept and it focuses to deepen the scope of construction in positive manner. With regards to recognizing connection of BIM and lean thinking logic have been utilized independently as huge individual ways to deal with entire development ventures change. Their mix, given few situations, presents chances for development and difficulties in usage (Hamdi and Leite, 2012). BIM usage mainly concern on the reduction of time cycle which belongs to lean principles too. Also it highly requires accomplished individuals to find its maximum benefits. The second priority moves across the efficiency and redeemable of owner's money (Sacks *et al.*, 2010). In contemporary situation time and money are the significant and tempting facts to be concern which BIM process simply assists and cover up already with the connecting key factors of experience and skills. So, in that sense BIM can be identified as a context changer which addresses to the existing exact needs accordingly. As long as it addresses to the contemporary needs and requirements, it is being accepted for the current construction industry and last till new demands and challenges gets in. Despite the fact that the principle of BIM does not fulfil the criteria of three dimensional geometry demonstrating, it goes afar and accomplishes more over with precised data (Smith and Tardif, 2009). In that way the great synergic fitting of lean and BIM cure to invigorate activities of one another.

3. LEAN CONCEPT

The big picture of 'Lean' is generating customer based significance over less possessions (Dombrowskia and Mielkea, 2014). The connecting fact can be identified as 'productivity' of these two ends of customer value and diminished waste and foremost focus is gathered around this connecting fact to exhaust the possibilities. With compare to mass production, it uses only half of human power, work spaces, investment and also most importantly the fact of time (Sundara *et al*., 2014).

Statement of most claims this 'lean' concept as a key cause of Japanese accomplishment. Developing lean management at Toyota Motor Company for the first time could be the reason for that and it happened just after the great impairment of Second World War would be backing up it in all the way (Jayaram *et al*., 2010). In that way even the initiate stage of developing the concept of 'Lean' hits the market where it's necessary and success of car industry which was established by TPS motivates to move parallel to it with all the way success with powerful and significant techniques (Jayaram *et al*., 2010). With the flexible quality of the concept most of the concerns have implemented lean in their own unique adequate way by evaluating its utilizable potentials (Torielli *et al.,* 2010).

4. THE TOYOTA PRODUCTION SYSTEM (TPS)

TPS is a lean manufacturing process initiated in Japan, around 1940 after great loss of World War II and Taiich Ohno has been credited as the father of TPS. In between 1948 and 1975 the system developed with the collaboration of Taiich Ohno, Shigeo Shingo and Eiji Toyoda and it was very famous after oil crisis occurred in 1973 with respect to its effective performances. The essence of TPS can be concluded into three figures of reduced set up times, small-lot production and employee involvement/empowerment with the inclusion of seven numbers of principles (Jayaram *et al*., 2010). Also, TPS is consisted of three concepts named JIDOKA (highlights the causes of problems because work stops immediately when a problem first occurs), Just-in-time (JIT) and Kanban system (Koskela, 1992; Liker, 2003). While the JIDOKA concept highlights problems, JIT complete elimination of waste and the duty of reducing excess production by the concept of Kanban. Goals of TPS have been identified as flexible production process, participation of all employees in the work process, reduce inventory through elimination of imperfection or problem, highly interdependent systems thinking-tools and techniques etc. and outcome of TPS, such as reduction of lead time to a great extent, quality improvement, one of ten largest companies in the world, largest car manufacturer low cost and fast response always back-up by them with a nice synergetic influence (Liker, 2003).

4.1. MAJOR THEMES IN TPS RULES AND TPS PRACTICES

The mandates of rooting out defects, eliminating waste and reducing lead time nicely blend the lean philosophy and TPS with respect to the actionable principles. The principles come along with the TPS are not represented through individual practices but through the processes of production system related to Toyota designs. Identification of new practices and principles causes innovations of Toyota and that stresses on the design decisions of TPS. The production system is defined in terms of ‘activities’, ‘connections’ and ‘pathways’ by the TPS experts and system design decisions guide splitting of business processes into individual activities, making direct connections between activities and streamlining pathways. Furthermore, TPS continues exploring new approaches and work methods based on the systematic problem solving method.

As per TPS guidelines are stressed under two topics of, making structural work plan facilitators for critical thinking by structurally organizing learning at the most minimal conceivable level in association and systematic critical thinking (Spear and Brown, 1999). As indicated by TPS, both inner and outside connections are associated when understanding the whole framework (See Figure 1). Its primary goal is to distinguish, evaluate and eliminate sources of variety with respect to whole framework.

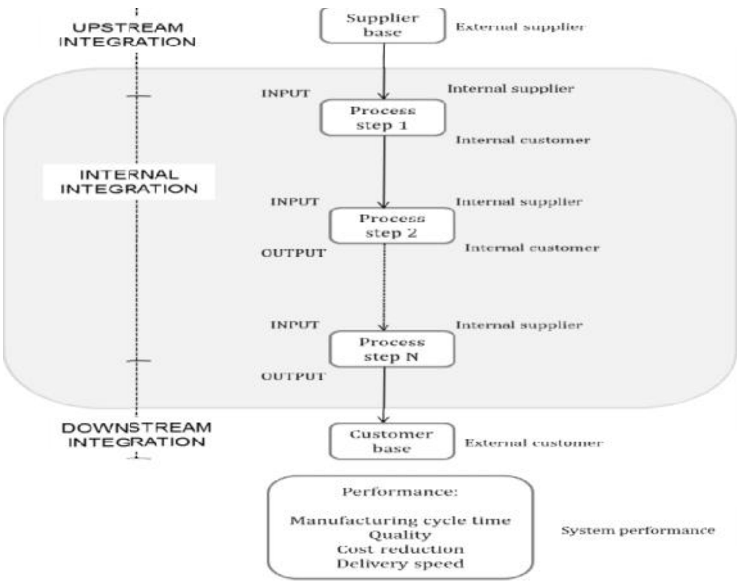

Figure 1: Structural Links Internal and External to the Organization

5. TPS VIRTUALLY TOWARDS BIM

The fundamentals of BIM have impressed the construction industry immensely. Though these two concepts TPS and BIM are autonomous in their origin, the collaboration of the two concepts have produced more impact (Eastman *et al*., 2008; Hattab and Hamzeh, 2015). The way BIM respond to eliminate waste in construction; approach of encouraging organizational forms by BIM regarding lean and characteristics generated by BIM to stand against to promote or interrupt flow could be pointed out as few synergies of them (Sacks *et al*., 2009a).

5.1. EMPIRICAL EVIDENCE LINKING BIM AND TPS PHILOSOPHY

A strong synergic effect has been observed between TPS principles and Computer Advanced Visualization Tool (CAVT), which concludes end results of improved flow, waste reduction and customer value by stressing on design stage of construction (Rischmoller *et al*., 2006). Similarly, integration of Virtual Design and Construction (VDC) and Lean Project Delivery System (LPDS) process is another attempt of linking TPS processes with BIM, due to the overlaps of underlying principles and technologies of them (Khanzode *et al*., 2006). The application of VDC at the correct stage is highly appreciated to meet its best improvements in the LPDS (Sacks *et al*., 2009a). Contribution of BIM potentials in regards to TPS principles to visualize the product and process aspects and found a significant reduction of 'variabilities' in the construction projects by allowing a "pull flow" mechanism (Sacks *et al*., 2009b)

Automated capture, semantic search capabilities and eternal data compatibility are identified as issues of knowledge management occur due to the integration of management and utilization databases (O'Brien and Hammer, 2006). Even though these capabilities are included in many projects, both BIM and TPS would be required to reach more capabilities all-inclusive and; preparation and organized careers are highly appreciated for backing both BIM and TPS philosophies (O'Brien and Hammer, 2006).

The interaction nature of BIM functionality and TPS philosophy always lead to success destination in a precised and detailed manner. The methodology part is given by the side of BIM and technical mechanism all the way come along with it and the utilization of that mechanism is fulfilled by the thoughtful ideas generated by TPS philosophy. With the synergy of technical and ideological ingredients it always creates logically acceptable effective results with more potential yet to be revealed.

5.2. BIM FUNCTIONALITY

BIM knowledge gives key aspects of functionality for assessing, altering, compiling and reporting data identify with building projects and this knowledge encourages BIM tools to develop building's structure, function and behaviour and that makes all conceivable functionality angles as underneath (Tommielein, 1999; Sacks *et al*., 2009c).

- Visualization of structure with the form
- Rapid generation and assessment of multiple design substitutions
- Maintenance of information and design model reliability
- Collaboration through design to construction
- Rapid generation and evaluation of multiple construction plan substitutions
- Online/electronic object-based communication

The shown functionality develop to the concern rather than the central technology, as for the reason for examination or more specified things touch exposed functionality concerning the advantages or disadvantages happen in their use.

6. METHODOLOGY

The preliminary stages of a research involve the review of the literature relevant to the topic under analysis. The main topics addressed within the literature synthesis were; lean concept, TPS and virtual to BIM towards lean construction. Literature review was done while developing the research methodology as well, as this study is a qualitative research which normally requires a broad knowledge to design the project. Since this research problem resembles a qualitative research approach rather than a quantitative one, the study was limited to a content analysis, whereby data are gathered by reading the data published on different sources. Interviews, questionnaires, and direct observation of human behaviour are highly sort after for the qualitative analysis. But was not achievable for this context as BIM and TPS is not in function in Sri Lanka.

7. FINDINGS AND DISCUSSION

TPS philosophy and BIM methodology synergy has brief in matrix as revealed in Table 1 to get a better understanding of the big picture and this figure is totally based on the lean principles related to TPS philosophy and BIM functionality features related to BIM methodology. Interaction of BIM functionality and lean principles creates a framework to move steps ahead by revealing possible and related potentials accept by the context. The synergy of TPS philosophy and BIM methodology most of the time backing by issuing positive face of results, but in some times with negative results too. If BIM makes effective impacts on philosophy with higher percentage at the end it counts under positive reaction and if the percentage is zero or below the rate, counts as negative by stimulating to research further to improve up to the acceptable rate under positivity.

BIM-Lean influence analysis depends on two main criteria and that system utilizing strides can be identified as proposing conceivable connections and looking for exact evidence to either strengthen or challenge them. According to this analysis it proposes 55 particular cooperation based on both research evidences and literature. All the interactions based on research evidences are properly justifiable with all necessary proofs under a debatable logic. But other interactions based on writing study, comes with questionable arguments as they do not proof yet on a logical platform. BIM functionality effects make by every feature belongs to it; evaluated by definitions accommodated for both principles related to philosophy and functionality related to methodology. Positive interactions shown with (*) while (x) denote negative interactions.

As listed in Table 1, the clarifications accommodated for every interaction propose the conceivable connections. They are not esteemed to be demonstrated by empirical evidence; but instead they are nominees for corroboration or inconsistency through estimation in future examination. Where episodic or other proof is accessible, the proper sources are referenced in the third section. The areas of reported proof has not been discovered, have noted ‘not yet available’ and these extents are possibly prolific ground for future empirical examination to substantiate or repudiate the associations.

Table 1: Lean BIM Interaction Matrix

Lean principles / BIM functionality		Reduce product variability	Reduce production variability	Reduce production cycle	Reduce inventory	Reduce Batch sizes	Reduce changeover times	Use multi skilled teams	Use pull systems	Level the production	Standardize	Institute continuous improvement	Visualize methods	Visualize processes	Simplify	Use parallel processing	Use only reliable technology	Ensure the capacity of the production system	Ensure comprehensive requirements capture	Focus on concept selection	Ensure requirement flow down	Verify and validate	Go and see for yourself	Decide by consensus, consider all options	Cultivate an extended network of partners
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Visualization of form	1	*													*				*		*	*	*	*	
Rapid generation of design alternatives	2	*		*									*	*		*									
Predictive analysis of performance	3	*	*	*			*												*	*		*			
Automated cost estimation	4		*	*												*						*			
Evaluation of conformances	5	*	*	*															*	*	*	*			
Single information source	6	*	*																		*				
Automated clash checking	7	*	*	*																		*			
Automated generation of drawings and documentations	8	*		*	x	*											*	*							
Multi user editing of a single discipline model	9			*						*						*									
Multi user viewing	10	*		*				*											*		*	*		*	
Automated generation of construction tasks	11	*		*	x		*								x										
Construction process simulation	12			*	x					*					x					*		*			
4D visualization of schedules	13	*		*	x						*		*	*		*						*		*	
Visualization of process status	14			*	*	*			*					*			x					*	*		
Online communication of process and product information	15	*		*	*	*			*		*		*	*			x				*			*	
Computer controlled fabrication	16	*		*			*																		
Integration with project partner databases	17		*	*					*								x								*
Provision of context fur states data collection	18		*		*	*			*			*					x					*	*		

7.1. *POSITIVE AND NEGATIVE INTERACTIONS OF IMPLEMENTING INTEGRATED TPS-BIM FRAMEWORK*

According to the matrix there are number of characteristics towards positive and negative interactions for specific BIM functionalities and lean principles. These characteristics help the management to observe and recommend guidelines while implementing lean and BIM, which will in return assist the managers to understand and realize the positive interactions in practice. Following are the highest concentration of unique interactions of lean principals

- "Get quality right the first time [reduce product variability]" (A),
- "Focus on improving upstream flow variability [reduce production variability]" (B),
- "Reduce production cycle durations" (C).

Above points have higher interactions comparatively to any other principles. Nevertheless interactions are not just bound to BIM functionalities but also influenced in design and construction. "Aesthetic and functional evaluation", "Multi-user viewing of merged or separate multi-discipline models", "4D visualization of construction schedules" and "Online communication of product and process information" are the BIM functionalities which have the highest concentrations of unique interactions. Even though these factors are not precise compared to the leading lean principals, three of these four factors are reflected in fabrication and construction management as BIM is recognized primitively as a design tool by many. It is identified that "Reduce inventory" (D), "Simplify production systems" (N) and "Use only reliable technology" (P) are the negatively impacted or least served principals. BIM helps to increase information inventory, and also it helps to well organize the flow of information. Due to technological advancement of the BIM tools if the users lack knowledge, skill or ability or if the applications are not rich process can be unstable. Also if the tools are not properly implemented and managed process can be complicated. And also buyers of model information are reluctant to rely on the models due to margin of error as models are often incomplete and detailing in different areas varies. The single information source is the BIM functionality which least offers the support for lean principals.

It has shown that use of Information Technology (IT) in construction management was not always a win to provide a positive impact on the return on investment. Under-utilization and interoperability issues are the key issues identified in BIM adoption and lean construction initiatives can be complicated due to lack of conceptual understanding.

Also it was established that compatible re-alignment of business processes is an important piece of IT benefits. In other words IT benefits rely on compatible re-alignment of business processes. As a matter of fact they develop this scope in the context of construction in order to affirm that re-alignment is required for basic understanding of the unique features of construction. When it comes to lean construction and BIM, information and material processes should not only logically dependent on these two but also be established firmly in conceptual understanding of the theory of production in construction.

Compared to traditional measurements from drawings, shorter cycle time is gained by extracting the quantity take-off from a building model. If the management recognizes;

That the shortened cycle time shifts the bottleneck in the process to other activities, and

That the overall design management approach can be re-aligned to bring designers and estimators to work together

It would help to increase efficiency by reducing repetitive design. No matter whether the project participants have an idea or not the cycle-time is reduced by BIM, even though the comprehensive benefits can be gained via thorough understanding of its meaning. As a crucial fact, rather than considering the interaction of lean principles and BIM in construction as the sum of the isolated parts better to consider as a whole and complete process while interpreting the interaction matrix. Multiple lean principles are supported by each functionality and conversely and more effective when working together rather than working alone. Due to the same reason experts cannot identify all of the interactions and their impacts. Exploration and trialling by practitioners help some to get through.

As examples of such holistic interactions, topics of BIM as a boundary object and construction tolerances can be taken into consideration even though they are not mentioned in the interaction matrix. In business and social interactions it has been identified that BIM technology as the entity which enhances the capacity of the theory. Nevertheless, these business and social interactions need organizational change and also it make the process smooth in the organizational change. Even though this is not an issue that most are familiar, lean transformation can use BIM technology as a stimulant.

Management of dimensional tolerances in construction is not handled properly. Even though advanced tolerance analysis and management capabilities were unavailable in previous 2D CAD versions, it helps BIM to improve tolerances related to space. This helps prefabrication and assembly of high tolerance components. In order to put up with leaner processes higher precision tolerances are required. This is due to reduction of variability, resultant wasted in the construction process and reduction of losses. As the effect is comprehensive and deviant, experiments should be carried out or should be proven via observations etc.

8. SUMMARY AND CONCLUSION

TPS-BIM framework made out of TPS philosophy and BIM methodology, provide surfeit of benefits for construction industry mainly by revealing potential of JIT delivery, eliminated waste and shorter production cycles and interactions between all necessary parties by utilizing potential and benefits. As a whole TPS-BIM framework creates impact on the construction industry by maximizing benefits and influencing to gain more in the future.

Individuality of BIM and lean principles derived from TPS do not achieve the maximum leanness of the construction; but with the synergy of them. Even though BIM elements capable to find it’s best at some application most of the time lean principles of TPS required to shape up and sharpen up the benefits of end result. The main reason for that is two different capabilities of these two components. That means, the strength of quantitative data handling by BIM get fills the gaps by TPS lean principles; where its’ strength covers the aspects related to quantitative criteria. Also it was emphasized and prove the effectiveness of BIM-TPS synergy with evidences in practical platform by revealing the strategy behind every success. According to the above mentioned evidences it also emphasize the improvements made by TPS on BIM as lean principles related to TPS always all the way focus on the human factors which is hard to manage and control. But that is where the management should highly practice as all these construction projects run on the practical situation with all the raises and falls. So in that way lean principles derived from TPS philosophy covers a really important and highly essential area which BIM cannot pay attention with its capabilities. So at the end, the combination of BIM and TPS creates effective end results by maximizing benefits it generates with its setup.

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RISK ALLOCATION BETWEEN MAIN CONTRACTORS AND SUBCONTRACTORS IN BUILDING PROJECTS IN SRI LANKA

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ABSTRACT

Risk is identified as a probability of occurrence of an event which may have an adverse impact on the project objectives. Therefore, risk identification and allocation in a well-defined manner is a mandatory prerequisite for a successful project. An optimum risk allocation between main contractor and subcontractor becomes crucial as because in most projects, considerable amount of risk is usually being allocated to subcontractors, and success of a project hugely depends on risk allocation decisions. Hence the aim of this research was to identify and prioritise risks which are common and significant to the relationship between main contractor and subcontractor and to develop a guidance to allocate those risks to the party best placed to manage them. To achieve the aim of this research first, an extensive literature survey was carried out to identify the common risks and to review the concept of risk allocation and its application to the construction industry. A questionnaire survey was carried out to prioritize those short listed risk factors and to find the optimum risk allocation between concerned parties. Through the analysis of collected data using RII, a 'risk register' and a 'risk matrix' were developed. It is recommended that the developed risk register be used as a guidance during the risk identification phase and risk matrix when allocating those risks between concerned parties.

Keywords: *Main Contractor; Risk Allocation; Risk Management; Risk Matrix; Subcontractor.*

1. INTRODUCTION

No construction project is risk-free. "Risk" can be defined as "unpredictable events that might occur in the future whose exact likelihood and outcome is uncertain" (Loosemore *et al.*, 2006, p.8).Construction industry is especially risk prone due to the fact that construction projects are one off projects with many features that make them unique to most industries (Taylor and Mbachu, 2014). According to Latham (1994 cited Lam *et al*., 2007), risk is "manageable, diminishable, transferable or acceptable but not ignorable". Therefore, a proper risk management process is essential to manage risks and successfully fulfil project objectives. Risk management can be viewed as a systematic approach to deal with risks (Edwards and Bowen, 1998). Risks, which are identified and allocated in a well-defined manner is a mandatory prerequisite for a successful project. Herein, risk allocation can be identified as a major function in risk management process, which allows the risks to be divided among the parties best placed to manage them (Hearn, 2004). Hence, in the context of construction projects, risk allocation becomes particularly imperative to project success.

In a construction project, main contractor is employed by the client and is responsible for the overall coordination of a project (Shekar, 2005). Nelson (2007) states that by entering in to a contractual agreement with client, main contractor explicitly assumes the risk of timely and complete performance of works agreed. By "subletting some or all parts of the work", the main contractor can "assign obligations and rights under the contract for building to others who are not parties to the contract, but at the same time retain the overall contractual responsibility as far as the head contract is concerned" (Uher, 2006). While risk allocation is mainly done through contract documents in the case of such subcontracts, this may not always yield results that are fair and is to the satisfaction of both parties (Lam *et al*., 2007). One reason for this is the unavailability and/ or non-usage of standard sub contract documents, which often results in main contractors preparing their own tailor made sub contract documents (Uher, 2006). This can

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often result in passing off the responsibility of most risks to others by the party that prepares the contractual documents (Lam *et al*., 2007).

Using a “risk register” and/or a “risk matrix” are precise ways of optimally allocating risks between parties. In the current construction context, these are used as tools, particularly in PPP/PFI (Public Private Partnership/ Private Finance Initiative) projects, to allocate risks between the client and the main contractor. Herein, “risk register” can be identified as a list of categorized risks and risk factors, while “risk matrix” in addition to above, shows to whom those risk should be allocated (Bing *et al.*, 2005; Ng and Loosemore, 2007). Hearn (2004) states that it may be prudent to develop a risk register or matrix to help identify risks and to keep track of how the risks are allocated and managed.

The risk allocation between the client and the main contractor has been vastly taken into consideration by many researchers. For instance, researchers such as, Grimsey and Lewis (2004); Bing *et al*. (2005); Ng and Loosemore (2007); Susilawati *et al.* (2009) have developed such risk registers/matrices for the purpose of risk allocation between clients and the main contractors. However, the risk allocation between the main contractors and the sub-contractors is often neglected in many researches (Artto *et al*., 2008). In research related to the Sri Lankan construction industry in particular, this area still remains untouched. Hence, the aim of this paper is to develop a risk register and a risk matrix, which can be used as a guidance for identifying and allocating the risks between the main contractor and the subcontractor in building construction projects Sri Lanka.

2. LITERATURE REVIEW

2.1. RISK MANAGEMENT

Both Royal Society (1991 cited Edwards and Bowen, 1998); CIDB (2004) have identified construction risk as a probability of occurrence of an event which may have an adverse impact on the project objectives in terms of time, cost and quality. Typically, risk is expressed in terms of probabilities and consequences (Loosemore *et al*., 2006). Herein, probability alludes to a judgement about the perceived relative likelihood of some event and consequences are measured in monetary terms (CIDB, 2004). Considering the above, risk can be assessed by multiplying the probability of the event by the consequence if it occurred (Hearn, 2004).

Risk = Probability of event x magnitude of loss/gain

According to Nieto-Morote and Ruz-Vila (2011) risks are neither ignorable nor fully eliminable. Therefore, as Baker *et al*. (1997) highlights the choice is between two options; either to accept the risks or to take measures to minimize their consequences. Both of these activities fall under the category of ‘risk management’, which could be described as the “process of proactively working with stakeholders to minimize the risks and maximize the opportunities associated with project decisions (Loosemore *et al*., 2006, p.29). The aim here is not to avoid risk but to take “calculated risks, make more informed decisions, avoid unpleasant surprises and identify opportunities” (Loosemore *et al*., 2006, p.29).

Baloi and Price (2001) argue that there is a direct relationship between effective risk management and project success. This is because risks are “assessed by their potential effect on the objectives of the project”. Loosemore *et al*. (2006) have strengthened the above argument by tracing failed projects with non-achievement of time, cost and quality back to the absence of proper risk management techniques. So it can be concluded that risk management is essential for the survival and success of construction projects. The following section of this paper briefly describes the risk management process.

2.2. RISK MANAGEMENT PROCESS

Risk identification, risk allocation, and risk handling/risk response are the key activities of the risk management process (Baker *et al*., 1997). From these, risk response; which is the process of developing strategic options, and determining actions, to reduce risk to the project’s objectives and enhance opportunities (Lam *et al*., 2007); is outside the scope of this paper. The focus of the paper is mainly on the first two activities, risk identification and risk allocation, which are further discussed below.

2.2.1. RISK IDENTIFICATION AND CLASSIFICATION

Nieto-Morote and Ruz-Vila (2011) has defined risk identification as a process of determining which risks may affect the project and documenting their characteristics. According to Flanagan and Norman (1993 cited Perera *et al*., 2009), an identified risk is no longer a risk, but a management problem. Classification of risk also falls under the risk identification category and entails identifying the type, consequence and impact of risk (Perera *et al*., 2009). The risk factors which were identified by the past researches that can be tabulated as given in Table 1.

Table 1: Risk Factors

Risk factor category	Risk factors	Reference					
		1	2	3	4	5	6
Political and Government Policy	Unstable government		✓	✓			
	Strong political opposition/hostility		✓				
Macroeconomic	Inflation rate volatility			✓			
	Interest rate volatility			✓			
	Influential economic events			✓			
Legal	Legislation change	✓					
	Changes in tax regulations	✓					
Natural	Weather					✓	
	Force majeure					✓	
	Geotechnical conditions					✓	
	Environment					✓	
Project Finance	Availability of finance			✓			
Residual Risks	Residual risks		✓				
Design	Delay in project approvals & permits	✓					
	Design deficiency	✓					
Construction	Construction cost overrun				✓		
	Construction time delay				✓		
	Material/labour availability				✓		
	Late design changes				✓		
	Poor quality workmanship				✓		
	Excessive contract variation				✓		
Relationship	Inadequate experience of contractor				✓		
	Inadequate experience of subcontractor				✓		
	Inadequate distribution of responsibilities and risks				✓		
	Inadequate distribution of authority in partnership				✓		
	Differences in working method and know-how between partners				✓		
	Bid shopping						✓
Third party	Staff crises					✓	

Source: Tchankova (2002); Harinarain *et al*. (2008); Edwards and Bowen(1998); Uher (2006); Loosemore *et al*. (2006); Hinze and Trazey (1994)

2.2.2. RISK ALLOCATION

Once the risks are identified, defined and classified, the next stage is to allocate these risks to different parties. Risk allocation involves the division of responsibilities associated with risks among concerned parties regardless of the methods (transferring, sharing, etc.) (Lam *et al*., 2007). Herein, it is important that the risks are allocated so that they rest with the parties that have control over them and are best able to manage them (CIDB, 2004). So, if one party is not in the best position to manage a concerning risk, there might always be another party willing to take that risk as the same risk event may create opportunities for the latter party (Loosemore *et al*., 2006).

2.3. ALLOCATION OF RISKS BETWEEN MAIN CONTRACTORS AND SUBCONTRACTORS

According to ICTAD(2007), main contractor is defined as a tradesman, who has signed a letter of acceptance with the client. Hinze and Tracey (1994) have defined 'subcontractor' as a specialty contractor, hired to perform a specific task of a project. According to Hinze and Tracey (1994), in many building projects, 80% to 90% of the total work is usually performed by subcontractors. Thus, success or failure and profit or loss of a project ultimately depends on the performance of the subcontractors (Nelson, 2007). Hence, optimum risk allocation between main contractor and subcontractor becomes crucial and ever important.

The issue of improper allocation of risks between main contractor and subcontractor and its resulting consequences have been highlighted by a number of researchers. Unavailability of the standard sub contract documents has been identified as a particular issue that can result in risks not being allocated to the party that is best able to effectively and efficiently manage them (Uher, 2006). Hanna *et a*l. (2013) note that the tailor made subcontract documents prepared by most main contractors are highly modified to suit their own requirements while allocating a large portion of risk to the subcontractor. Improper risk allocation between main contractor and subcontractor is further enhanced by client's limited involvement in sub contractual matters (Uher, 2006) and the practice of pre exposing subcontractor's bid price to prospective subcontractors (i.e. bid shopping) in order to come up with a significant lower bid price (Trangkanont and Charoenngam, 2014).

Risk matrix can be identified as a method of showing to which party, each specific risk is allocated together with their category and source if needed (Bing *et al*., 2005; Ng andLoosemore, 2007).Such risk matrices make it easier for parties to keep track of how the risks are allocated and managed between concerned parties (Hearn, 2004).

3. RESEARCH METHODOLOGY

This research aims to develop a 'risk register' by identifying and prioritising the risks between main contractor and subcontractor and a 'risk matrix' that could guide risk allocation decisions. A questionnaire survey was used as the main data collection approach in achieving this aim.

As shown in Table 1, 28 risk factors were identified through the comprehensive literature review and these were used to develop the initial questionnaire. This initial questionnaire was refined using four informal expert interviews (two main contractors and two sub-contractors). These informal interviews were useful to ensure 'sensitivity to participants' language' and 'privilege' [from] their knowledge', especially relating to the Sri Lankan context (Fossey *et al*., 2002). Considering the input of the interviewees, the initial questionnaire was further refined by removing three of the risk factors (i.e. 'unstable government', 'force majeure' and 'staff crises') identified in Table 1. The interviewees noted that these risks are not passed down to the subcontract level and are usually borne by the client or determined at the main contract level. Hence, the three factors were omitted from the final questionnaire as they were deemed not applicable to the relationship between the main contractor and subcontractor in the Sri Lankan construction context. Four new risk factors (i.e. 'political support', 'price increasing of materials', 'working capital' and 'specialized design') were instead included considering the interviewees' suggestions. These factors were not identified through the literature review, but were deemed important by the interviewees as they were prevailing risks when it comes to the Sri Lankan context. Altogether, 29 risk factors were included in the final questionnaire sent out to respondents (refer Table 2).

The developed questionnaire consisted of two main sections. The first section focused on identifying the frequency (or likelihood) of occurrence of each risk factor and their impact to the project objectives. This was necessary to develop a ranked risk register indicating significant risk factors related to the relationship between main contractor and subcontractor. Five point Likert scales were used to ascertain the frequency of occurrence (1-rare to 5-almost certain)and the level of impact (1-negligible to 5-severe) of each identified risk factor. The second section of the questionnaire, focused on allocation of risks between main contractors and subcontractors. Herein, two separate five point Likert scales were used to ascertain the optimum allocation for main contractor and subcontractor of identified risks.

The scope of this research was on main contractors with ‘C1’ CIDA grading and MEP sub contractors with ‘EM1’ CIDA grading in the Sri Lankan construction industry. Further, it was limited to building projects under conventional procurement method and to projects exceeding One Million Rupees of subcontract value. Convenience sampling technique was used to select the sample and questionnaires were distributed among 25 quantity surveyors (QS) from main contractors and 25 subcontractors satisfying the above criteria. Out of these, 21 main contractor QSs and 18 subcontractor QSs responded to the questionnaire.

3.1. DATA ANALYSIS

The Relative Importance Index (RII) can transform the findings of 5-point Likert scales in such a way that facilitates ranking of all the factors (Tan *et al*., 2010). Hence, it provided a useful tool to rank the risk factors from the data gained through the first section of the questionnaire. RII also provided a basis for calculating risk allocation percentages for both main contractor and subcontractor. RII was calculated using the following formula in this research:

$$\boldsymbol{RII} = \frac{\sum \boldsymbol{w}}{\boldsymbol{A} \times \boldsymbol{N}} \times \mathbf{100}\% \qquad \text{Eq: 01}$$

Where, W = Weight given to each factor by respondent, A= The highest weight, N = Total number of the respondent

Ranking risk factors: It is important to consider, both probability and consequences when assessing risk. This is because although something may have a very low probability of occurring, extreme consequences can make it a very high risk (CIDB, 2004). Therefore, for the purpose of ranking/prioritizing risk factors (i.e. the focus of the first section of the questionnaire), a rating value was derived considering RII values of both occurrence and impact of risk factors. Ease of referring a single figure value rather than considering both RII values of occurrence and impact at the same time, which could be complex, was also reason to derive a rating value.

The rating value was derived through following steps.

1. Calculated RII (RII_f) for frequency of occurrence (likelihood) of risk factors.
2. Calculated RII (RII_i) for impact for project objectives of risk factors.
3. Calculated rating value by multiplying results from 1 and 2 (RII_f and RII_i).

Risk cut off criteria: Several researchers have developed cut off criteria, which can be used to determine whether a particular risk factor is to be considered as significant or not. According to Sun *et al.* (2008); Kamalanathan (2013) if a risk factor fails to fulfil any of the following requirements, it can be regarded as a not significant risk factor to the concerning context. Those requirements are;

1. With a rating of 0.360 or above
2. With RII of 0.600 or above for the frequency of occurrence (since the rating is 1-5, point 3 considered as the neutral point)
3. With RII of 0.600 or above for the impact on project objectives

Risk allocation: The focus of the second section of the questionnaire was to determine the optimum allocation of risk factors between parties. For this, main contractor QSs and subcontractor QSs were requested to provide their opinions on allocation of risk factors for each party (main contractor and subcontractor) on two different Likert scales. Then RII values of each risk factor for main contractor (RIImc) and subcontractor (RIIsc) were calculated separately, as follows;

- RII values of each risk factor for both main contractor and subcontractor separately, as per the opinion of main contractors’ perspective (RIImc - by 21 respondents from main contractor organizations)
- RII values of each risk factor for both main contractor and subcontractor separately, as per the opinion of subcontractors’ perspective (RIIsc - by 18 respondents from subcontractor organizations)

According to Uher (2006); Kamalanathan (2013), percentages represented by Likert scale can be considered as follows;

- Point 1 - from0% to 20%
- Point 2 - from 21% to 40%
- Point 3 - from 41% to 59% (neutral point)
- Point 4 - from 60% to 79%
- Point 5 - from 80% to 100%

Considering the above, the following criteria were used in this study to determine the allocation of risks. For each risk factor, if the percentage derived from RII is;

- From 0% to 40% - allocated to the relevant single party
- From 41% to 59% - shared by both parties
- From 60% to 100% - allocated to the relevant single party

4. RESEARCH FINDINGS

4.1. *FREQUENCY OF OCCURRENCE OF RISK FACTORS AND THEIR IMPACT TO PROJECT OBJECTIVES*

The 29 risk factors used in the questionnaire survey could be categorised into nine categories as shown in Table 4. Calculated RII values considering the frequency of occurrence (RII_f) and the impact for project objectives (RII_i) of each risk factor, rating values, ranks within each risk category and overall ranks are given in Table 2.

Table 2: Ranking Risk Factors

	RISK FACTOR	[A] OCCURRENCE RII (RII_f)	[B] IMPACT RII (RII_I)	[A]x[B] RATING VALUE	RANK	OVERALL RANK
	POLITICAL AND GOVERNMENT POLICY					
01	Political support	0.728	0.683	0.497	1	13
02	Strong political opposition/hostility	0.583	0.606	0.353	2	18
	MACROECONOMIC					
03	Price increasing of materials	0.739	0.822	0.607	1	6
04	Inflation rate volatility	0.739	0.706	0.522	2	11
05	Interest rate volatility	0.561	0.633	0.355	3	17
06	Influential economic events	0.472	0.450	0.212	4	28
	LEGAL					
07	Legislation change	0.728	0.722	0.526	1	10
08	Changes in tax regulations	0.561	0.617	0.346	2	20
	NATURAL					
09	Weather	0.733	0.772	0.566	1	8
10	Geotechnical conditions	0.628	0.650	0.408	2	16
11	Environment	0.494	0.472	0.233	3	27
	PROJECT FINANCE					
12	Working capital	0.856	0.844	0.722	1	1
13	Availability of finance	0.744	0.761	0.566	2	7
	RESIDUAL RISKS					
14	Residual risks	0.494	0.572	0.283	1	24
	DESIGN					
15	Design deficiency	0.817	0.772	0.631	1	4
16	Specialized design	0.617	0.744	0.459	2	15
17	Delay in project approvals and permits	0.533	0.650	0.346	3	19
	CONSTRUCTION					
18	Construction time delay	0.806	0.794	0.640	1	3

19	Construction cost overrun	0.822	0.744	0.612	2	5
20	Late design changes	0.694	0.706	0.490	3	14
21	Excessive contract variation	0.511	0.639	0.327	4	22
22	Poor quality workmanship	0.544	0.589	0.320	5	23
23	Material/labour availability	0.522	0.517	0.270	6	25
	RELATIONSHIP					
24	Inadequate distribution of responsibilities	0.806	0.867	0.699	1	2
25	Inadequate distribution of authority in	0.789	0.700	0.552	2	9
26	Bid shopping	0.689	0.728	0.502	3	12
27	Inadequate experience of Sub-contractor	0.572	0.594	0.340	4	21
28	Differences in working method and know-	0.517	0.517	0.267	5	26
29	Inadequate experience of contractor	0.452	0.447	0.202	6	29

- Recognized as non-significant

Out of the 29 risk factors, only 17 were identified as significant risk factors considering the criteria discussed in section 3.0. ‘Working capital’ was identified as the highest ranked risk factor and ‘Inadequate experience of contractor’ had the lowest rank.

Under the category of ‘political and government policy’, ‘political support’ risk factor has become dominant having relatively higher RII values for both occurrence and impact. But ‘strong political opposition/hostility’ has become a non-significant risk factor, due to relatively low RII_f, which implies that likelihood of occurrence of this risk factor may be relatively low. It may also be ascertained that latter risk factor is too remote to be included in the relationship between main contractor and subcontractor.

In the ‘macroeconomic’ category, the risk factors ‘price increasing of materials’ and ‘inflation rate volatility’ both have a high impact on project objectives having RII_i values of 0.822 and 0.706 respectively.

Under ‘legal’ risk factor category, ‘legislation change’ have become a significant risk factor with dominating RII_f and RII_i values with an overall rank of 10. Though RII_i is high, due to relatively less RII_f, ‘changes in tax regulations’ have become a non-significant risk factor. This implies that, although the impact on project objectives is high, the respondents consider changes in tax regulations are less likely to happen in the Sri Lankan context.

‘Weather’ and ‘geotechnical conditions’ have become dominating risk factors in ‘natural’ risk factor category, having relatively values higher than 0.600 for both RII_f and $RII_{i.}$

Under ‘project finance’ risk factor category, ‘working capital’ was identified as the predominant risk factor. This also had an overall rank of 1 considering all the identified risk factors. It had the highest RIIf and second highest RII_i, implying that ‘working capital’ is a very likely risk factor to take place in the Sri Lankan context and has a very high impact on project objectives if it occurs.

On the other hand, ‘residual risks’ was identified as a non-significant risk factor having a relatively low RII_i. Under the ‘design’ risk factor category, ‘design deficiency’ and ‘specialized design’ risk factors were identified as the dominant risk factors having relatively high values for both RII_f and RII_i.

Under ‘construction’ risk factor category, ‘construction time delay’, ‘construction cost overrun’ and ‘late design changes’ were identified as significant risk factors.

Under ‘relationship’ risk factor category, ‘inadequate distribution of responsibilities and risks’, ‘inadequate distribution of authority in partnership’ and ‘bid shopping’ were identified as significant risk factors. Out of these three, ‘inadequate distribution of responsibilities and risks’ has become predominant having an overall rank of 2 and highest RII value for impact. On the other hand, ‘inadequate experience of contractor’ had the lowest rank out of all of the risk factors and emerged as a non-significant risk factor considering the criteria mentioned in section 3.1. As this research was limited to the C1 main contractors, EM1 subcontractors and projects above LKR 1 million subcontract values, this risk factor would be rare in such contexts.

The above findings were used to develop the risk register (refer Table 3).

Table 3: Proposed Risk Register

Risk meta level	Risk factor category	Risk factors	Rank
Macro level risks	**Political and Government Policy**	Political support	13
	Macroeconomic	Price increasing of materials	6
		Inflation rate volatility	11
	Legal	Legislation change	10
	Natural	Weather	8
		Geotechnical conditions	16
Meso level risks	**Project Finance**	Working capital	1
		Availability of finance	7
	Design	Design deficiency	4
		Specialized design	15
		Delay in project approvals and permits	17
	Construction	Construction time delay	3
		Construction cost overrun	5
		Late design changes	14
Micro level risks	**Relationship**	Inadequate distribution of responsibilities and risks	2
		Inadequate distribution of authority in partnership	9
		Bid shopping	12

4.2. *Optimum Risk Allocation between Main Contractor and Subcontractor*

In the second section of the questionnaire, the respondents were requested to indicate how those risk factors, which were identified and shortlisted in the risk register (refer Table 3), should be allocated in order to get those risks managed in the best possible way. For this, main contractor QSs and subcontractor QSs were requested to provide their opinions on allocation of risk factors for each party (i.e. main contractor and subcontractor) on two different Likert scales. Using RII values, allocation percentage for each risk factor were derived as discussed in section 3.1. Table 4 provides the percentage allocation of risks from the perspectives of main contractor and sub-contractor.

Table 4: Allocation of Risks between Main Contractor and Sub-contractor

	Risk Factor	**Main Contractor's Perspective**		**Sub Contractor's Perspective**	
		Percentage allocation to main contractor	Percentage allocation to sub-contractor	Percentage allocation to main contractor	Percentage allocation to sub-contractor
	POLITICAL AND GOVERNMENT POLICY				
01	Political support	60%	40%	63%	37%
	MACROECONOMIC				
02	Price increasing of materials	38%	62%	64%	36%
03	Inflation rate volatility	31%	69%	65%	35%
	LEGAL				
04	Legislation change	56%	44%	54%	46%
	NATURAL				
05	**Weather**	56%	44%	58%	42%
06	Geotechnical conditions	41%	59%	55%	45%
	PROJECT FINANCE				
07	Working capital	40%	60%	63%	37%
08	Availability of finance	36%	64%	62%	38%
	DESIGN				
09	Design deficiency	42%	58%	40%	60%

10	Specialized design	35%	65%	30%	70%
11	Delay in project approvals and permits	55%	45%	59%	41%
	CONSTRUCTION				
12	Construction time delay	38%	62%	54%	46%
13	Construction cost overrun	42%	58%	55%	45%
14	Late design changes	60%	40%	70%	30%
	RELATIONSHIP				
15	Inadequate distribution of responsibilities	40%	60%	70%	30%
16	Inadequate distribution of authority in	43%	57%	62%	38%
17	Bid shopping	65%	35%	73%	27%

Consequently, a risk matrix was developed as shown in Table 5, which can be used as guidance when allocating risk between main contractor and subcontractor.

Table 5: Proposed Risk Matrix

Risk factor	**Risk Allocation**			
	Main contractor	Sub-contractor	Shared by both	To be decided after further negotiations
Political support	✓			
Price increasing of materials				✓
Inflation rate volatility				✓
Legislation change			✓	
Weather			✓	
Geotechnical conditions			✓	
Working capital				✓
Availability of finance				✓
Design deficiency		✓		
Specialized design		✓		
Delay in project approvals and permits			✓	
Construction time delay				✓
Construction cost overrun			✓	
Late design changes	✓			
Inadequate distribution of responsibilities				✓
Inadequate distribution of authority in				✓
Bid shopping	✓			
Total	*3*	*2*	*5*	*7*

Out of the 17 risk factors, under agreement of both parties, 3 risk factors were allocated to main contractor, 2 for subcontractor and 5 risk factors were shared by both parties. However, regarding rest of the factors (7), both parties had contradictory views. This was due to either, 1) both parties were transferring those risk factors to the other party or 2) while one party suggest that other party should bear the risk, other party suggest to share the risk instead. However, allocation of those risk factors in question might depend on the nature of the project or let to be further negotiated between parties. Moreover, the three top ranked risk factors of significance were also among those which were not agreed by parties, of allocation.

Practitioners in construction industry can use this risk matrix as guidance for allocating risks between main contractor and subcontractor for building projects in Sri Lanka. This risk matrix would help to get a general idea on what risk factor should be allocated to which party and what risks should be shared among parties, during the risk allocation process. However, limitations of this research discussed under section 3.0 should be taken into consideration, whenever using this risk matrix.

5. CONCLUSIONS AND RECOMMENDATIONS

In the context of construction projects, risk cannot be completely avoided or evaded. Therefore, a proper risk management process is essential to identify and allocate risks in a systematic manner.

This study investigated 29 risk factors, which were identified as affecting the relationship between the main contractor and subcontractor. Out of these, 17 risk factors were found to be significant based on their frequency of occurrence and impact to the project objectives. Risk of “working capital” was the highest ranked risk to the relationship between main contractor and subcontractor, while “inadequate experience of the contractor” was lowest ranked. According to Loosemore *et al*. (2006), although a risk may have a very low probability of occurring, extreme consequences can make it a high risk. Based on this view, some risk factors such as ‘interest rate volatility’ and strong political opposition and hostility, which were identified as not significant, may have the probability to develop into such risks.

When it comes to the allocation of risks, practitioners must be careful to make both the parties understand that managing risks is a joint responsibility. It is important that ownership of as many risks as possible are determined and allocated to an appropriate party as any risks without ownership may lead to disputes and/or claims later on. Out of the 17 significant risk factors, under agreement of both parties, 3 risk factors were allocated to main contractor, 2 for subcontractor and 5 risk factors were shared by both parties. However, regarding the remaining 7 risk factors, both parties had contradictory views. Finally risk register and risk matrix were developed by using short listed and allocation determining criteria.

It is recommended that the developed risk register be used as a guidance during the risk identification phase and risk matrix when allocating those risks between concerned parties. The research findings revealed that, it is important to consider, both probability and consequences when assessing a risk, because although something may have a very low probability of occurring, extreme consequences can make it a very high risk. Therefore, practitioners must be very careful not to reject risks which have either low probability or low impact by only considering one aspect. Moreover, as it is always important to be proactive rather than being reactive when it comes to risk management, practitioners should be careful enough to consider each and every aspect of the project and related environment to identify and allocate every possible risk before it is too late to manage it later on.

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RISK ASSOCIATED WITH FACILITIES MANAGEMENT OUTSOURCING AND ITS IMPACT ON SERVICE PERFORMANCE

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ABSTRACT

In Sri Lanka, Facilities Management (FM) outsourcing has shown steady growth in recent years. Although FM outsourcing has become popular, organizations do not aware about what risks are involved with outsourcing and its impact on service performance. Therefore, the purpose of this study is to develop the strategic framework to analyse risks associated with FM outsourcing and their impact on service performance. Firstly, a literature review was done to identify FM outsourcing risks and its impact on service performance. Further, management strategies were reviewed to overcome FM outsourcing risk with a view to improving performance. A quantitative research approach based on questionnaire was followed to achieve research aim. The initial literature survey findings and preliminary survey finding were included in the questionnaire. Subsequently, questionnaire survey was conducted among the professional experts in both FM service provider companies and client organisations. The results were analysed using descriptive and inferential statistical methods. Accordingly, 31 factors were identified among the analysed 32 FM outsourcing risk factors. The relationship between FM outsourcing risks with service performance attributes were identified by using correlation analysis and FM service provider related risks were rated at the high side of correlation. The factor analysis was also carried out and six management strategies were identified as the most efficient strategies. Finally, a framework to enhance the FM outsourcing practice was developed based on the research findings, in order to suggest appropriate solution to overcome FM outsourcing risk. Hence developed framework can be used to effectively manage FM outsourcing practice for FM practitioners.

Keywords: *Facilities Management; FM Outsourcing; Management Strategies; Risks.*

1. INTRODUCTION

The core business of any organization can be succeeded with effectively planned facilities and supporting services (Alexender, 2013). Therefore, facilities within the organization and other supporting services are considered as an essential business need that helps to achieve the corporate objectives of the organization (Chotipanich and Nut, 2008). The Facilities Management (FM) has thus become important in organizations to achieve their corporate objectives (Missingham and Kenly, 2010). As a result, FM has become an emerging profession to produce effective management of facilities (Kurdi *et al*., 2011).

Over the past decade, there has been a new trend which concentrates on outsourcing non-core supportive functions in an organization (Ventovuori and Lehtonen, 2006). When considering different modes of managing facilities, outsourcing is identified as the most common strategy used in organizations for various benefits including better efficiency (Adeleye *et al*., 2004). FM outsourcing means, transferring the operation and maintenance of facilities of an organization to an outside FM service provider company (Kurdi *et al*., 2011). It is done under a contract in between client organization and FM services provider company (Atkin and Brooks, 2009).

Though FM outsourcing has become increasingly popular, risks factors associated with this were identified (Dorasamy *et al*., 2010; Zsidisin and Ellram, 2003). Most of these risks are usually associated with adverse or negative impact on the performance of facilities (Ikediashi *et al.*, 2012). However, majority of organizations are outsourcing their functions without considering the risks involved (Adeleye *et al*., 2004).

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However, outsourcing is used as a strategic choice to optimize cost, time and quality as performance aspects of facilities (Kurdi *et al*., 2011). But results of the FM outsourcing cannot be confirmed without considering risk factors (Ikediashi *et al*., 2012). Most of the researchers have identified importance of outsourcing as strategy for improving performance of organization. Lack of literature regarding impact of FM outsourcing risks on service performance is another problem. Therefore, both client and FM service provider company need to consider the risks associated with FM outsourcing and its impact on service performance and it should be assessed in a systematic manner.

Moreover, outsourcing FM in Sri Lanka has seen a steady growth over the recent years. At present, world recognized FM companies have been established in Sri Lanka. But still majority of organizations are outsourcing their operation and maintenance of facilities without considering the risk involvement. Therefore, this research expects to address the research gap of identifying the risk factors associated with FM outsourcing in Sri Lanka and identifying their impact on service performance of client organization. It may help to develop appropriate standards for a successful FM outsourcing procedure. Given the background above, the preliminary objectives of this research are to use data from Sri Lankan FM industry,

- To identify the critical risk factors associated with FM outsourcing and their impact on service performance attributes.
- To assess the impact of risk factors to services performance and management strategies
- To develop a strategic framework for analysing critical risks associated with FM outsourcing and its impact on service performance

2. FM OUTSOURCING RISKS

FM outsourcing is a strategic option to improve in the effective and efficient management of FM resources. However, over the past decades, the relationship between FM services provision and decision to outsource is becoming increasingly complex (Ikediashi and Mbamali, 2014). Mainly, it occurs due to risk associated with an organization’s FM service through the process of outsourcing with a view to improving performance. Therefore, according to studies there are three major determinants as client related risk, FM service provider related risk, contract related risk. Table 1 shows the three latent variables, their respective risk factors and their sources identified from literature.

Table 1: Risk Associated with FM Outsourcing

Risk Sources	Risk Factors	Sources
Client related risks	Lack of communication	Harland *et al*. (2005); Kremic *et al*. (2006); Nakatu and Lacovou (2009); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Inexperienced client	Kremic *et al*. (2006); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Interruption to supply of services	Redding (2007); Atkin & Brooks (2009); Ikediashi *et al*. (2012)
	Unclear responsibility and target	Harland *et al*. (2005); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	High management overheads	Redding (2007); Atkin an Brooks (2009); Ikediashi *et al*. (2012)
	Excessive monitoring of performance	Atkin & Brooks (2009); Ikediashi *et al*. (2012)
	Financial failure of chosen FM service provider during contract period	Harland *et al*. (2005); Redding (2007); Atkin and Brooks (2009)
	Wrongly communicated	Nakatu and Lacovou (2009); Atkin and Brooks (2009)
	Failure to manage end-user expectation	Kremic*et al*. (2006); Atkin and Brooks (2009)

FM service provider related risks	Poor quality of services	Redding (2007); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	FM service provider underperformance	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Critical service failure	Redding (2007); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Minimal FM service provider accountability	Redding (2007); Atkin and Brooks (2009); Ikediashi *et al*., (2012)
	Call out charges for labour	Redding (2007); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Risk of dependency on providers	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Risk of opportunism by providers	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Excessive high FM service provider rates	Redding (2007); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Lack of education and training in FM service provider	Redding (2007); Nakatu and Lacovou (2009); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Absence of shared owner outcomes	Atkin and Brooks (2009; Ikediashi *et a*l. (2012)
	In adequate staffing by service provider and FM service provider viability	Nakatu and Lacovou (2009); Atkin and Brooks (2009); Ikediashi *et al*. (2012)
Contract related risks	Absence of benchmark for quality	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Loss of strategic flexibility	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Loss of core activities	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Inadequate definition of scope of services	Kremic *et al.(*2006); Redding (2007); Atkin and Brooks (2009); Ikediashi *et al.* (2012)
	Inadequate planning of policies implementation	Atkin& Brooks (2009); Ikediashi *et al.* (2012)
	Lack of standard forms of FM contracts	Atkin and Brooks (2009); Ikediashi *et al*. (2012)
	Fall in employee morale	Ikediashi *et al.* (2012)
	Unfavorable contract terms	Redding (2007); Atkin and Brooks (2009)
	Inappropriate allocation of risks and resource	Redding (2007); Atkin and Brooks (2009)
	Poor relationship between FM service provider & clients	Kremic *et al.(*2006); Redding (2007); Atkin and Brooks (2009)
	Absence or poor system for providing incentives for performance	Atkin and Brooks (2009); Ikediashi *et al.* (2012)
	Improper invoicing and billing practices	Redding (2007)

2.1. IMPACT OF KEY RISK FACTORS ON SERVICE PERFORMANCE

Several studies have been conducted about outsourcing risks impact on service or organization performance. But, the impact of outsourcing risk on service performance has been largely unexplored. Most of the researchers have identified the importance of outsourcing as strategy for improving performance of organizations. Therefore, literature regarding impact of FM outsourcing risks on service performance is of very low level.

The scope of service performance indicators for FM services is depended on need of the client organization. Therefore, service performances are measurable subjective attribute of FM services. Most of the researches have focused on four main criteria as service performance attribute of time, quality, cost and user satisfaction (Swan and Khalfan, 2007). Other than that, most of the researches were concerned outsourcing were only cost effective method. But it affects more than that other service performance.

Therefore, this research were used time performance, quality performance and user satisfaction as indicators for measuring service performance.

3. MANAGEMENT STRATEGIES TO OVERCOME FM OUTSOURCING RISKS

Client organization considers FM outsourcing as a cost saving solution and transfer full responsibility to service provider (Kurdi *et al*., 2011). However, this process may also have unique risks when it comes to service delivery (Redding, 2007). But, the correct management strategies can overcome risk associated with FM outsourcing. Table 2 shows management strategy to overcome FM outsourcing risks.

Table 2: Management Strategy to Overcome FM Outsourcing Risks

Sources	**Management strategies**	**Sources**
Client related risk	Information sharing	Redding (2007); Kurdi *et al*. (2011)
	Documenting a baseline from the financial	
	Identified Critical Services	
	Full Commitment of Client	
	Identify the critical service level	
	Documenting of all information regarding FM outsourcing	
FM service provider related risk	Evaluating competence, knowledge in Selection phase	Redding (2007); Kurdi *et al*.(2011); Lee *et al*.(2012)
	Evaluating specific technological capabilities in Selection phase	
	Evaluating successful partnership with the Client in Selection phase	
	Information sharing	
	Evaluating financially stable over the life of the agreement in Selection phase	
	The details of the implementation plan, all activities	
	Details about proposed staffing, processes and technology	
	Secure client organization's confidential data as well as customer's confidential data	
Contract related risk	Negotiate with relevant parties	Redding (2007); Kurdi *et al*. (2011); Lee *et al*. (2012)
	Provider requires a clear definition of each management team's role	
	The details of the implementation plan, all activities and milestones identified	
	Both parties take ownership for creation of a successful solution	
	The pricing structure must align the FM service Provider's profit with the clients success	

4. RESEARCH METHODOLOGY

The specific purpose of this research is to identify the risk associated with FM outsourcing and its impact on service performance. Therefore, in order to achieve the aim of this study, it is required to select suitable risk factors from literature according to the Sri Lankan context and also need to identify the impact of those risk factors on service performance. In addition, management strategies are considered to overcome the risks relating to FM outsourcing. Hence, research requires dealing with statistical way. Therefore, the quantitative research approach based on questionnaire was followed to achieve research aim. In order to capture data related to the research problem, the questionnaire was prepared by using comprehensive literature review. It consisted following aspects,

- Identify the risk factors associated with FM outsourcing
- Identify the service performance aspect which is impacted by risk factors
- Identify the management strategies to overcome identified risk factors

Preliminary and detailed questionnaire survey used to gather the opinion of respondents by using 5 point likert scale where “5” and “1” denote the two extremes of extremely positive and extremely negative impact respectively.

The main objective of the preliminary survey was to validate the literature findings relating to Sri Lankan FM context and make the way to achieve the best outcome from detail survey. Therefore, the structured interviews were carried out among two professionals from both client organization and FM service Provider Company. These professionals were selected mainly based on their experience, rank and responsibilities within FM industry. All respondents have experience of more than 10 years. Based on the information of questionnaire, the several modifications were done to understand anybody and some factors were improved in simple manner. Final results of preliminary survey were provided satisfactory picture for the entire questionnaire.

According to Sri Lankan context, main FM service provides and client who are in the building which are maintained by FM service provider were considered as population for this research. As per the information were collected from experts in the FM industry, there were nearly 06 FM service providers which carry out their business in Sri Lanka. Exact number of FM service provider in Sri Lanka could not be mentioned properly, since they were not registered in recognized resource. Therefore, the experts who represent client and FM service provider company were varying from building to building. Therefore, exact value for population could not be presented for this research.

Without knowing population sample method cannot be used effectively. Therefore, non-probability convention sampling method was adopted to collect the data for this research. This method obtained readily available lists is a convenience sample and all respondents were selected to take more than 2 years of experience. In order to ensure the reliability of data, target respondents were considered based on their senior position (Facility managers, Operation managers, Property managers, Maintenance engineers and Facilities executive). Therefore, the questionnaires were distributed among 50 number of experts who represent FM service providing company and client who were in the buildings which are maintained by FM service provider. But only 43 questionnaires were received for the analysis.

5. DATA ANALYSIS AND FINDINGS

The results were analysed by using descriptive and inferential statistical method. When collecting data through questionnaire survey, it was consisted with questions that were not consistent to the research problem or received data may have lot of variance within the respondents. Therefore, Cronbach’s alpha was used as reliability analysis for the data set of questionnaire. Reliability coefficient 0.7 or higher is considered “acceptable” in most social science researches (Parrant, 2010). According to results, all data set was between 0.7 and 0.8. As well as, it indicated large alpha value. Therefore, it could be assumed that data sets are reliable for analysis.

One-sample t-test was used to identify significant level (p value) of tested variable. It was used to identify whether the mean of a population significantly differs from a specific value. In hypothesis testing, these hypotheses were tested using t-values (one-tailed) at 5 per cent significant level. Therefore, the critical t-value at the approved degree of freedom and α value was compared with calculated t value.

Further a null hypothesis is rejected for p-value of less than 0.05 and accepted for p-value is equal or greater than 0.05 (Field, 2005). One of the important points to be considered is sample mean of risk factors were compared with assigned value 3. Through the literature survey and preliminary survey most of the identified risk factors have some impact on the service performance. Therefore, opinions of most of the respondents were equal or greater than 3. Therefore, mean value of most of the FM outsourcing risk factors were higher than three. Based on above reason value 3 was assigned only for this analysis. One sample t-test was conducted by using MINITAB in order to identify the most significant risk factors for each separate risk category with following hypothesis,

Null Hypothesis:

H_0: Mean level of concern with risk factors associated with FM outsourcing < 3

Alternative Hypothesis:

H_1: Mean level of concern with risk factors associated with FM outsourcing $\geq$ 3

By considering to critical t-value and significant level of 0.05 except the factor "Call out charge for labour", all other 31 factors were able to reject null hypothesis. According to that decision, there was an opportunity to accept alternative hypothesis highlighting significant factors over mean value. Table 4.7 shows finalized risk factors impact on service performance

Table 3: Significant Risk Factors Impact on Service Performance

1	**Client related risk factor**	Lack of communication
2		Failure to manage end-user expectation
3		Wrong Communicated
4		Interruption to supply of services
5		Financial failure of chosen FM service provider during contract period
6		High management overheads
7		Inexperienced Client
8		Excessive monitoring of performance
9		Unclear responsibility and target
1	**FM service provider related risk**	FM service provider underperformance
2		Poor quality of services
3		Critical services failure
4		Inadequate staffing by service provider & service provider viability
5		Lack of education & training in FM service provider
6		Minimal FM Service provider accountability
7		Risk of opportunism by provider
8		Absence of shared owner outcomes
9		Risk of dependency on provider
10		Excessive high FM service provider rates
1	**Contract related risk**	Inadequate definition of scope of services
2		Lack of standard forms of contract
3		Unfavorable contracts terms
4		Improper invoicing & billing practices
5		Absence or poor system for providing incentives for performance
6		Inadequate planning of policies implementation
7		Poor relation between FM service provider & client
8		Loss of strategic flexibility
9		Fall in employee moral
10		Loss of core activity
11		Absence of benchmark for quality
12		Inappropriate allocation of risk & resource

Once significant risk factors were identified, the correlation analysis was performed to establish relationships among risk factors with service performance attributes (time, service quality, user satisfaction). Table 4 indicates correlation analysis for FM outsourcing risk with service performance attributes.

Table 4: Correlation Analysis for FM Outsourcing Risk with Service Performance

Correlated Variable	Pearson Correlation value		
	Client related risks	**FM service provider related risks**	**Contract related risks**
Time (Ability to achieve on-time schedule)	0.398	0.596	0.468
Service Quality (Ability to achieve improved consistency with laid down quality standard)	0.513	0.596	0.468
User Satisfaction (Ability to achieve user requirement perfectly)	0.430	0.666	0.360

Since each risk indicate a positive correlation value, change in one risk was directly correlated with changes in service performance attributes. FM service provider related risks were rated at the high side of correlation in each service performance attributes. It could be presumed that, FM services can be delivered on time with quality standard and ability to achieve user requirement perfectly, by which FM service provider related risks are properly managed. Therefore, management strategies need to consider to FM outsourcing risks. However, other risks also have some certain relationship with service performance attributes. Therefore, the service performance can be improved by managing the each FM outsourcing risks.

The factor analysis was also carried out and six management strategies were identified as the most efficient strategies. The factors were identified based on the principle component method the factor solutions eigen value greater than or equal to one. And also the variables which are greater than 0.45 are regarded as most efficient factors (Ikedishi and Mbamali, 2014). Finally, a framework to enhance the FM outsourcing practice was developed based on the research findings, in order to suggest appropriate solution to overcome FM outsourcing risk. Hence developed framework can be used to effectively manage FM outsourcing practice for FM practitioners.

6. DISCUSSION OF FINDINGS

When considering the developed strategic framework, it consists with significant risks associated with FM outsourcing and its impact on service performance attribute and suggestions to enhance the FM outsourcing practice.

Significant risk factors were identified based on main sources which are involved in FM outsourcing practice with the view of service performance. The identified main sources were client related risks, FM service provider related risks and contract related risks. t- Test was conducted to identify most significant FM outsourcing risk. According findings of this analysis, 31 risk factors out of 32 risk factors were significantly impacted on service performance. Further, finding reveal that “call out charge for labours” has not much effect on the service performance. Since each risk indicate a positive correlation value, change in one risk was directly correlated with changes in service performance attributes. In addition to that, among these risk sources, FM service provider related risks were the most relative risk sources with each service performance attribute. Therefore, FM service provider related risks mainly impact on service performance than other risk sources. Then, suggestions were given considering client related risk, FM outsourcing risk and contract related risk. Furthermore, six strategies under above risk category were identified as the most efficient strategies. Each category consists with two suitable strategies. Since there are lot of risk factors which directly affect to FM outsourcing practice, necessary strategies were given to mitigate these factors also.

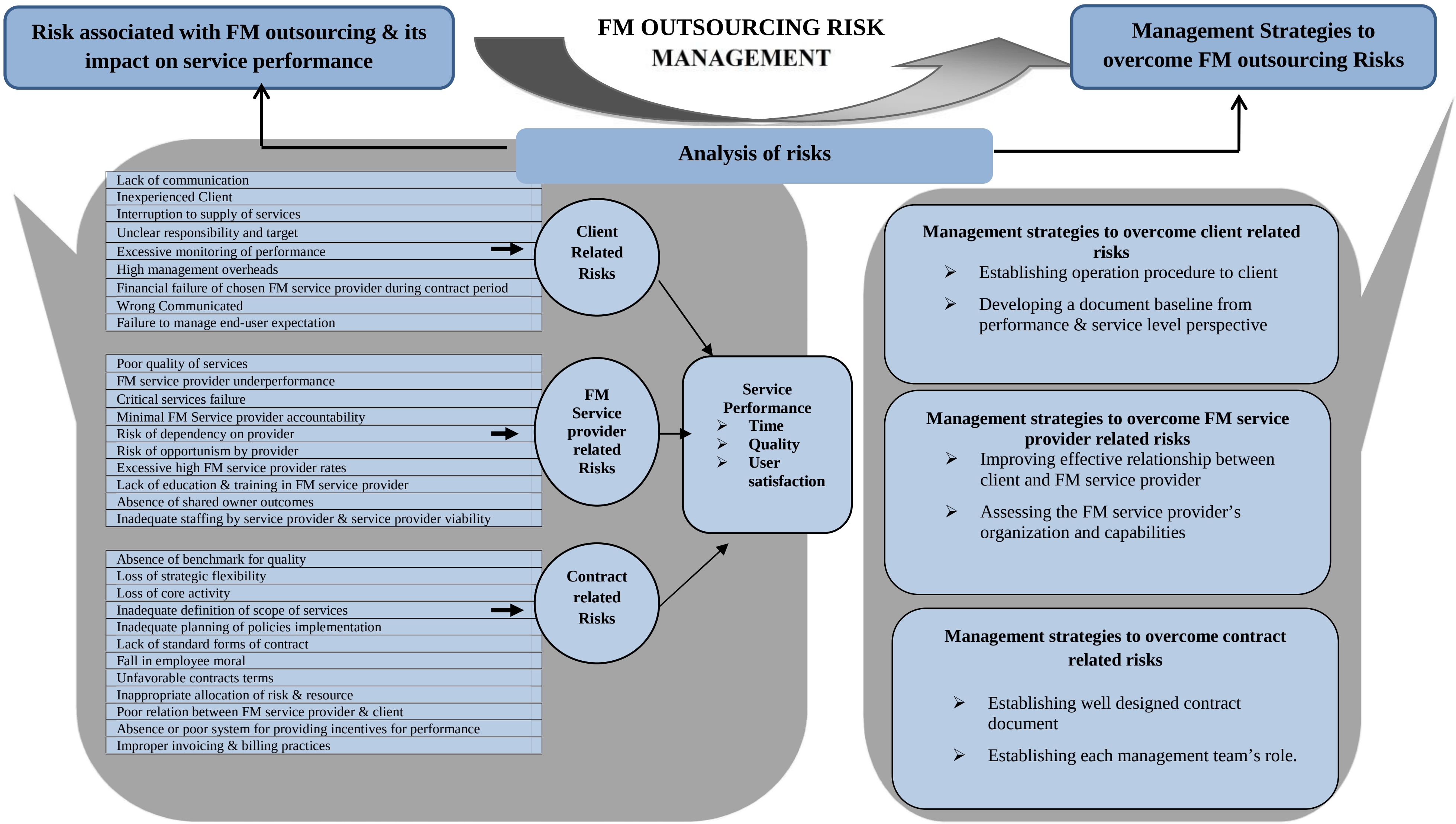

Figure 1: Framework

7. SUMMARY

Most of researchers have investigated importance of FM outsourcing as strategy for improving performance of organization. But, impact of FM outsourcing risks on service performance has been largely unexploded. This research addresses the risk associated with FM outsourcing and its impact on services performance. In addition, management strategies were introduced to overcome FM outsourcing risk with a view of improving service performance.

According to findings of several research studies, identified FM outsourcing risks were divided into three determinants such as client related risk, FM service provider related risk and contract related risk and this research used time performance, quality performance and user satisfaction as indicators for measuring service performance. In addition, management strategies were identified from literature.

In order to capture data related to the research problem, the questionnaire was prepared by using compressive literature review. It was consisted with 32 risk factors regarding client, FM service provider and contract and as per the information was collected from expertise in the FM industry. There are nearly 06 FM service providers which carry out their business in Sri Lanka. But, exact number of FM service provider in Sri Lanka could not be mentioned properly. Since FM service providers were not registered in recognized resource. Therefore, the expertise that was representing client and FM service provider company are varying from building to building. Therefore, exact value for population could not present for this research.

According to findings of statistical significant analysis, identified FM outsourcing risk factors were highly impacted on service performance. Further, statistical analysis finding reveal that “Call out charge for labours” was not much effect on the service performance. Therefore, it was not regarded by respondent as the critical factors while considering FM outsourcing as a procurement option. Each other factors were rated according to the identified alternative hypothesis. Therefore, it indicated that, each factors are significantly impact on service performance. Correlation analysis indicated that, FM service provider related risk was rated at the high side of correlation in each aspect of service performance. It could be presumed that, service performance can be highly improved; the FM related risks are properly managed. Then Factor analysis was conducted in order to identify most efficient strategies, there were six strategies under client related risks, FM outsourcing risks and contract related risks were identified as the most efficient strategies.

Suggestions were given considering client related risk, FM outsourcing risk and contract related risk. Furthermore, six strategies under above risk category were identified as the most efficient strategies. Each category was consisted with two suitable strategies. Since lot of risk factors which directly affect to FM outsourcing practice. Therefore, necessary strategies are given to mitigate these factors also.

The final outcome of the research developed a strategic framework to enhance the FM outsourcing practice. It provides the suggestion to mitigate identified risk factors under client related risk, FM service provider related risk and contract related risk.

Developed framework would direct for FM practitioners, stakeholders in the FM profession understanding FM outsourcing risk impact on service performance. It could impact on entire business of both client organization and FM service provider company. Therefore, management team of these organization can be used this developed framework as a FM outsourcing risk management tool.

This framework was developed based each FM practice facilities in Sri Lanka. As well as, developed framework can also be expanded to different facility. Depending on the circumstance, FM practitioners could customize framework according to their preference.

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RISK MANAGEMENT STRATEGIES FOR FACILITIES MANAGER'S IN SRI LANKA

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ABSTRACT

Value is a function of risk and return. Every decision either increases, preserves, or erodes value (COSO, 2004). Given that risk is integral to the pursuit of value, strategic-minded enterprises do not strive to eliminate risk or even to minimize it, a perspective that represents a critical change from the traditional view of risk as something to avoid. Rather, these enterprises seek to manage risk exposures across all parts of their organizations so that, at any given time, they incur just enough of the right kinds of risk-no more, no less-to effectively pursue strategic goals. The Facilities Management (FM) industry delivers a range of services and products through the spectrum of the facility life cycle, all of which carry varying degrees of risk, identifying risks and being prepared to manage them will minimise any negative impact they may have. Effective Risk Management (RM) planning and practice is an essential component of the practice of FM. Delivering on strategies that enable the organisation to realise the opportunities in their activities while appropriately managing risk is the central to successful management of Facilities. The purpose of this paper is to provide leadership to manage risks within Sri Lankan FM context with an overview of risk assessment approaches and techniques that have emerged as the most useful and sustainable for decision-making.

Keywords: *Facilities Management; Risk Management; Sri Lanka; Office Buildings; Case Studies.*

1. INTRODUCTION

It is obvious that the secret behind returns on invested facilities lies upon proper and effective management of the built environment (Redlein and Poglitsch, 2010). Thus, the attraction of FM has become increasingly common as forward-looking organisations are beginning to realise FM as a function with clearly defined objectives and a strategic and commercially-oriented discipline (Pathirage *et al.*, 2008). FM is frequently described as "an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organization in order to create an environment that strongly supports primary objectives of that organization" (Atkin and Brooks, 2000, P.4). According to Atkin and Brooks (2000), FM services encompass broad and a large number of functions and roles towards a strategic concern.

Gleisner (2008), defines risk in a company as a "the possibility of deviating from planned objectives resulting in the unforeseeable future caused by 'incidental' disturbances". As far as Enterprise Risk Management (ERM) is concerned, COSO (2004) defines ERM as a process, affected by an entity's board of directors, management and other personnel, applied in strategy-setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives.

Risk Management (RM) is crucial for organizations to thrive and succeed hence; it's the way in which enterprises get a handle on how significant each risk is to the achievement of their overall goals. To accomplish this, enterprises require a risk assessment process that is practical, sustainable, and easy to understand (COSO, 2004). The process must proceed in a structured and disciplined fashion. It must be correctly sized to the enterprise's size, complexity, and geographic reach. While ERM is a relatively new discipline, application techniques have been evolving over the last decade (Redlein and Giller, 2008). ERM is recognised as good business sense and a way to demonstrate good governance (Alexander, 1992). Current global events have increased the focus on managing uncertainty. Given the nature of FM and the

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significance of infrastructure, assets, facilities and service supply, the responsibility for most of this planning and recovery or response rests with those who manage facilities (Alexander, 1992).

Since nature of managing risks is not well defined in FM context, applicability of RM strategies in to the FM profession is not well understood (Redlein and Giller, 2008). In Sri Lankan FM context, there are no adequate research done in the area of ERM, however, adopting ERM strategies to Sri Lankan FM industry is utter most important considering it's emerging and challenging nature. This created the knowledge gap for this research and emerged the research question for the study. Hence, the research question that was developed for the study is 'How to apply RM strategies to Facilities Manager's in Sri Lanka.' Due to the evolving nature of FM profession in Sri Lanka, exploratory case studies were carried out to explore answerers to the research question. The key findings from the literature review are discussed next in this paper.

2. KEY LITERATURE FINDINGS

The buildings, installations and facilities to which FM is relevant represents important company assets. According to a study carried out by the International Facility Management Association (IFMA), these assets are the source of 10 to 19% of company expenditure and represent 25 to 50% of company assets. Therefore, in the case of all companies, and not just real estate companies, FM processes influence company figures and are formidably significant within the framework of ERM.

Gleissner and Romeike (2005) differentiate between financial and operational risks. Furthermore, operational risks are classified into strategic risks (e.g. the risk that a certain company strategy does not result in the best possible outcome) and operative risks that can arise as a result of inadequate performance of technologies, processes, personnel or organisations, or external events. The second area is particularly relevant to FM because it exposes to infrastructure for the core business and can, for example, be caused by false assumptions (an inadequate service level), production failure or even a high level of illness.

The Internal Control Systems (ICS) is part of ERM and is aligned with operative processes. According to COSO, an ICS relates to all processes, methods and control measures that are carried out under the order of the supervisory board and/or senior management and serve to ensure that business operations function correctly. The organisational measures of the ICS are integrated into operating procedures. This means that they occur during the course of work performed take place directly before or after a work activity (COSO, 2004). The methods by which companies should proceed with the implementation of a Enterprise Risk Management strategies and ICS are presented in below sections.

2.1. IMPLEMENTATION/OPTIMISATION OF AN ENTERPRISE RISK MANAGEMENT SYSTEM

First, senior management must define the company's risk appetite in order to align an organisation's inclination to take risks with its strategy (Redlien and Giller, 2008). In addition, this will enable risk-related decisions to be taken. As a second step, related key risks are defined and subsequently evaluated (Redlien and Giller., 2008). Both the risks and opportunities that are seen as significant to the company are defined at the senior management level using brainstorming techniques (Redlein and Poglitsch, 2010). In order to facilitate easier definition of a risk map, a best-practice map, is depicted in Figure 1.

In order to support the client in minimising risk, the graphic displays the opportunities and risks of large companies covered by FM through an internal department as well as those covered by facility service providers.

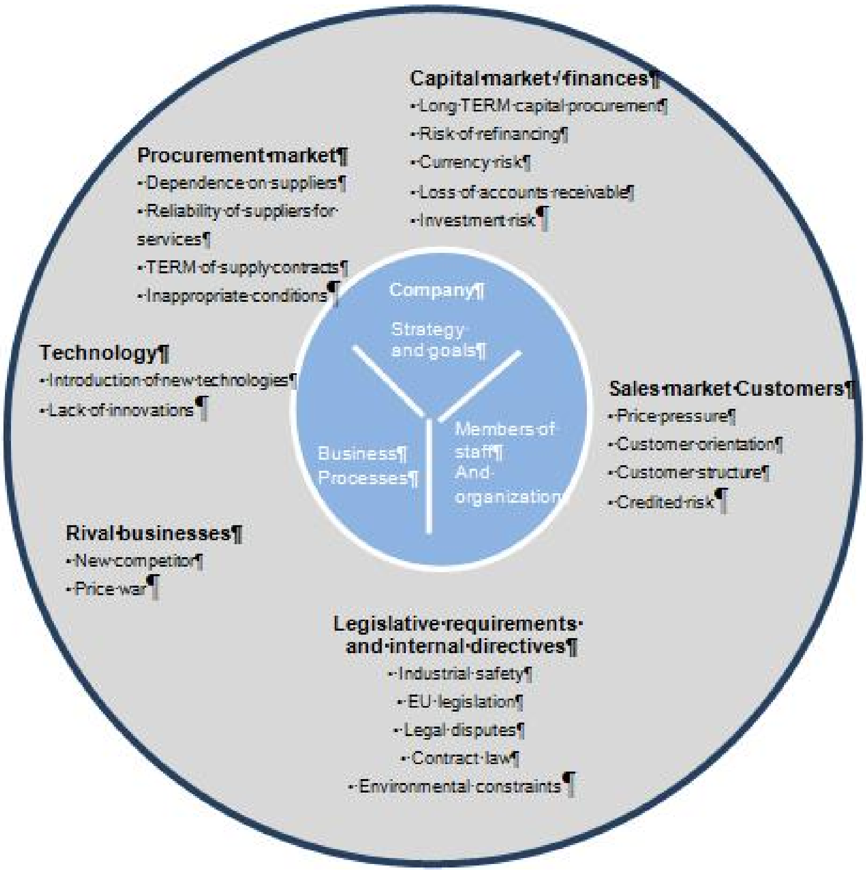

Figure 1: FM Risk Map
Source: Alexander (1992)

Particularly in the case of FM, large companies are faced with the strategic decision of whether to "make or buy" - this refers to whether they should carry out the implementation themselves or subcontract it to a professional provider of facility services and hence transfer risk. Many users also assess the area of legal compliance - meaning compliance with legal requirements - as a risk. This mainly involves the areas of industrial safety and fire protection but also covers environmental protection.

For service providers, this entails competitive pressure, price wars and maintaining/ optimising quality. After listing risks and opportunities in the risk map, a quantitative evaluation of risks and opportunities with respect to the extent and likelihood of occurrence has to be performed.

Two examples are mentioned here:

1. Server room: Failure of the server infrastructure resulting from overheating can have dramatic consequences depending on the IT infrastructure dependencies of the organisation (insurance companies, banks). Therefore, the company, in the course of identifying risks, will analyse the issue, classify the risk according to the likelihood of occurrence and impact, and thus determine appropriate corrective action. Naturally, these can also affect FM: Service level agreements with subcontractors, backup solutions, investment in better cooling systems, adaptation of the maintenance intervals, and so on.
2. Elevators: In production areas, failure of a goods elevator can result in grave disturbances to the flow of material. Therefore, in this area also, during the course of the risk evaluation process, risk is classified and appropriate measures are taken. Based upon this data, the risks are entered into a company-wide risk matrix (see Figure 2) and classified into the following groups: significant risks, risks that should be monitored, risks to be observed.

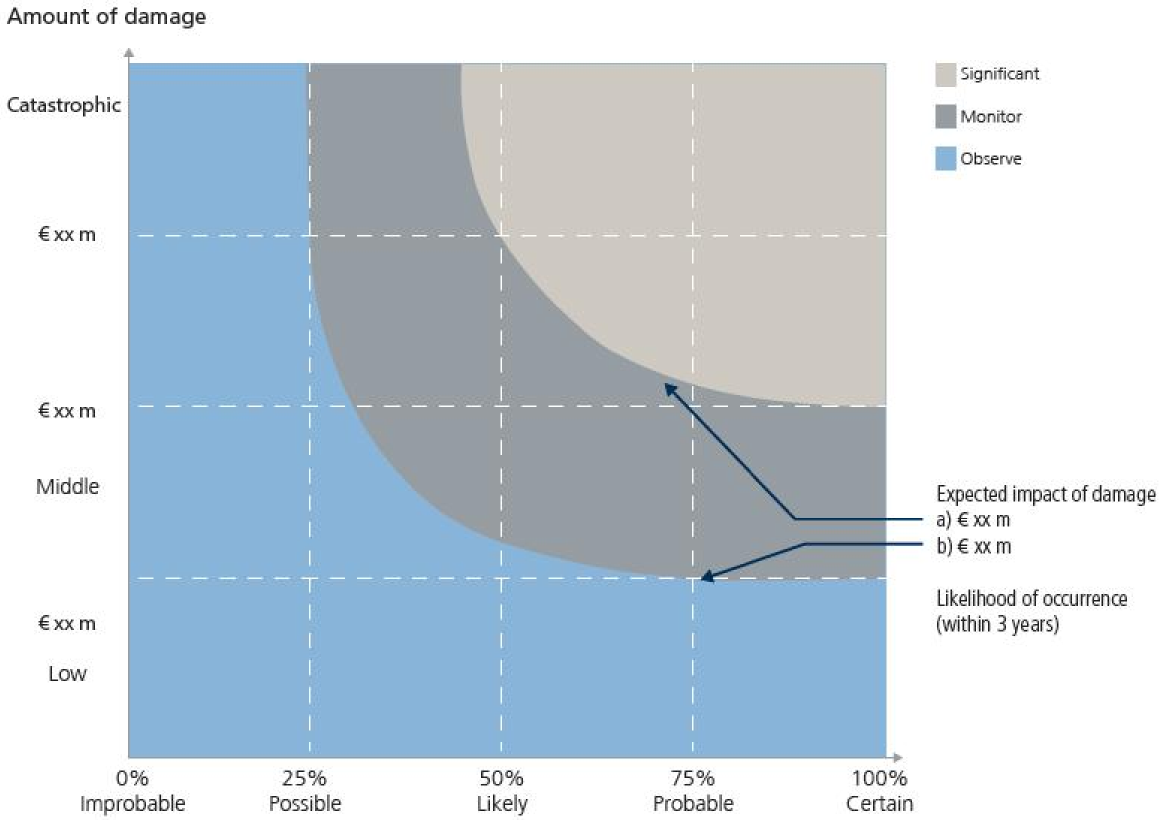

Figure 2: Risk Matrix
Source: Alexander (1992)

The possible control measures can be deduced from the matrix:

- avoid the risk → refrain from doing
- minimise the risk → internal measures, process improvement
- share the risk → transfer the risk to another, e.g. insurance companies, or outsource facility services to a professional partner to minimise risk
- accept the risk → consciously bearing the risk

The result of Enterprise Risk Management is that risk owners carry out and evaluate actions, and manage risks within defined tolerance limits.

2.2. ENTERPRISE RISK MANAGEMENT FRAMEWORK

Findings of literature is summarised in to the following framework of Enterprise Risk Management to facilitate adoption and application of it to the Facilities Management Industry.

Figure 3: Enterprise Risk Management Framework
Source: Accenture (2013)

3. RESEARCH METHODOLOGY

This research took an exploratory nature and it required access to FM professionals, who could explain their views and experience. As such, case study has been selected for this research. In Sri Lankan office building sector, there are very few facilities management in-house divisions, who are practicing FM in its full sense. Three such FM divisions in office buildings were selected for these case studies. Within one organization, three professionals from the FM division were interviewed. The description of cases and professionals interviewed are given below.

CASE A

With over 750,000 square feet of prime office and retail space, this organization is an international business complex on par with premium grade buildings in major cities around the world. Built to the highest standards, this impressive landmark comprises two 39 storey towers connected by a 4 storey retail block. It has attracted prestigious local, international and multinational companies as tenants, making it the most sought after business address in Sri Lanka. With its prime location in the heart of the city in the Central Business District (CBD) and easy access to all main banks, major five star hotels, government offices, shops and headquarters of some of the largest businesses, this towering business complex is Sri Lanka’s tallest and most impressive commercial landmark. Within this organization, interviews were conducted with the Facilities Manager, Assistant Facilities Manager and Electronic Engineer.

CASE B

This organization is a largest banking and financial services organization. It has more than 32,000 skilled professionals operating out of 15 group service centres present in five countries in Asia, including India, China, Malaysia, Philippines, and Sri Lanka. The service centre in Sri Lanka is managed by the business process outsourcing a ERM of the group and it is occupied by the bank's back offices service providing professionals within over 350,000 square feet. Interviews were made with the Facilities Manager, Assistant Facilities Manager and the outsourced Facilities Manager in this organisation.

CASE C

This organization is one of the leading government banks in Sri Lanka. This building is a 32 storied head office building with a total built up area of 600,000 square feet. It was constructed in 1987 to house all administrative offices, international division and corporate branch of the bank. Managing this building is done with the involvement of well qualified and experience FM related professionals. So, data has been collected from three key FM related professionals namely Maintenance Manager, Human Resource Manager and the Electrical and Plumbing Engineer.

While interviewing, note taking and tape recording (with permission of the interviewee) were performed to maintain the accuracy of data collection. The data gathered from the interviews were analysed by manual code-based content analysis. Finally, conclusions about the overall research problem were drawn by analysing the findings as described next.

4. RESEARCH FINDINGS

Applicability of Developed Enterprise Risk Management Framework was tested throughout the case studies. In doing so, following scenario was presented and used to test the successful application of the Enterprise Risk Management framework developed through literature findings.

4.1. IMPLEMENTATION/OPTIMISATION OF AN ENTERPRISE RISK MANAGEMENT SYSTEM (APPLICABILITY OF ERM FRAMEWORK)

Example: Inspection and maintenance of facilities and installations

The objective of the process is to analyse the current conditional state of facilities and installations as well as the maintenance or improvement of this state through maintenance measures. It comprises the planning and execution of inspection, and maintenance of facilities and installations, although it does not deal with specific activities in detail. Process steps have been added to this procedure, whereby inputs case studies via expert interviews have been taken into consideration.

Based on the activities defined in the detailed reference procedure, experts were subsequently interviewed in order to indicate possible risks and related enterprise risk management and control activities. The result of that is presented in Table 1.

Table 1: Inspection and Maintenance of Facilities and Installations - Risk and Control Matrix

Activity	Risk or Risks	Enterprise Risk Management/Control Activity (ies)
Tactical level		
Analyse available information (evaluation, objectives, costs) and collect missing data	Undiscovered objects, lack of information	▪ Periodic inspection of relevant facilities and installations, updating documentation
Define maintenance strategy and required infrastructure availability	False assumption(s) with regard to the necessary availability/the risk of infrastructure failure	▪ Carrying out periodic review of the requirements of the core business and taking practical experience into consideration
Level of operative planning		
Update list of relevant objects	Undiscovered objects	▪ Periodic inspection of relevant facilities and installations, updating

Activity	Risk or Risks	Enterprise Risk Management/Control Activity (ies)
		documentation
Define/Update activities per object	Failure to perform timely maintenance on facilities and installations (including necessary procurement)	▪ Orientation of maintenance/inspection intervals to the life cycle data, relevant standards and the practical experience of experts, taking required time for procurement into consideration
Define maintenance/Inspection intervals	Maintenance intervals too frequent or too seldom	▪ Verify standards and documentation
Preform economic efficiency. analysis and plausibility check	Verification of check is not carried out by all responsible persons Specific requirements are not taken into consideration, e.g. as a result of the location of facilities or installations	▪ Verify allocation of responsibilities consideration of specific requirements during the cost effectiveness study
Create maintenance/inspection schedule	No Risks Involved	
Operative level	No Risks Involved	
Plan execution	No Risks Involved	
Use internal resources	No Risks Involved	
Procure service	Procurement risks	
Procure material	Procurement risks	
Inspect material quality and Quantity	No Risks Involved	
Accept material	Material is not available Use of wrong spare parts or wrong material	▪ Stock spare parts and relevant material, check specifications
Preform maintenance/inspection	Use of wrong material Inadequate execution of maintenance/ inspection	▪ Check performance and material check service manual
Review performance and consumption of material	Inspection cannot be carried out or cannot be carried out adequately because of lack of special knowledge on the part of the personnel responsible	▪ Taking the availability of personnel into consideration, improving the selection and training of personnel
Document service/material	Incomplete documentation	▪ Define standards for documentation

The second column of Table 1 can be considered a “risk inventory” of the reference processes. This is a basis for the risk and control matrix of the specific company. However, within the scope of implementation, an additional quantitative risk evaluation carried out by the specific company is necessary.

4.2. IMPLEMENTATION/OPTIMISATION OF INTERNAL CONTROL SYSTEMS

Example process: Carry out equipment management activities

The process “Carry out equipment management activities is associated with serious risks (e.g. server room, lifts) and has been identified as relevant to determination of the risk map. As a result, ICS activities have been devised and introduced for the purpose of operative implementation in order to reduce the likelihood of a risk's occurrence (see Figure 2: risk matrix)

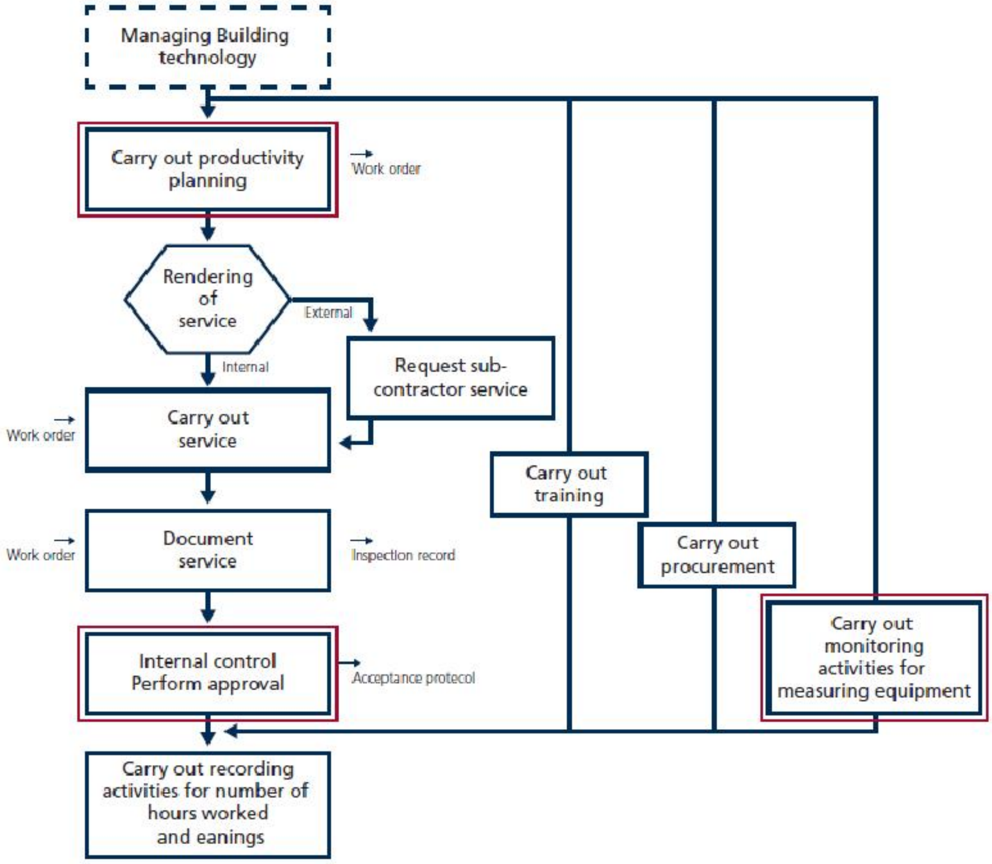

Figure 4: Building Technology Management Process

Overview of activities that are relevant to ICS (see marking above) including the control activities implemented:

Table 2: Overview of Activities that are Relevant to ICS

Activity	Risk or Risks	Enterprise Risk Management/Control Activity(ies)
Carry out productivity planning	• Installation failure due to lack of/poor maintenance • Statutory audits are not held	• Illustration of all components → maintenance schedule • Automatic escalation if deadlines are not met
Preform inspection/approval	• No accurate documentation of the activities performed • Individual implementation (no standard available)	• The work order is created in the Computer Aided FM (CAFM) tool and defines exactly which activity is to be performed
Carry out monitoring activities for measuring equipment	• Quality statements are carried out with measuring equipment which has not been calibrated → statements flawed and not understandable	• Monitoring measuring equipment managed in the CAFM tool

5. SUMMARY

The research findings confirmed that the, profession of Facilities Management involves with great number of risks, hence, adopting ERM strategies in to the profession is utter most vital to ensure success of the profession. Risks needed to be identified, analysed and mitigated across business functions which include operations, business process and strategic and throughout the building and project life cycle to ensure smooth operation of the building facilities and delivering clients / occupants expectations.

Despite of it is application basic ERM approach (framework) follows its basic steps of risk identification, risk classification, analysis and mitigation. More importantly, case study findings revealed, despite of it is approach, Enterprise Risk Management Frameworks largely facilitates in identifying risks inheritant in it functions and analysing those, defining mitigation actions and appointing risk owners.

Mainly in addressing the research gap, conceptual framework developed based on the key literature findings was tested with the help of industry professionals. The outcome is mainly presented in the data analysis.

However, success of adopting ERM strategies in to Facilities Management largely depends on continuous monitoring of risks for its movement accordingly with its mitigation actions' implementation. After the initial setting up of risk registers are done continuous, brainstorming sessions and risk workshops needs to be carried out until its completion and throughout its continuous life cycle to ensure Enterprise Risk Management Strategy implementation within the Facilities Management functions and its profession.

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SAVING ENERGY IN OFFICE BUILDINGS WITHOUT COMPROMISING THEIR INDOOR ENVIRONMENTAL QUALITY

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ABSTRACT

The concept of Internal Environmental Quality (IEQ) has emerged as a determinant of the performance of built environments due to its direct impact on the health, comfort and satisfaction of the occupants of the buildings and also due its role in ensuring a productive work environment. However, IEQ indicators such as thermal comfort, indoor air quality, and lighting level are associated with the most energy consuming utilities, namely HVAC and lighting. While IEQ and energy efficiency have been researched extensively, there is no published research on energy saving strategies that will optimize the IEQ in office buildings. Therefore, the aim of this study was to identify energy efficient strategies that will optimize the IEQ in office buildings. The research problem was approached through a case study analysis of four office buildings. The study identified energy efficient strategies that can be practiced without compromising the IEQ of a building. However, findings also asserted that there is no common platform to optimize the IEQ performance while achieving the best energy performance of a building. Energy efficient strategies to be adopted can depend on various internal and external factors of a facility. The findings will be useful for building managers who manage office buildings.

Keywords: *Built Environment; Energy Efficient Strategies; Indoor Environmental Quality; Office Buildings.*

1. INTRODUCTION

Due to economic and environmental reasons, organizations around the world are constantly under pressure to reduce their energy consumptions. As energy cost is one of the major cost factors of businesses, a reduction in their energy consumptions leads to a reduction in their operating costs thereby helping to improve their profitability (Jayamaha, 2006). The energy in office buildings is mainly utilized for heating, cooling, and lighting purposes while a significant portion of it is consumed by office equipment (Santamouris, 2002). Managing a building's energy efficiency may soon be an integral component of managing its operational and financial performance (Landsberg, Lord, Carlson, and Goldner, 2009). The energy consumption of buildings depends significantly on the criteria used for the design and operation of their indoor environments as well as the buildings themselves (Bluyssen, 2002).

A majority of people carry on their lives inside buildings which have to satisfy the objective and subjective requirements linked to vital functions of the occupants (Wolkoff, 2012). Therefore, the Indoor Environmental Quality (IEQ) plays a major role in the overall performance of a building (Quang *et.al*,. 2014). In today's world, people spend more than 90% of their time in built environments such as residences, workplaces and similar buildings (Levin and Emmerich, 2013). The built environment or indoor environment of a building should be at an acceptable IEQ level for the comfort and satisfaction of the occupants and for a productive work environment (Bluyssen, 2011).

The cost of energy used to maintain acceptable standards is often high. (Abbaszadeh *et al*., 2006) On the other hand, a good IEQ could improve the overall work performance of workers by minimizing building related illnesses and absenteeism (Brimblecombe, 2002)., Thermal comfort and IAQ are two dominant factors among IEQ parameters, while indoor air temperature and indoor CO2 concentrations are the

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control parameters of environmental control systems of many air-conditioned office buildings (Bluyssen, 2011).

A good energy policy for indoor environment should respond to the needs of both energy conservation and a desirable healthy indoor environment by users of the built environments (Abbaszadeh *et al*., 2006). Several studies have addressed the requirement of optimizing the energy performance in buildings and also their IEQ. However, there is little research that has addressed both energy efficiency and IEQ optimization within a single paradigm. Thus, there exists a research gap in coupling energy performance with IEQ optimization.

AIM

The aim of this research is to identify strategies to save energy in office buildings without compromising their indoor environmental quality.

OBJECTIVES

- To identify IEQ indicators and problems related to them in office buildings
- To identify currently practiced energy efficient strategies in office buildings
- To investigate energy saving strategies that will optimize IEQ in office buildings

2 LITERATURE SYNTHESIS

The Building Performance (BP) of a built environment addresses a set of coordinated strategies that are mainly aimed at assessing the quality of that built environment, in terms of the extent to which all requirements of performance such as safety in operation, air quality, energy performance, acoustics, thermal comfort and visual comfort are satisfied (Hapurne, Baran and Bliuc, 2012). The BP of a built environment depends upon consumer satisfaction including users' needs such as those of physiological, physical, sociological and psychological nature and mental health. These have to be satisfied together with users' spatial ergonomics and their thermal, air, acoustic and visual quality needs which are interrelated with user satisfaction related to BP (Frontczak *et al*., 2012).

2.1 INDOOR ENVIRONMENTAL QUALITY INDICATORS

The concept of IEQ is growing as a new and very useful concept of building performance and quality (Catalina *et al*., 2011). It is because people spend most of their time inside buildings with various aspects of the indoor environment affecting their wellbeing and performance (Prakash, 2005). Furthermore, the quality of the indoor environment reflects health, comfort and productivity of occupants of building environments (Singh, 1996). Moreover, it has been emphasized that IEQ parameters are important and that a better IEQ would improve existing working conditions while minimizing complaints from occupants (Catalina *et al*., 2011). Therefore, the increasing interest in this IEQ concept has placed additional pressure on professionals such as architects, facility managers, building investors, engineers and health officials. Occupants also seek practical guidelines on creating a safe, healthy, and comfortable built environment (Kumar and Fisk, 2002).

Past research has identified thermal comfort, lighting quality, acoustic quality and indoor air quality and workspace as the most important indicators of IEQ (Mahbo *et al*., 2011). Figure 1 illustrates the main indicators relating to IEQ performance.

Figure 1: IEQ Indicators
Source: Mahbob *et al.* (2011)

However, out of the above mentioned five indicators of IEQ, only thermal comfort, IAQ, and lighting level make a measurable impact on energy consumption of a building (Catalina *et al*., 2011). Thus, only those three indicators were taken in to consideration in this study.

3. RESEARCH METHODOLOGY

The research was initiated with a literature synthesis to identify common issues relating to the indoor environmental quality in office buildings. A case study was undertaken using a mixed approach, the best suitable method for the research. A case study examines existing phenomenon within a real life context especially when boundaries between phenomenon and context are not clearly evident (Yin, 2009). Hence, in a case study, data is gathered from real life practices. Furthermore, different cases offer multiple sources of evidence and a possible replication of findings. Therefore, four multi-storey buildings providing similar services were selected as case studies. All four cases had central air conditioning systems, glazed windows and 20-25 floors.

A questionnaire survey and semi-structured interviews were selected as the data collection method. Office workers usually spend many working hours at their desks. Therefore, they become more sensitive to the working environment. Thus, their opinions about the IEQ were sought through a questionnaire survey in each case. Twenty office workers were selected from each case and thus the sample consisted of a total of 80 workers. Data was processed using simple statistics (weighted average).

The questionnaire survey was focused on three main indicators of IEQ identified from literature as having a significant impact on energy efficiency, i.e. IAQ, thermal comfort and lighting level. The five point Likert scale was used to collect occupants' responses. The scale was 1 - Unbearable, 2 - Not pleasing but bearable, 3 - Moderate, 4 - Good, and 5 - Very pleasing.

A separate five point Likert scale was used to collect occupants' responses for disease symptom analysis as well as for subsections under thermal comfort. This scale was 1 - Never, 2 - Rarely, 3 - Occasionally (few times a month), 4 - Often (few times a week) and 5 - Very frequent (almost daily).

Semi structured interviews were carried out with the managements involved in the energy management of the selected cases and content analysis was used to analyse the collected data. Table 1 denotes the interviewee profile.

Table 1: Interviewee Profile

Case Study	Interview Code	Designation	Experience
A	A_1	Manager, O & M Division	10 years
	A_2	Manager, HVAC	20 years
B	B_1	Chief Engineer	15 years
	B_2	Assistant Engineer	8 Years
C	C_1	Head, FM division	25 Years
	C_2	Facilities Manager	20 Years
D	D_1	Chief Engineer	25 years
	D_2	Assistant Engineer	18 years

4. RESEARCH FINDINGS AND ANALYSIS

4.1 IMPORTANCE OF IEQ IN OFFICE BUILDINGS

Building owners and managers during the past few decades have become increasingly knowledgeable about the importance of a good indoor environmental quality (IEQ) in their buildings (Landsberg *et al*., 2009). Building owners and managers may have heard about how good IEQ in a building can help their occupants to improve their productivity, Tenants may wish to judge IEQ on absentee rates and create productivity rates specific to their businesses. However from a building-industry perspective, it is difficult to nail down productivity specifics as studies done are not that definitive (Bluyssen *et al*., 2011).

Office workers spend most of their time in commercial buildings for carrying out their daily work as well as for having meals and entertainment. These buildings in modern cities are typically fully air conditioned high-rises in which the indoor environmental quality essentially lies in the proper operation and management of their facilities such as the air conditioning systems, electrical lighting and, sanitary and drainage systems (Joseph and Francis, 2007). The research by Gensler (2005) identified the impact an office working environment has on improving the productivity and job satisfaction of employees. Therefore, maintaining an acceptable IEQ would enable better occupant comfort in built environments.

4.2 ISSUES RELATED TO IEQ IN OFFICE BUILDINGS

Epidemiological studies such as the European Audit Project, the WHO study in Europe, and the BASE-study in the US have all shown how complex the relationships between building conditions (thermal comfort, lighting, indoor air quality and noise) and human well-being are (Bluyssen *et al*., 2011). Leea and Brand (2005) have illustrated that a majority of respondents believed that the office environment had a direct influence on their well-being and self-assessed productivity. When dissatisfaction with the environment and job were high, there was a low level of self-assessed productivity. Table 2 provides IEQ related issues that are most common in office buildings.

Table 2: Identified IEQ Issues in Office Buildings

IEQ Indicators	Causes	Issues in Office Buildings
Thermal Comfort	▪ Operating air temperature	▪ Common cold ▪ Heavy headed feeling ▪ Dry nose ▪ Dry lips ▪ Dry skin

Indoor Air Quality	▪ Ventilation problems with insufficient fresh air ▪ A high concentration of CO_2. ▪ Recirculation of air	▪ Headaches ▪ Fatigue (tiredness, lack of energy and mental fatigue) ▪ Shortness of breath ▪ Stuffiness ▪ Irritation
	▪ Low relative humidity & warm temperatures	▪ Skin problems – Dryness – Itching ▪ Drying of the mucous membranes and skin
	▪ High air velocity	Difficulty in breathing
Lighting Comfort	▪ Poor luminance ▪ Lack of exposure to day light	▪ Fatigue (tiredness, lack of energy and mental fatigue) ▪ Drowsiness ▪ Nausea ▪ Eye irritations

Sources: Ncube and Riffat (2012)

4.3 ENERGY EFFICIENT STRATEGIES IN OFFICE BUILDINGS

Building Orientation

With regard to energy saving strategies, all of the interviewees agreed that the control of solar radiation that comes into the building would have a significant effect in controlling the consumption of energy within a building since HVAC systems had the highest energy requirement in office buildings. With respect to energy saving strategies, all interviewees agreed that proper building orientation and the building location and layout at the site would highly influence the consumption of energy within the building. Interviewee B1 stated that the building orientation has a significant impact on the energy consumption. Interviewee further said that if the building is receiving direct sunlight, it will be hard to maintain the indoor temperature as well as the natural lighting supply and that therefore, it is important to design the building properly. Managements of Cases A and C stated that when constructing buildings, special building orientation factors were considered to reduce their energy consumptions.

Internal Shading Methods

Another important feature stated by many interviewees was that internal shading methods are used to control solar radiation coming into office buildings. Most of the interviewees stated that they were using “curtains”, “blinds” and “tinted glasses” in their building to control solar radiation. Interviewees D1 and D2 stated that in the morning, the building is directly exposed to direct sunlight and that therefore in order to control the solar radiation coming into the building, they install blinds at each floor. All of the occupants in the building have the freedom to adjust internal shadings to suit their requirements. Interviewee D1 stated that blinds were installed in some parts of the buildings to automatically adjust the luminance level at each floor level. These types of blinds help in controlling the solar radiation coming into the building.

HVAC System

All buildings had central air conditioning systems and several methods were being used to cool the inside of the buildings. Except Case D, all other buildings used Air Handling Units (AHU) to cool and dehumidify air at each floor. Case D used a fan coil unit at each level. The Variable Air Volume (VAV) method is used to control the air floor volume in ducts especially in areas where occupancy loads could vary considerably depending on the time of the day. The building in Case B did not have VAV installed and a constant air flow rate was provided through the duct line in each of the floors at all times. Variable Speed Drives (VSDs) had been successfully installed on fan and pump motors for a range of variable load applications. According to interviewee C1, the use of variable speed drives has caused energy savings of

35 to 50% in comparison to conventional constant speed applications. All four buildings had VSDs installed.

Lighting Systems

The types of lighting lamps presently used in the selected cases are fluorescent lamps, Halogen bulbs, CFL bulbs and LED bulbs. Fluorescent lamps were being used in all four buildings. All the interviewees stated that most of the office buildings still use fluorescent lamps. Halogen bulbs were used only in Case B and Case C to light up the outdoor garden. LED lights were being used only in Case C and Case D.

To control lighting, several methods can be used such as manual handling and the use of sensors, timers and building management systems. In most of the buildings, lights were controlled manually by the occupants and workers themselves. Except Case B, all other buildings used timers to control lighting systems. Every building under study used metering to measure the consumption of the HVAC system. Table 3 shows the energy consumption of the HVAC systems during the past three months.

Table 3: Energy Consumption of the HVAC Systems

Energy Bill (kWh)	**Case A**	**Case B**	**Case C**	**Case D**
June	249429	690208.4	344516	182325
July	260564	693703.2	327969	187707
August	234954	698194.4	319846	169420
Average energy consumption by HVAC	248316	694035.3	330777	179817
Number of square feet in the building	300930	598421	750000	179686
KWh required to cool 1 square foot of floor area	0.83	1.16	0.44	1.00

Case C needed only 0.44 kWh to cool one square foot of the building. When compared to other buildings, it had the lowest energy consumption. Case A needed 0.83 kWh to cool one square foot of the building which is the second lowest energy consumption. Case D and Case B required the highest amount of energy to cool one square foot of their respective buildings. Case D required 1.00 kWh and Case B required 1.16kWh.

4.4 ENERGY EFFICIENT STRATEGIES THAT WILL OPTIMIZE IEQ

Occupant survey and management interview findings were analysed to identify IEQ related problems and the type of energy saving strategies currently practised in buildings. Results obtained by simple statistical analysis and cross case analysis were compared to achieve more relevant data. Through this the final objective of the research, the investigation of energy saving strategies that will optimize indoor environmental quality in office buildings, was achieved. Figure 2 denotes the occupants' perception of IEQ in the four cases.

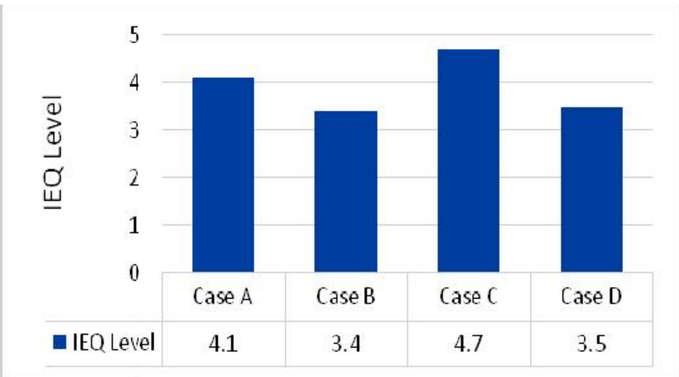

Figure 2: Occupants' Perception of IEQ in the Four Cases

Case A has obtained an average of 4.1 for IEQ level satisfaction. This indicates that its occupants perceive the quality of the indoor environment to be between the levels, good and very pleasing. Occupants of the building in Case B had rated its IEQ with an average of 3.4 which falls between moderate and good levels. Case C indoor environment conditions have been rated as 4.7, indicating that its occupants are very pleased with the quality of the indoor environment. An average of 3.5 was achieved by Case D regarding IEQ levels denoting that occupants perceive the IEQ to be between the levels of moderate and good.

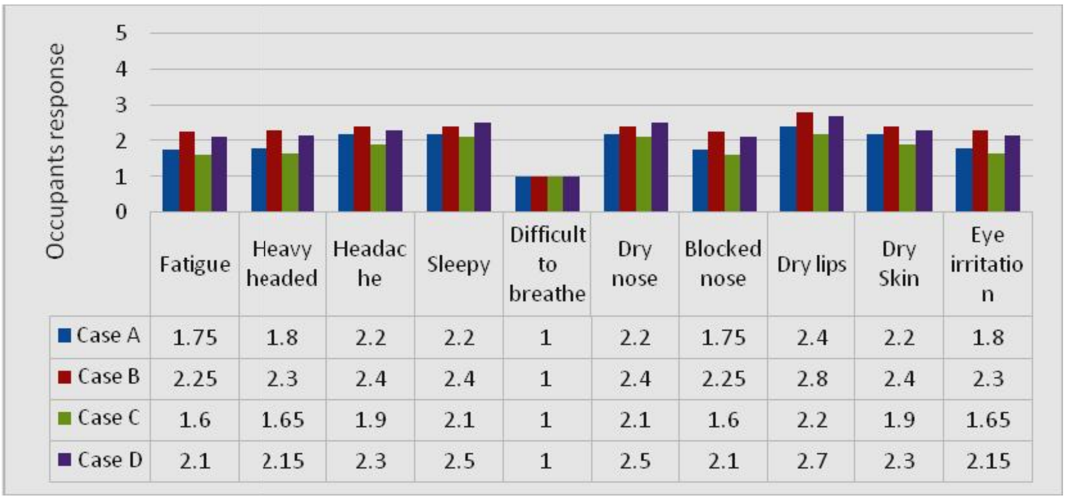

Figure 3: Distribution of Issues Caused by IEQ

Accordingly, issues related to the level of IEQ in each case were surveyed and apparently Case C had the lowest probability of occurrence of issues that can be caused by a bad IEQ. Figure 3 depicts the distribution of issues related to IEQ in the four cases.

The study investigated energy saving strategies used in four cases and calculated the energy consumed in cooling a unit space in each of the four cases. Table 4 presents the findings.

Table 4: Energy Saving Strategies Used in the Four Cases

Cases	kWh consumed to cool 1 square foot of the floor area	Energy Savings Strategies		IEQ Perceived by Occupants
		HVAC	Lighting	
Case A	0.83	- Building Orientation - Heat Gain Reduction Strategies – External Strategies ▪ Tinted Glasses ▪ Blind Walls – Internal Strategies ▪ Curtains ▪ Blinds - Variable Air Volume - Variable Speed Drives - Chiller Optimizde Start - Chilled Water Reset	- Use of Lighting Types ▪ Fluorescent Lamps ▪ CFLs - Lights Switching Method ▪ Manual ▪ Sensors ▪ Timers	4.1

Case B	1.16	Heat Gain Reduction Strategies – External Strategies ▪ Tinted Glasses ▪ Blind Walls – Internal Strategies ▪ Curtains ▪ Blinds – Variable Speed Drives	- Using Lighting Types ▪ Fluorescent Lamps ▪ Halogen Bulbs - Lights Switching Method ▪ Manual	3.4
Case C	0.44	- Building Orientation - Heat Gain Reduction Strategies - External Strategies ▪ Tinted Glasses ▪ Blind Walls - Internal Strategies ▪ Curtains ▪ Blinds - Variable Air Volume - Variable Speed Drives - Chiller Optimize Start - Electrical Demand Limiting - Chilled Water Reset - Fan Cycling	- Use of Lighting Types ▪ Fluorescent Lamps ▪ Halogen Bubs ▪ LEDs - Lights Switching Method ▪ Manual ▪ Sensors ▪ Timers	4.7
Case D	1.00	- Heat Gain Reduction Strategies - External Strategies ▪ Tinted Glasses ▪ Blind Walls - Internal Strategies ▪ Curtains ▪ Blinds - Variable Speed Drives	- Use of Lighting Types ▪ Fluorescent Lamps ▪ CFLs ▪ LEDs - Lights Switching Method ▪ Manual ▪ Sensors ▪ Timers	3.5

5. CONCLUSION AND RECOMMENDATIONS

With a growing number of hours being spent in built environments today, the indoor environmental quality is becoming a major consideration among building occupants. In office buildings, energy is mainly consumed for heating, cooling and lighting purposes. These activities are directly related to the Indoor Environmental Quality (IEQ) indicators. Four objectives were formed to achieve the aim of the study and as the research progressed, these objectives were achieved from literature and empirical studies.

This study evaluated IEQ issues that emerged in each case along with different energy performance strategies employed in those buildings. It was found that in cases which were able to minimize the energy consumption, it was also possible to provide its occupants with comfortable working conditions. Higher energy consumptions were seen in cases which had been unable to provide a comfortable indoor environment to their occupants. Proper building orientation, internal and external heat gain reduction methods such as the use of tinted glass, blind walls, curtains and blinds, use of VAV, VSD in HVAC systems, electrical demand limiting, chilled water resetting, fan cycling, use of energy efficient lamps such as fluorescent lamps, Halogen bulbs and LEDs and the use of sensors to control lighting were identified as successful strategies. The strategies identified can be applied depending on the nature of the building and the status of its utilities. This makes it evident that the effectiveness of an energy performance strategy of a building will depend on the inherent features of that respective building.

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STAKEHOLDER MANAGEMENT IN ROAD CONSTRUCTION PROJECTS IN SRI LANKA: A CONTRACTOR PERSPECTIVE

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ABSTRACT

Possessing rights and abilities to influence the project activities, project stakeholders have become a major source of uncertainty in construction projects. Road construction projects are associated with such a varied range of stakeholders and it is necessary to recognize and manage them properly to complete projects successfully. Being in constant interactions with many of the project stakeholders daily within the project lifecycle, contractor requires a proper management of stakeholders from their standpoint. Thus, this research intends to analyse the power (importance level of impact) and interest (influence probability of those impacts) of stakeholders in road construction projects and recommend suitable strategies to manage them. This aim was approached through a quantitative research methodology using a questionnaire survey including a random sample of 43 contractors' personnel from different construction projects in Sri Lanka. The research findings revealed that client, consultant, government authorities, funding bodies and subcontractors are imposing a high level of impact on project decisions and are with a high probability of having an impact on project decisions. Thereby, contactors suggest adaptation and compromising strategy to manage those stakeholders. Further, suppliers, environmental pressure groups and general public are unable to impose a high level of impact on project decisions but they are with a high probability of bringing in some sort of impact on project decisions. Thus, contractors suggest compromising and influence strategy to manage them. Finally, a matrix developed incorporating the aforementioned findings would serve as a guideline for contractors to manage stakeholders in road construction projects in Sri Lanka.

Keywords: *Interest; Power; Road Construction; Stakeholder Management.*

1. INTRODUCTION

A construction project is a complex process of planning and managing array of activities which project management requires to be focused. Therefore, many stakeholders, who involve in numerous ways bring in different types of influences in different levels for the project operations (Atkin and Skitmore, 2008). Hence, the stakeholders play a major role in the successful accomplishment of the project objectives due to the decisions and actions that are taken by them (Karlsen, 2002). Often, each and every stakeholder has different stakes or interests and their engagement itself cause conflicts of interests (Chinyio and Olomolaiye, 2010). Therefore, the project management needs to manage them towards success of the project according to their individual needs and concerns (Olander and Landin, 2005). Thereby, the concept of stakeholder management has been established to clearly identifying the project stakeholders, their potential impact on project as well as for implementing appropriate strategies (Bourne and Walker, 2005).

The stakeholders of the construction industry are more complex compared to other industries due to participation of a large number of stakeholders such as client, consultants, contractors and regulators to name some (Bourne and Walker, 2005). Generally, there is a high probability to arise disagreements between the parties which can adversely affect to project management and delivery of the project within the time, budget and expected quality. According to Assefa *et al*. (2015) these disagreements leading to number of claim situations occur in construction projects due to improper identification and management of the project stakeholders. Olander and Landin (2005) also mention that the construction industry

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worldwide has a poor record of Stakeholder Management during the past decades. Elmualim (2010) highlight that with the direct involvement of relationships and power structures, culture in different levels (national, organisational and individual) has a direct influence on stakeholder management in construction. Thereby, a contention could be brought in that localised understanding of stakeholders is essential in proper stakeholder management. Hence, there is a need to investigate stakeholder management in Sri Lankan construction industry for the purpose of developing better stakeholder management practices in that local context. Thus, the aim of this research is to analyse the stakeholder management in road construction projects in Sri Lanka.

This paper is structured in five sections. Initially, the concept of stakeholder management in construction industry is explained highlighting the three steps in stakeholder management process. Next, the research methodology adopted is described following the elaborations on research findings proposing a matrix for stakeholder management in road construction projects in Sri Lankan context. Finally, the conclusions have been drawn.

2. THE CONCEPT OF STAKEHOLDER MANAGEMENT IN CONSTRUCTION INDUSTRY

A stake is an interest and a stakeholder is an individual with a stake (Weiss, 2006). The most commonly used and widely accepted definition of a stakeholder in organisational context by Freeman (1984) states that any individual or group who is affected by or can affect the achievement of an organization's objectives is identified as a stakeholder. Newcombe (2003, p.15) has defined stakeholders in a project context as "individuals or organizations who are involved in a project, or whose interests may be positively or negatively affected to project execution and successful project completion". Construction projects are often complex and large which consist of individuals and groups with different "stakes". As number of stakeholders involved increase, the project can dramatically increase uncertainty of the situation (Freeman and McVea, 2001). Accordingly, the stakeholders' contribution is very essential for successful completion of a project. As the project stakeholders have different stakes which impact positively and negatively on project, the concept of stakeholder management has been built up to manage the relationships for the project success (Chinyio and Olomolaiye, 2010). According Rawlinson *et al.* (2008), stakeholder management is to maximize positive influences and minimize negative influences of stakeholders, by implementing project strategies.

2.1. STAKEHOLDER MANAGEMENT PROCESS

Researchers such as Olander (2006); Jepsen and Eskerod (2009); Walker *et al*. (2008); Kalsen (2002) have described many frameworks for project stakeholder management processes. However, out of all these models, Olander's (2006) model, which consists the management functions seems the most popular and heavily referred by recent researchers. The seven steps of the stakeholder management model by Olander (2006) include; identification of stakeholders, gathering information, identification of mission of the stakeholders, determining strengths and weaknesses, identification of stakeholder strategy, prediction of stakeholder behavior, implementing stakeholder management strategy. When all these project stakeholder management processes are analysed, it can be identified that all authors have basically given their concern on the three steps; identifying stakeholders, prioritizing stakeholders and implementing strategies. Following subsections include elaborations of these three basic steps.

2.1.1. IDENTIFYING THE STAKEHOLDERS

Generally, a stakeholder can be recognized from their contribution to the project such as being the source of finance or fund, personnel or material and impact in either action or inaction to the project. Bourne and Walker (2006) recommended identification of project stakeholders was based on their stakes such as; interest, rights, ownership, knowledge, impact or influence and contribution.

As stakeholders influence to a construction projects in various ways, the project managers should understand the attributes of stakeholders to determine how those affect to the project performance. Number of authors have described that the stakeholder's attributes can be recognized as a leading assessment factors for analysing the stakeholder's impact for the project as described in Table 1.

Table 1: Stakeholder's Attributes

Attributes	Description
Attitude	Attitudes of stakeholders can be recognized as the capability and eagerness to corporate or else intimidate the project (Savage *et al*., 1991). In the opinion of McElroy and Mills (2000), stakeholder attitude decides upon to whether to contribute or to go against the project.
Interest	Olander and Landin (2005) state that stakeholders can be identified as a sector under a proposed project who persuade in the execution of construction in order to safeguard their personal interest. According to Yang *et al*., (2009); Freeman *et al*. (2007) it is vital to identify the stakeholder's interest as they can be varied due to the complexity of the project in the fields of product safety, reliability on financial reporting new product services and financial returns.
Collaboration/conflict among stakeholders	Involvement of stakeholders internally (directly) or externally (indirectly) or in both ways could results in conflicts in a construction project. The difference of indirect stakeholders has results in the difficulty of resolving their conflicts with regard to the defect in establishing procedures to work incorporate with them (Weaver and Bourne, 2002).
Power	Power can be defined as an individual or group which might enduringly alter or end the project or any other work. Further, power is considered as a foremost driver of the dealings between manger and stakeholders (Mitchell *et al*., 1997)
Legitimacy	According to Freeman *et al*. (2007), the legitimacy can be identified as a requirement to accomplish dealings among the stakeholders. In addition to that Mitchell *et al*. (1997) specify that according to various researchers, stakeholders have legal interactions with the project due to contracts, legal rights and ethics.
Urgency	The extent that stakeholder declare for an instantaneous notice can be explained as urgency (Mitchell *et al*., 1997). Stakeholder's attributes can be decided upon the scope to which they persuade the project manager by means of urgent actions.
Influence	Olander (2007) states that the project stakeholders influence the process of project managers. Further, he describes in order to plan and execute a sufficiently rigorous stakeholder management process, identification of the influence of stakeholders is essential. In order to evaluate possible impact of stakeholders, level of influence assist to understanding effect of different stakeholder's in impact and nature of influence in a project.

2.1.2. PRIORITIZING THE STAKEHOLDERS

Once identifying the stakeholder's attributes, it is necessary to prioritize them to determine their likely impact on the project. Therefore, many authors have got effort to priorities project stakeholders in many ways. Olander and Landin (2005); Winch (2010) have mapped the stakeholders involved in several stages of construction projects and they have prioritized the stakeholders by using power and interest matrix. Further, Newcombe (2003) has proposed two methods of grouping each stakeholder who is likely to enforce its expectation on the project and who has the means to do so based on the power possess. The two methods are power/predictability matrix and the power/interest matrix. Nguyen *et al*. (2009); Olander (2006) have argued that these methods lead to certain problems in conducting an external stakeholder analysis, thus, the relative levels of power and interest need to be evaluated on a finer scale than one of high or low. For an example, although one has power or one has an interest, it is hard to assess each stakeholder on a scale. Therefore, Olander (2007) proposes impact/probability matrix as depicted in Figure 1.

Nguyen *et al*., (2009); Bourne and Walker (2005) have further developed the concept of 'probability of impact' and 'level of impact' as 'vested interest levels' and 'influence impact levels' by considering stakeholder's impact level of each attributes of stakeholders as indicated in Figure 2.

According to this latest technique, the project stakeholders have been analysed based on their importance level and the influence level for the project. Further, Nguyen *et al.* (2009) indicate;

Importance level of impact of the stakeholder = total impact level of each attributes

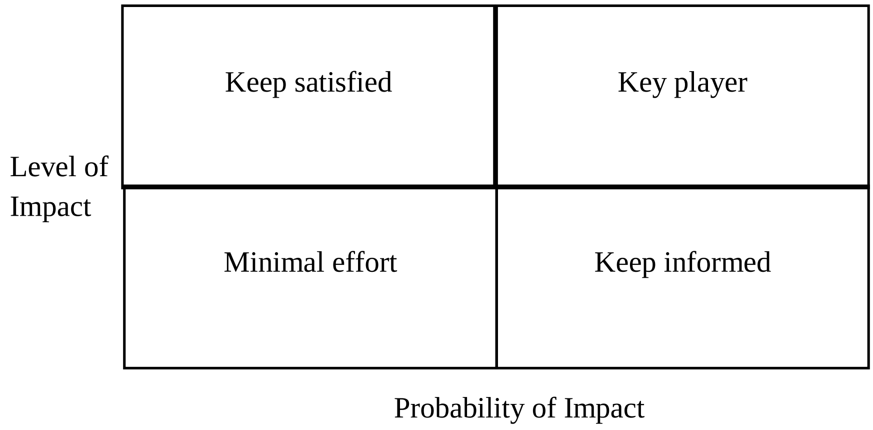

Figure 1: Impact/Probability Matrix
Source: Olander (2007)

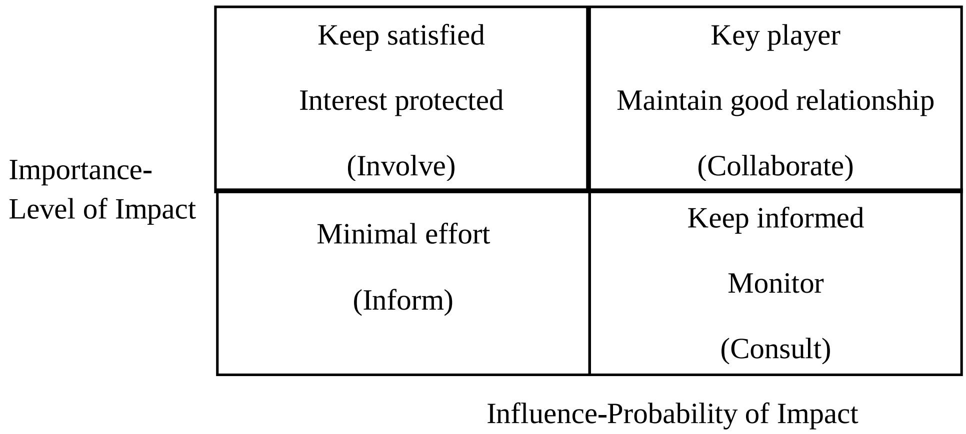

Figure 2: Importance vs. Influence Probability of Impact
Source: Chinyio and Olomolaiye (2010)

Further, Bourne and Walker (2005) indicate;

Influence probability of impact = level of influence of the stakeholder

Chinyio and Olomolaiye (2010) in their studies related to construction projects reveal that the client, consultant, donor and contractor are considered as the key players of the project. Further, these stakeholders have been mapped as high level of importance as well as high level of influence. Moreover, the stakeholders like beneficiaries, government and non-government organisations are considered as high importance and low influence level for the project. However, general public belongs to both low position as their studies. Thus, these two scales within a matrix can be adapted to analyse the stakeholders in Sri Lankan road construction projects.

2.1.3. IMPLEMENTING STRATEGIES

The project management needs strategies in dealing with different types of stakeholders. Chinyio and Olomolaiye (2010) describe four levels of stakeholder's engagement and explained four strategies: inform, consult, involve, and collaborate for each type of engagement to deal with them. Further, Aaltonen and Sivonen (2009) state that there are various ways to deal with the stakeholder's pressure and they propose five basic strategic responses as described in Table 2.

Table 2: Implementing Strategies

Strategy	Definition
Adaptation strategy	Obeying the demands and rules that are presented by stakeholders. It is considered that in order to cope with the demands and to achieve the objectives of the project it is better to adjust to the external stakeholder pressures.
Compromising strategy	Negotiating with the stakeholders, listening to their claims related to the project and offering possibilities and arenas for dialogues. Making reconciliations and offering compensation. Opening the project to the stakeholders.
Avoidance strategy	Loosening attachments to stakeholders and their claims in order to guard and shield oneself against the claims. Transferring the responsibility of responding to the claims to another actor in the project network.
Dismissal strategy	Ignoring the presented demands of stakeholders. Not taking into account the stakeholder related pressures and their requirements in the project execution.
Influence strategy	Shaping proactively the values and demands of stakeholders. Sharing actively information and building relationship with stakeholders.

Once identified and prioritized the category of the stakeholders, the five strategic responses which have been identified by Aaltonen and Sivonen (2009) can be applied to manage the project stakeholders. Next, the methodology adapted for the research is explained.

3. RESEARCH METHODOLOGY

Considering the type of Research Questions (RQ) to be answered in this research including "what" questions (RQ-1. What is the importance-level of impact of each project stakeholder?, RQ-2. What is the influence-probability of impact of each project stakeholder? RQ-3. What is the appropriate stakeholder management strategy for each stakeholder?), survey method was selected as the research strategy.

Initially, three semi-structured interviews were conducted with the participation of three managing directors of three construction contracting firms (interviewees A,B,C) to find the applicability of the literature findings to Sri Lankan construction industry: the concept of stakeholder management, the process of stakeholder management, determining attributes of stakeholders which impact to the project and the strategies manage the stakeholders. The professionals were selected mainly based on their experience of more than 20 years within the construction industry. The software program NVivo (NUD*IST Vivo Version 7.0.281.0) produced by QSR (Qualitative Solutions and Research Ltd.) for coding function during data analysis for the semi-structured interviews.

Next, the questionnaire survey was conducted to collect data on the stakeholder's importance-level of impact, influence-probability of impact and the most recommend strategies to manage them. Random sampling technique was adopted to select a sample of 60 contractors' personnel in Sri Lankan road construction industry including construction managers, site managers, project quantity surveyors and civil engineers to name some.

Relative Importance Index (RII) was used to rank the stakeholders according to impact level of each attribute during data analysis. Accordingly, respondents were requested to rate the level of impact for each stakeholder's attribute and the probability level of influence for the project. Five point Likert scale was provided to obtain aforesaid ratings. Initially, the mean of each attribute was calculated to deliver an indication of the "Importance level of impact" and "Probability level of influence".

The mean value indicates the impact level of each stakeholder's attribute. Finally, total importance level of impact of each stakeholder was calculated by taking average of all the mean values calculated for all attributes (refer Eq:01).

$$Ma = \frac{M1+M2+M3+M4+M5+M6+M7+M8}{m}$$ …... (Nguyen *et al.*, 2009) (Eq: 01)

Where,

Ma = average mean value of the stakeholder (importance level of impact)

M1, M2, M3, M4, M5, M6, M7, M8= mean values of the attributes

m= number of attributes

As per the purpose of prioritising the stakeholders, the mean value of the attribute “influence” was separately used as the influence-probability of impact.

Further, the “mean” values calculated were validated by using the standard deviation. Finally, the Importance-Performance Analysis (IPA) was used as the mapping tool to map and prioritize stakeholders to the importance/influence matrix. Final step of data collection was to identify the implementing strategies to manage stakeholders. Through the literature, five numbers of strategies were identified as the suitable strategies. In the data analysis, the most suitable strategy for particular stakeholder was identified, based on the recommendation of majority of the respondents i.e. the mode value of each strategy recommended by the respondents. Research findings are presented in the subsequent section.

4. RESEARCH FINDINGS

The preliminary semi-structured interviews allowed to refine the list of most popular stakeholders in road construction projects including; client, consultant, sub-contractors, suppliers, government authorities, general public, insurance companies, media, environment pressure groups and funding bodies. As per the interviewees A and C, often the client and the consultant of grade B type road construction projects is the Road Development Authority (RDA) and grade A roads and highway construction involve a consultant from an external organisation. Further all the interviewees described the beneficiaries of a road construction project is the general public. Moreover, interviewee A specially pointed out that funding bodies of most of the road construction projects are foreign organizations such as (Japan International Cooperation Agency (JAIKA), United Nation (UN), and Asian Development Bank (ADB) to name some. Further, both interviewees B and C described environment pressure groups can often be identified as a community representatives in the road construction projects.

The list of attributes of stakeholders which were identified in the literature synthesis (attitude, interest, power, collaboration/conflict among stakeholders, legitimacy, urgency, influence) were accepted by all interviewees. As per interviewee B, relationship of the stakeholder also affects to the project operations. Further, stakeholder’s relationships with the main contractor such as contractual/non-contractual, long term/short term etc. depend on managing the stakeholder. Interviewee C pointed out knowledge of the stakeholder also affect to the project performance. This knowledge can be related to specialized construction knowledge, new technologies etc. Moreover, if a particular stakeholder aware about his/her importance to the project, he/she can tend to demand his/her value for the project. Therefore, the stakeholders’ knowledge level needs to be assessed during stakeholder management. Thus, the two new attributes; relationships and knowledge were added to the list of attributes identified from literature review.

The stakeholder management strategies, which were identified in the literature synthesis were accepted by all interviewees as required to manage stakeholders in road construction projects in Sri Lanka. Interviewees A and B pointed out adaptation strategy has to be considered when the present demand of the stakeholder cannot be disregarded or controlled by the contractor other than obeying the same. As per the interviewee C, the compromising strategy is more useful to retain the stakeholders within the industry. Further, interviewee pointed out there is cooperate social responsibility to strengthen the stakeholders within the industry. Interviewee A stated that avoidance and influence strategies more useful for resolving conflicts among stakeholders automatically with the time. As per the interviewee B, the dismissal strategy has to be taken when any stakeholder continuously act an adversarial role (unfair business approaches and discourage the project operations) and his/her absence may not highly affect to the project objectives (time, cost and quality).

Questionnaire survey was carried out to analyse the impact level of each attribute of the project stakeholders identified and recommend strategies to manage them.

Total number of questionnaires distributed was 60 and only 43 responses were gained with a response rate of 72%. The working experience of most of the respondents was fallen between to five to ten years.

According to the results of the calculations of average mean values, the selected stakeholders were mapped by using IPA grid as shown in Figure 3. The IPA matrix contains four categories of quadrants; A - high importance level of impact/low influence probability of impact, B - high importance level of impact/high influence probability of impact, C - low importance level of impact/high influence probability of impact, D - low importance level of impact/low influence probability of impact. The stakeholder management strategies suggested by the respondents have also been indicated for each quadrant. Although five strategies were found through literature, contractors prefer using four of them to manage the stakeholders. The adaptation strategy, avoid strategy, compromising strategy, influence strategy were accepted by the most of respondents, thereby dismissal strategy happened to be dropped from the matrix. Detail explanations of research findings for each quadrant is as follows:

- Quadrant A

After mapping the selected stakeholders, it was apparent that no stakeholder is belonged to quadrant A. Therefore, in Sri Lankan road construction context, most of the stakeholders who have high importance level of impact, are also seem to be having high influence probability of impact.

- Quadrant B

As per the contractor' perspective, quadrant B is consisted of client, consultant, funding bodies, government authorities and sub-contractor, who have a high importance and high influence on road construction projects. According to Chinyio and Olomolaiye (2010), only client, consultant, funding bodies and contractor have been considered as the key players who have high importance level and high influence level. As per this research findings, sub-contractor and government authorities have also been considered as stakeholders who have high influence level and high importance level for road construction projects in Sri Lankan context from the contractor's perspective. As the quadrant B includes key players of the project, contractor is required to pay high attention for those stakeholders. This can be because, client, consultant and funding bodies are the stakeholders who have the finance, needs and knowledge to implement the project and who expect required quality, minimum cost and on time completion of project from the main contractor. According to the responses received from contractors' personnel, either adaptation or compromising strategy was more suitable for managing the stakeholder relevant for this quadrant.

- Quadrant C

According to the mapping, quadrant C consists with general public, suppliers and environment pressure groups who have low importance and high influence for the project. From contractor's perspective, these stakeholders could be less important but they have high influence in road construction context because often the general public and environment authorities tend to disrupt the construction massively. This may be because general public and the environment are continuously exposed to disturbances due to road construction activities.

According to the Chinyio and Olomolaiye (2010), general public in construction context have been positioned as low importance and low influence category. However, according to the road construction projects in Sri Lankan context, aforementioned literature finding is contradictory making general public tend to be highly influential to project activities although not considered as important. As per the survey findings, the most suitable strategy to manage stakeholders of road construction projects belonging to quadrant C is either using compromising or influence strategies.

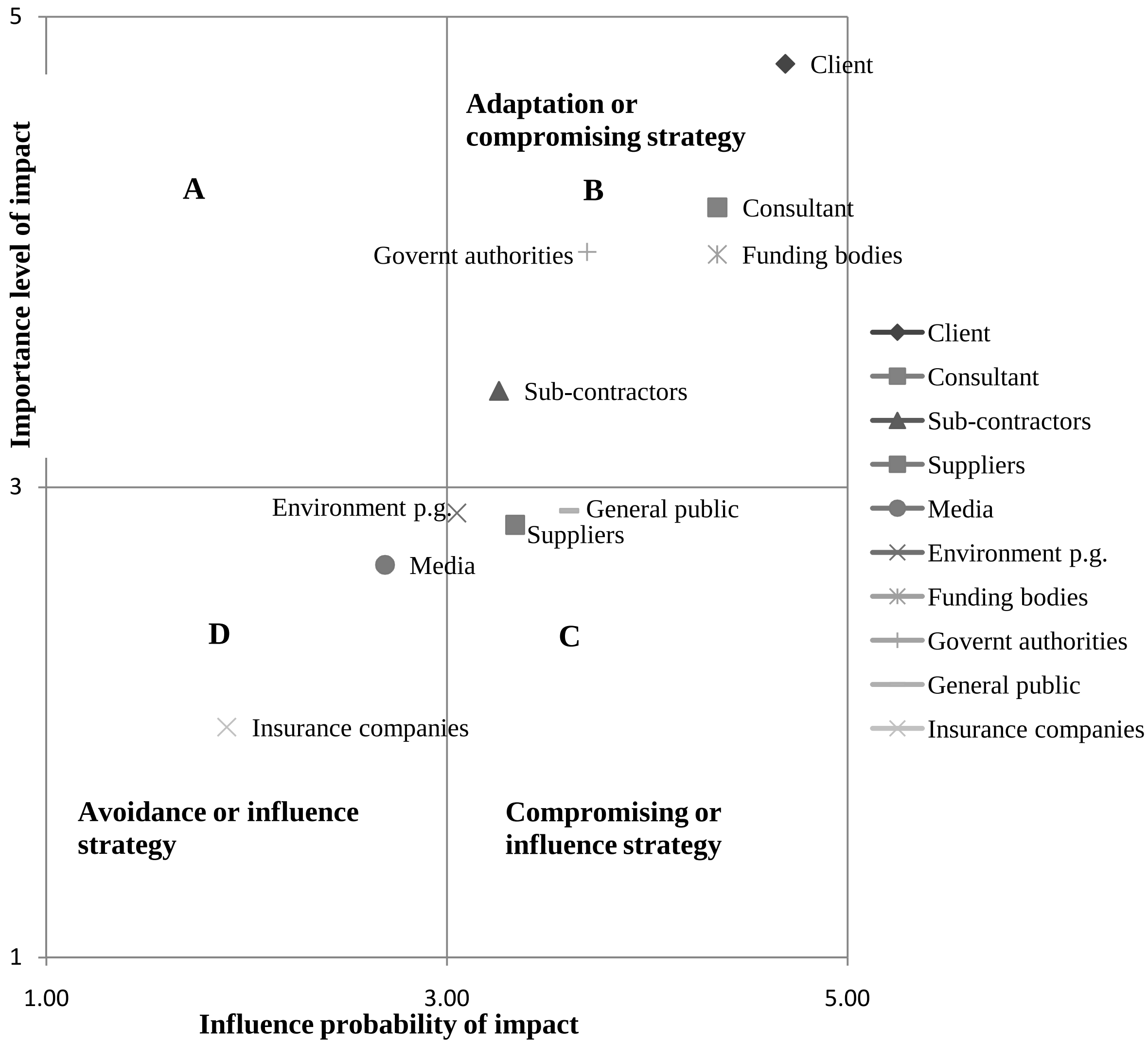

Figure 3: Proposed Matrix for Stakeholder Management in Road Construction Projects

- Quadrant D

The stakeholders in this quadrant are media and insurance companies, who have low influence level and low importance level for road construction projects. The media often creates adversarial situations and however, the contractors' point of view they have less ability to influence a road construction project. Although, the involvement of insurance companies is mandatory to transfer many risks of road construction projects, the insurance companies hold comparatively low importance level within the project from the contractors' perspective. Avoidance or influence strategies have been identified the most suitable to be used in managing stakeholders in quadrant D. Next, the conclusions drawn from the research is discussed.

5. CONCLUSION

This research aimed to analyse the stakeholder management in road construction projects in Sri Lankan context. The initial step of stakeholder management process included identifying the stakeholders. The most popular stakeholders in road construction projects were identified as; client, consultant, sub-contractors, suppliers, government authorities, general public, insurance companies, media, environment pressure groups and funding bodies. The next step of the stakeholder management is prioritizing the stakeholders. Eight number of stakeholder attributes were identified as visible with stakeholders in road construction projects. These include; attitude, interest, power, collaboration/conflict among stakeholders, legitimacy, urgency, influence, relationship and knowledge. Although many authors have used different techniques to prioritise the project stakeholders, the importance/influence analysis technique was identified as the most appropriate one which considers the all attributes in prioritizing process. The prioritising technique is consisted with two scales as “importance level of impact” and “influence probability of impact”.

According to the prioritization of stakeholders in road construction projects in Sri Lanka, the client, consultant, funding bodies, government authorities and sub-contractors held high impact level of importance and high influence probability of impact. These stakeholders were identified as the key players in road construction projects in Sri Lankan context. The general public, environment pressure groups and suppliers were belonged to low importance level of impact and high influence level of impact. In addition, media and insurance companies were belonged both low importance level of impact and low influence probability of impact.

The final step of stakeholder analysis consisted of identifying implementing strategies to manage stakeholders. From contractors’ perspective, either adaptation or compromising strategy was more suitable for managing the client, consultant, funding bodies, government authorities and sub-contractors. General public, environment pressure groups and suppliers were suggested to be managed either using compromising or influence strategies. Further, media and insurance were suggested to be managed using avoidance or influence strategies. Dismissal was not regarded as suitable strategy to manage stakeholders in road construction projects from contractors’ perspective.

Therefore, the proposed matrix in Figure 3 can be used as a guideline to assist the contractors in managing the stakeholder effectively in Sri Lankan road construction projects.

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STRATEGIC APPROACH TO ENSURE PROCESS SAFETY IN APPAREL MANUFACTURING INDUSTRY USING TOTAL PRODUCTIVE MAINTENANCE (TPM)

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ABSTRACT

Accidents in the apparel manufacturing process lead to huge monetary and productivity loses. Total Productive Maintenance (TPM) can be identified as a rapidly spreading process improvement tool which is targeting zero defects, zero breakdowns and zero accidents. The aim of this research was to explore the suitability of TPM to ensure Process Safety (PS) in the apparel industry. An extensive literature review was carried out to identify process safety, process accidents and relationship between process safety TPM in the apparel industry. Accordingly set of accidents and existing Occupational Safety and Health (OSH) practices were identified in the apparel manufacturing process.

Both qualitative and quantitative approaches were used for the effective fulfilment of research aim. During first phase of data collection questionnaire survey and document survey were carried out with support of OSH experts to gather knowledge regarding process related accidents. Second phase of data collection was conducted using semi structured interviews and observations to identify TPM approaches used to enhance the PS in apparel manufacturing process.

Findings of the study revealed that implementing TPM led to improve the process safety in the apparel manufacturing process up to some extent. But 90% of the identified TPM approaches focused to ensure the production and quality systems. Therefore, process safety was not adequately addressed by identified TPM approaches in both cases. Hence after implementing TPM, still there were accidents in the apparel manufacturing process. Since the research highlighted the importance of paying adequate attention to process safety when implementing TPM otherwise achieving zero accidents remains as a challenge.

Keywords: *Apparel Manufacturing Process; Process Safety (PS); Total Productive Maintenance (TPM); Safety Health and Environment (SHE).*

1. INTRODUCTION

Apparel industry in Si Lanka acts as the major contributor in Sri Lankan economy among the other different types of manufacturing industries and exports garments to many leading buyers in the world. Quality of garments manufactured in the country is a key contributor to retain in the international market. Therefore, it is vital to maintain the quality of the garments along with the productivity (Kapuge and Smith, 2007). There are different mechanisms available to improve the product quality and the productivity of the process and among that Total Productive Maintenance (TPM) can be identified as one of the key contributor.

TPM is a resource based management tool which directly influences to the worker-subsystem and machine-subsystem in the manufacturing process (McKone *et al*., 2001). The core TPM initiatives can be classified into eight TPM pillars or activities to accomplish the manufacturing performance improvements which includes Autonomous Maintenance, Focused Maintenance, Planned Maintenance, Quality Maintenance, Education and Training, Office TPM, Early Management and Safety Health and Environment (SHE) (Ahuja and Khamba, 2008). Considering the different pillars of the TPM SHE pillar directly relates to improve the process safety by minimising the accidents.

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SHE pillar focuses on creating a safe workplace and a surrounding area that is not damaged by production process or procedures. This pillar plays an active role integrating each of the other pillars on a regular basis. SHE pillar targets are zero accident, zero health damage, and zero fires (Wakjira and Singh, 2012).

Apparel manufacturing industry is more labour intensive and therefore, number of potential accidents are higher in the process. According to a research done by Calvin and Joseph (2006) physical, chemical, biological and ergonomics hazards are the major hazards allied with the apparel industry. Both minor and major, accidents are frequently occurred in the apparel industry and minor accidents include falls, cutting and bruising, major accidents include fingers can get caught in the machines, puncture, incise wound, blunt injury, pinch points, amputation and injuries due to chemical splashes (Basso *et al*.,2004).

Further, in an analysis of process accidents in Sri Lanka by Gunasekara and De Alwis (2008), categorise the stage of accident taken place as processing, loading/unloading, maintenance/repair, transportation (onsite/offsite), storage and unknown. Among these stages most of the accidents occur, due to human failures and technical failures, occurred during the manufacturing process. Since the apparel industry is highly labour intensive, the risk is applicable to the industry up to a greater extent. In mitigating such accidental risk various standards are implemented, such as Occupational Safety and Health Assessment System (OHSAS) 18001, Ethical Trading Initiative (ETI), Worldwide Responsible Accredited Production (WRAP), CT-PAT, other international safety standards and buyer's standards.

Even though such standards, audit systems, precautionary methods and commitment exist still workplace accidents are often occurred in apparel industry. Therefore, the need has risen to improve the occupational safety and health. TPM can be identified as a tool to improve the processes and also it can be applied to improve the process safety of the apparel industry. According to Gunasekara and De Alwis (2008) also the stage where the accidental risk is higher also during the manufacturing process/stage. Therefore, to improve the process safety TPM can be applied specially concerning the SHE pillar. Based on the factors the research problem was how TPM can ensure the process safety in apparel manufacturing. The research was aimed to explore the suitability of TPM to ensure Process Safety in the apparel industry and to achieve such aim, following objectives were set.

- Identify process related accidents in apparel industry
- Review the approach of promoting TPM to ensure process safety
- Evaluate the reduction in process accidents by implementing TPM

2. LITERATURE SYNTHESIS

According to Howard (1993), apparel manufacturing is an assembly oriented production process with a great range of raw materials, product types, production volumes, supply chains, retail markets and associated technologies. Production process of apparel manufacturing includes number of functions such as cutting, sewing, quality checking, washing, finishing, inspection and packing (Park-Poaps, 2009).

In the production process proper safety precautions should be taken to minimise or eliminate the accidents. According to Langerman (2015), process safety can be achieved in several ways such as proper designing, engineering techniques and operating and maintenance practices. Process safety leads to prevent and control the events with potential to create hazardous activity. When it comes to the Sri Lankan context Ministry of Health estimates that nearly 15% of the total admissions due to injuries at the Colombo National Hospital in 2011 were work-related (Madurawala, 2015). Therefore, the process safety has become a factor to be considered by the organizations.

2.1. PROCESS RELATED ACCIDENTS

On the other hand, in Sri Lankan context, compensation paid by employers to the victims of work related accidents in 2007 is Rs.65,417,100.00 and in 2012 is Rs.77,119,389.57 (Central Bank of Sri Lanka and Ministry of Labour and Labour Relations, 2009; Central Bank of Sri Lanka and Ministry of Labour and Labour Relations, 2012). Nevertheless, these amounts are only in respect of cases notified to the Commissioner for Workmen's compensation. However the total cost of occupational injuries mainly consists of non-financial human costs, costs of the lost production, medical costs, compensation for lost wages, production disturbance and administrative and legal overheads and it is not only the employers, workers and the governments who bear the costs of occupational injuries and diseases (Rao, 2007).

In cutting and sewing processes there are different types of machines used and some are used to knit and weave, sew or cut patterns and cloth, some press or steam, and others transport apparel pieces on the factory floor (Czarnecki, 2000). These large number of different machines can cause major accidents, such as puncture, incise wound, blunt injury, pinch points, and amputation (Aneziris *et al*., 2013).

2.2. SIGNIFICANCE OF TPM FOR PROCESS SAFETY

TPM which is an equipment management approach and the methodical application of maintenance interact all workers company wide, allowing organisations to accomplish their objectives of zero breakdowns, zero defects and zero accidents (Nakajima, 1989). In other words, according to Poduval *et al*. (2013), the passion of TPM is incorporated in the three words. “Total” means the whole workforce from top management to the machine operator, “Productive” means how to get greater excellence work out of employees and finally, “Maintenance” is the encouragement of sense of possession in operators.

Safety, Health and Environment (SHE) is the last TPM pillar and carryout a procedure to initiative in the direction of the accomplishment of zero accidents (Tsang and Chan, 2000). Even though made known as the last pillar of TPM, the TPM Safety and Environmental pillar is in the same way, if not more, vital than the seven other pillars (Wireman, 2004). The application of SHE approaches take place during the TPM setting out process and SHE activities are at no time complete (Ahuja and Kumar, 2009).

SHE pillar initiatives aim to reactively remove the root causes of occurrences that have happened, to avoid reoccurrence, and proactively decrease the risk of future probable occurrences by aiming near misses and potential hazards (Cooke, 2000).

Suzuki (1994), delivers illustrations of how TPM expands safety and environmental protection,

- Defective or unreliable equipment is a source of danger to the operator and the environment. The TPM objective of Zero-failure and Zero-defects directly supports Zero-accidents.
- Autonomous Maintenance teaches equipment operators how to properly operate equipment and maintain a clean and organized workstation. 5S activity eliminates unsafe conditions in the work area.
- TPM-trained operators have a better understanding of their equipment and processes and are able to quickly detect and resolve abnormalities that might result in unsafe conditions.

The immediate benefits of implementing the SHE pillar are to prevent reoccurrence of lost time accidents and reduce the number of minor accidents as well as preventing environmental system failure. This has a direct financial saving in the cost of containment, investigation and compensation as well as reputational impact (Sharma *et al*., 2006).

3. RESEARCH METHODOLOGY

Initially, an extensive literature review was conducted to primarily identify the importance of apparel sector to Sri Lanka, occupational safety and health issues in apparel sector and TPM concept. Then data collected through two phases.

Phase I was used to validate the accidents determined through the literature survey. Two professionals were contributed to the survey to specifically identify the process related accidents in apparel sector. The professionals were selected mainly based on their experience, rank and responsibilities within the department. All the respondents had experience in the department for more than 2 years. Twelve identified accidents were presented for the phase I data collection to search for actually existing process related accidents. Additionally, document surveys were conducted to collect the numerical values regarding accidents occurred before and after implementing TPM. Further, respondents were requested to recommend some additional accidents that take place in their premises which was not identified in the literature review. Final Interview guideline was developed with the findings of literature review and phase I data collection. The Interview guideline was consisted with accidents identified in literature review and phase I data collection. Phase II data collection was done to identify TPM process improvements which ensure the process safety in apparel manufacturing process. TPM pillars and accident root causes were presented to find most appropriate TPM technique to avoid those accidents. Respondents are requested to give their recommendations in line with the implemented techniques and as well as from theoretical background.

Multiple case study approach was identified as a suitable method because TPM implementation in process wise and plant wise different to each other. Therefore, two case studies were selected considering the number of years plant occupied, number of employees and number of phases of TPM implemented.

Hence all plants were occupied more than 10 years in industry. Furthermore 1,000 exceeds employees were working daily in selected plants. For an example 1,750 direct employees were engaged in the production lines of case study A. With all the other departments it will be 2,200 total employees in case study A. In the same way all plants were in second phase of the TPM implementation. It means they have done TPM implementation to production process and support services also. Therefore, it was easy to gather data which relevant to achieve the aim and objectives

Data analysis was carried out as statistical analysis and content analysis. Accordingly, in the statistical analysis significant accidents were identified by using the number of occurrences and lost time creation due to the accidents. Lost time was measured by using man-days. In addition, three equations were used to compare, the number of occurrences and lost man-days produce, before and after TPM implementation, namely annual man days lost rate, standardised lost man days per employee and rate of reduction in annual man days lost rate. Annual man days lost rate was calculated using the following formula:

$$\text{Annual man days lost rate} = \frac{\sum_{i=1}^{n} lt\ \mathrm{i}}{W \times d} \qquad \text{(Eq: 01)}$$

Where, *lt* = Lost time, *w* = Number of workers, *d* = Number of working days per year, *i* = Particular accident and *n* = Annual number of occurrences in particular accident.

Annual man-days lost rate represent ratio between lost man-days due to particular accidents to total number of man-days per year. Hence, identified annual lost rate of particular accidents separately. Furthermore, most lost man days created accidents were identified and included to the semi structured interview and then expert opinions were gartered for the same.

Standardised lost man-days per employee calculated using the following formula,

$$\text{Standardised lost man days per employee} = \frac{\sum_{i=1}^{n} lt}{w} \qquad \text{(Eq: 02)}$$

Where, *lt* = lost time, *i* = accident type and *w* = number of workers.

Standardised lost man days per employee represents ratio between lost man days due to particular accidents to total number of employees. The standardised lost man days per employee was calculated separately for each and every accident, which helped to further identify the accidents which had most impact to the productivity of the organization. Moreover, accident comparison between before and after implementation of TPM could be done using figures from these equations.

Rate of reduction in annual man days lost rate calculated using following formula,

$$\text{Rate of reduction in annual lost rate} = \frac{X1 - X}{X1} \times 100\% \qquad \text{(Eq: 03)}$$

Where, *X1* =annual lost rate before implementing TPM and *X* = annual lost rate after implementing TPM.

Rate of reduction in annual lost rate represent the reduction of the accidents after implementing TPM compared to before implementing the TPM. Most TPM approaches addressed accidents could be identified by the rate of reduction in annual lost rate.

Content analysis was carried out by analysing the responses of each interviewee. Respondents were requested to elaborate how TPM techniques were used to avoid listed accidents and how they have overcome the root causes in their places. Findings of semi structured interviews, was comprehensively discussed in this section. The section also contains a detailed discussion on improved and possible improvement strategies of TPM.

4. Data Analysis and Findings

Twelve types of accidents were identified in apparel manufacturing process in both cases. Number of accidents and lost time created by particular accidents were collected in phase I data collection. Incise wound accident was the mostly occurred accident in both cases before implementing TPM and the total of both cases amounted to 161 times (Case A - 80 times and Case B - 71 times). After implementing TPM, only 59 times incise wound accidents were occurred in both cases (refer Table 1).

When considering the prick injury accidents, it was identified as the second highest number of accidents which were occurred before implementing TPM in both cases. In total 135 accidents which distributed as 75 and 60 in cases A and B respectively before implementing TPM. After implementing TPM, prick injury accidents were occurred only 42 times in both cases, as 22 accidents in Case A and 20 accidents in Case B (refer Table 1). Third highest number of accidents count was recorded from contusion accidents before implementing TPM in both cases. In total 99 contusion accidents were occurred in both cases before implementing TPM and respectively 45 accidents in Case A and 34 accidents in Case B. After implementing TPM total contusion accidents reduced to 41 accidents, as 24 accidents in Case A and 17 accidents in Case B (refer Table 1).

Laceration injury accident was occurred 96 times before implementing TPM in both cases as 49 accidents and 47 accidents were occurred in the Case A and Case B respectively. However, after implementing TPM total laceration injury accidents have reduced to 33 accidents (refer Table 1).

Furthermore, irritation of eyes accidents occurred 79 times in both cases before implementing TPM. Respectively, 47 accidents and 32 accidents was happened in case A and case B. After implementing TPM total number of irritation of eyes accident was reduced to 26 times (refer Table 1).

Table 1: Number of Accidents Before and After Implementing TPM

Accident Type	Case A		Case B		Total	Case A		Case B		Total
	2011	2012	2011	2012		2013	2014	2013	2014	
Prick Injury	43	32	25	35	135	12	10	9	11	42
Sprain	20	13	10	14	57	25	30	20	17	92
Blunt Injury	1	1	2	1	5	1	2	0	4	7
Pinch points	0	1	1	0	2	0	2	1	1	4
Contusion	43	22	15	19	99	14	10	10	7	41
Laceration injury	30	19	18	29	96	9	7	11	6	33
Electrical shock	2	0	2	1	5	0	1	3	1	5
Irritation of eyes	30	17	12	20	79	5	8	9	4	26
Incise wound	48	32	34	47	161	21	12	16	10	59
Hair stuck	1	0	0	0	1	1	1	1	0	3
Compound fracture	3	0	3	2	8	3	2	1	2	8
Soft tissue injury	1	2	1	2	6	3	2	1	1	7

Table 2: Number of Loss Man-days Before and After Implementing TPM

Accident Type	Case A				Case B				Case A				Case B			
	Man days lost 2011	Man days lost 2012	Annual man days lost rate	Standardized lost man days per employee	Man days lost 2011	Man days lost 2012	Annual man days lost rate	Standardized lost man days per employee	Man days lost 2013	Man days lost 2014	Annual man days lost rate	Standardized lost man days per employee	Man days lost 2013	Man days lost 2014	Annual man days lost rate	Standardized lost man days per employee
Prick Injury	15	25	0.00877193	0 .021053	20	27	0.00783333	0.018800	9	8	0.0037281	0.0089474	7	9	0.00266667	0.006400
Sprain	47	30	0.01688596	0.040526	23	33	0.00933333	0.022400	58	70	0.0280702	0.0673684	46	39	0.01416667	0.034000
Blunt Injury	3	3	0.00131579	0.003158	6	2	0.00133333	0.003200	3	6	0.0019737	0.0047368	0	10	0.00166667	0.004000
Pinch points	0	5	0.00109649	0.002632	5	0	0.00083333	0.002000	0	8	0.0017544	0.0042105	4	3	0.00116667	0.002800
Contusion	89	45	0.02938596	0.070526	31	39	0.01166667	0.028000	31	22	0.0116228	0.0278947	22	14	0.00600000	0.014400
Laceration injury	38	24	0.01359649	0.032632	23	37	0.01000000	0.024000	11	8	0.0041667	0.0100000	14	7	0.00350000	0.008400
Electrical shock	4	0	0.00087719	0.002105	4	2	0.00100000	0.002400	0	2	0.0004386	0.0010526	7	2	0.00150000	0.003600
Irritation of eyes	68	39	0.02346491	0.056316	27	46	0.01216667	0.029200	11	18	0.0063596	0.0152632	20	9	0.00483333	0.011600
Incise wound	63	42	0.02302632	0.055263	44	61	0.01750000	0.042000	27	15	0.0092105	0.0221053	20	13	0.00550000	0.013200
Hair stuck	3	0	0.00065789	0.001579	0	0	0.00000000	0.000000	2	3	0.0010965	0.0026316	3	0	0.00050000	0.001200
Compound fracture	3	0	0.00065789	0.001579	3	2	0.00083333	0.002000	4	2	0.0013158	0.0031579	2	3	0.00083333	0.002000
Soft tissue injury	2	2	0.00087719	0.002105	4	2	0.00100000	0.002400	4	2	0.0013158	0.0031579	5	1	0.00100000	0.002400

Considering the number of accidents, most significant impact for the business was lost time created by those accidents. The production was considerably affected due to those accidents. Lost time related to accidents occurred before and after implementing TPM was further elaborated using annual man days lost rate and standardized lost man days per employee (refer Table 2).

Man day lose before and after can be shown by taking one accident as an example. Comparing all the accidents, highest loss man days were created by incise wound accidents before implementing TPM. It was 210 man-days in both cases and each case amount to 105 man days (refer Table 2). These 210 loss days were created due to 161 accidents in both cases. Hence average loss man days per accidents was 1.5 man days. After implementing TPM in both cases number of lost days due to incise wound accidents were reduced to 75 man days. It was average of 1.2 man days was loss due to incise wound accidents after implementing TPM in both cases. However, after implementing TPM still incise wound accident was the highest in loss man-days.

When consider about the annual man-days loss rate before implementing TPM, in Case A it was 0. 02302632. Even though the calculated figure was a very smaller value since it has considered the total man days of two years. This value can be used to compare and identify the rate of lost man-days reduction.

Likewise standardized lost man days per employee in incise wound accidents before implementing TPM in Case A was 0.05526316. As same in above calculations this figure can be interpreted as follows,

$$\text{Standardized lost man days per employee} = \frac{\text{Total loss man days per partcular accident}}{\text{Number of employee}} \qquad \text{(Eq: 04)}$$

Hence, standardized lost man days per employee give the figure as a ratio to total number of employees. Therefore 0.05526316 can be interpret as,

$$\text{Man days lost per employee out of total man days per two years} = \text{Standardize lost man days per employee} \times \text{Total number of employee} \qquad \text{(Eq: 05)}$$

$$= 0.05526316 \text{ x } 950$$

$$= 52.5 \text{ man days}$$

It indicates there was a possibility of losing 52.5 man days from an employee out of total working man days in a year. So in a year, from an employee 52.5 man days were lost due to incise wound accidents in Case A. After implementing TPM this figure was dropped to 21.5 man days from an employee. Similarly, before implementing TPM in Case B standardised lost man days per employee due to incise wound accidents was 52.5 man days in a year. After implementing TPM this figure was reduced to 16.5 man days in a year. Accordingly, these figures can be calculated based on the data available in Table 2.

The empirical findings highlighted a different influence of TPM implementation four different types of accidents based on the above calculations incise wound, price injury, irritation of eye, contusion and laceration injury were reduced and sprain, electrical shock, blunt injury, pinch points, hair stuck, soft tissue injury and compound fracture accidents did not show any influence to reduce number of accidents even after implementing TPM.

5. CONCLUSIONS

The empirical study was focussed on studying the TPM implementation in the apparel industry and the relationship of TPM and the process safety. The literature review was focussed on identifying the different types of accidents available in the garment manufacturing process. Then the accidents identified through the literature were reviewed for the adequacy and availability through the industry survey.

Based on the statistical analysis it was revealed most significant accidents by cross checking the lost time created due to those accidents. Further, aforesaid statistical analysis used to compare accident count before and after TPM implementation and to identify the accidents that have been mostly addressed through TPM. The results showed a reduction of the number of occurrences of some accidents and lost time produced by accidents after implementation of the TPM. Nevertheless, there were accidents still remained same as before or increased after implementing TPM too. Based on the perceptions of experts and the observation of the process also revealed that process safety of the manufacturing process was increasing through TPM implementation. However, the reduction of accidents was not applicable for all types of accidents since there were accidents which were reduced after TPM implementations also according to the expert perceptions which confirmed the results of the statistical analysis. It was revealed that there is a gap between the expected level and actual level in process safety improvement using TPM since the zero accident level was not achieved in any of the selected cases.

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STRATEGIES FOR TACTFUL TIME MANAGEMENT FOR QUANTITY SURVEYORS

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ABSTRACT

More than ever before, today's global competition is driven by time. Many issues constituted problems for construction professionals, among them central issue is the time frame. Especially Quantity Surveyor's day to day work involves management of activities and achievement of the short-term goals of the project. Therefore this study focuses on tactful time management for Quantity Surveying professionals practicing worldwide. Literature synthesis and preliminary survey were undertaken to establish the research problem of this study that emphasised lack of awareness and training among Quantity Surveyors on time management. Survey method was adopted whereby initially a preliminary survey was conducted among 10 Quantity Surveyors who are having vast experience in the field of study. Further questionnaires were distributed among 90 Quantity Surveyors and semi-structured interviews were conducted with 7 experts having specialised knowledge and experience in Quantity Surveying, Time management, Human Resource Management and Project Planning.

The research findings acknowledged Quantity Surveyor's roles and duties in a typical organization followed by critical activities that consume more time among the other duties such as preparation of final accounts and agreements and procurement and coordination of stakeholders etc. while dominant causes were lack of experience in Quantity Surveying practices and type and requirements of clients. The survey findings also offered possible techniques to maximise time management such as effective team work and Key Performance Indicators (KPIs) and identified barriers that could arise in implementing them. MANOVA test was carried out with the aid of SPSS tool, which verified the influence of type of sector, type of organisation, country of practise and managerial position employed on each factor. Further NVIVO software package was used to produce cognitive map to visualise the overall picture of study. Ultimately the solutions that emerged from the research findings were used to formulate guidelines to assist Quantity Surveyors achieving tactful time management in professional career - the aim of this research.

Keywords: *Construction Industry; Quantity Surveyors; Tactful; Time Management; Sri Lanka.*

1. INTRODUCTION

The construction industry is usually considered to be the backbone in any economy (Enshassi*et al*., 2010). The nature of the industry is such that it is not capable of being planned, i.e. its dynamic environment prevents any long and medium term planning (Yisa *et al*., 1996). Ringen *et al*. cited in Hoffmeister *et al*. (2011) argued that in the construction industry, the tight deadlines and working with and around other trades can create an atmosphere of tension and anxiety. As a result, difficulty with the availability and management of time was the primary cause of stress for the professional groups. Thus, effective time management skills are increasingly important to enhance the performance of professionals (Hawkins and Klas, 1997).

Among the construction professions, quantity surveying is an important discipline (Olatunji *et al*., 2010). According to Ferry *et al*. cited in Matipa *et al*. (2008) on frequent occasions, quantity surveyors (QS) do not have enough space of time to perform their functions. In addition, Female QS felt that jobs in the construction industry are masculine in nature, are stressful and demanding, and entail long working hours.

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Dainty *et al*. cited Ling and Poh (2004) have also found site work to be time consuming and infringing on social activities and family responsibilities. Moreover, time management will be more difficult for QS in future (Claessens *et al*., 2007).

As a result, identifying and analysing the time management issues faced by QSs and providing practical solutions to overcome those problems is vital and valuable for the young QSs to succeed in their professional life. As well it will be beneficial for the construction industry as a whole and ultimately for the nation. This paper initially provides a comprehensive literature review in order to mine the background of the profession 'Quantity Surveying' and its relationship to the time management phenomena. Then the findings of the preliminary survey, questionnaire survey and experts' interviews are presented and further subjected to a discussion. Finally, conclusions are drawn from the findings.

2. TIME MANAGEMENT

Time is the most precious, invaluable and limited resource and unless it is carefully managed, nothing else can be (Hassanzabeh and Ebadi, 2007). In addition, Britton and Tesser (1991) argued that for most of the cases time is one of the important factor determine the success of any activity. However in today's society, ability to handle time is becoming more and more critical factor (Harung, 1998). In addition Rehnquist cited in Margol and Kleiner (1989), stressed that the real reason for excelling in managing one's time was to lead as fulfilling a life as possible, but balancing all of the family and personal role with work commitments is not an easy task as timing plays an important part. Therefore it's essential to focus on time management phenomenon for the betterment of professional life as well as personal life. During the last two decades, there has been a growing recognition of the importance of time in the organizational literature. A number of authors discussed the need for better incorporating time in theoretical models and research designs (Claessens *et al*., 2007). However none of them contemplated time management for quantity surveying professionals. As a result, this research aims to study the time management behaviours of QSs and attempts to develop some general guidelines on tactful time management that can be applicable for QSs working worldwide.

2.1. TACTFUL TIME MANAGEMENT

There is no agreement on the definition of time management in past studies. Several authors described time management in different ways. Therefore, Claessens *et al*. (2007) found it was difficult to determine the exact content of time management in past research. As a result a definition was suggested by them for time management as: *"Time management is a set of behaviours that aim at achieving an effective use of time while performing certain goal-directed activities. These behaviours comprise of assessment behaviours, planning behaviours and monitoring behaviours"*. In addition, Oxford Dictionary (2014) defines the meaning of tactful as "having or showing skill and sensitivity in dealing with others or with difficult issues". Accordingly tactful time management can be described as: *having or showing skill and sensitivity on time management.* According to the definition of tactful time management, it's essential to identify time management skills. Time management may be aided by a range of skills, tools, and techniques used to manage time when accomplishing specific tasks, projects and goals complying with a due date (Ahmad *et al*., 2012). Further time management skills are ones abilities to recognize and solve personal time management problems. Accordingly time management can be presented as a set of time management skills described by Hassanzabeh and Ebadi (2007) as: Goal setting, Planning, Prioritizing, Decision making, Delegating and Scheduling.

2.2. ROLES AND DUTIES OF QUANTITY SURVEYORS

Due to the dynamic environment of the construction industry the quantity surveyor's role has seemingly continual evolution over the years (O'Brien *et al*., 2014). The prime and essentially, the core role of quantity surveyor rotate around the concept of cost control (Senaratne and Sabesan, 2008). Willis *et al*. (2007) advocated three types of roles to replicate this, namely traditional, evolved, and developing as shown in Figure 1.

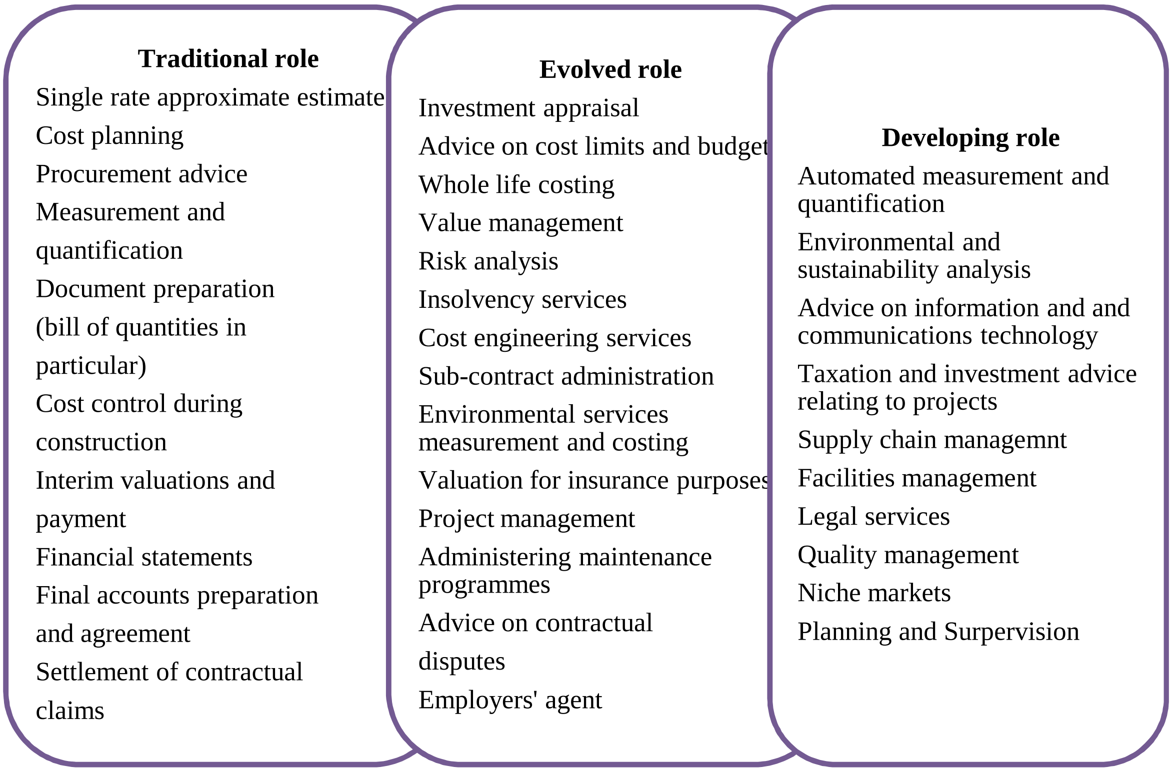


Figure 1: Clusters of Quantity Surveyors' Roles

O'Brien *et al*. (2014) identified some of the duties of QS according to construction phases as illustrated in the Table 1.

Table 1: Quantity Surveyors' Duties based on Construction Phases

Pre-construction Duties	Construction Duties	Post construction Duties
Tendering and winning jobs in a highly competitive market	Scope change and variation management	Agreeing final accounts
Estimating reliably when there is poorly documented design information	Cash flow monitoring and reporting	Obtaining practical/ final completions and Code Compliance Certificates
Cost data integrity and reliability of cost advice	Margin maintenance	Capturing and valuing costs associated with snagging requirements
Accuracy of budgeting and cash flow forecasting	Reconciling and estimate assumptions with onsite cost realities	Management of Defects rectification liability
Effective contract negotiation	Conflict management, negotiations and Dispute resolution	Retentions release
Appropriateness of contingency/ risk margins and allocations	Contract administration	Cost analysis/ cost modelling
Prediction of market trends and their impacts on proposed project	Cost -to-complete forecasts	Liquidated and ascertained damages
Gaining and sustaining clients' confidence	Industry Capitalisation Overdraft/ credit facilities	Arbitration/dispute resolution
Adequacy of tender and contract documentations.	Record keeping	Satisfying client - gaining repeat commissions
Resolving tags in tender evaluation	Communication and reporting	Documenting and sharing lessons learnt for use in future jobs

3. RESEARCH METHODOLOGY

The research initiated with a literature synthesis to establish a theoretical background on the concept of time management phenomenon for Quantity Surveyors using existing knowledge. However it was revealed lack of studies on time management; especially for Quantity Surveyors. As a result preliminary survey was conducted among 10 experts in Quantity Surveying field in order to identify the critical duties that consume more time among the Quantity Surveying functions, possible causes behind poor time management and practical solutions to achieve tactful time management. Consequently the survey approach was adopted as the best suitable method for the research among Quantity Surveying professionals working in Sri Lanka and outside the country to ascertain their perception on the above mentioned aspects. Questionnaire survey and semi-structured experts' interviews were used as two separate techniques to collect data under the survey approach (in addition to preliminary survey). Questionnaires were distributed among 90 Quantity Surveying professionals and semi-structured experts' interviews were conducted among 7 experts having specialised knowledge and experience in Quantity Surveying practice, Human Resource Management, Project Management and Time Management. MANOVA test (to consider the effects of more than one independent variable on combined set of dependent variable) was used to analyse data collected through questionnaire survey, and data collected through interviews were analysed using content analysis with the aid of NVIVO software package to arrive at suitable conclusions and recommendations. Sampling strategy for data collection was convenience sampling under non-probability sampling technique.

4. PRELIMINARY SURVEY

The information lacking from the literature review was collected through preliminary survey conducted among 10 Quantity Surveyors working across client, consultant and contractor organisations. Amongst those 8 were local interviews and 2 were from outside the country surveyed through electronic mail. Initially the critical duties that consume more time compared to other functions were acknowledged as illustrated in Figure 2.

Client Organization

- Getting approvals
- Procurement and coordination of stakeholders to the project
- Tendering procedures
- Evaluation of alternative proposals
- Preparation of project budgets
- Feasibility studies

Consultant Organization

- Preparation of tender documents (especially BOQ)
- Checking final accounts
- Claim report analysis
- Evaluation and selection of suitable contractors
- Cost planning and estimating
- Evaluation of interim payment applications

Contractor Organization

- Preparation of final accounts and agreements
- Estimating & tendering
- Preparation of claim reports
- Several negotiations
- Post contract administration
- Preparation of interim applications
- Sub contractor selection
- Sub contractor evaluation andpayments

Figure 2: Critical Duties of Quantity Surveyors that Consume More Time

Consequently the possible reasons behind poor time management were examined and each respondent's answers were collected and compiled into one set of document. Further, those responses have been divided into three categories, as Personal Causes, Organizational Causes and Other Causes are demonstrated in Figure 3.

Personal Causes

- Inadequate training and/or education level
- Experience in quantity surveying practices
- Poor teamwork
- Improper allocation of tasks among team members
- Improper planning
- Lack of specialization skills in quantity surveying
- Personal attitude or life style
- Personal competencies
- Working attitude
- Social activities
- Personal life issues
- Improper communication
- Lack of practical knowledge
- Other commitments
- Addicted to the technology to perform QS's job
- Lack of proper documentation

Organizational Causes

- Organizational policies
- Organizational structure – Top management
- Type and number of projects
- Overloaded work
- Working environment
- Company priorities
- Next authorized person or superior
- Managerial decisions which affects QS activities
- Salary
- Inadequate education of subordinates
- Number of QSs at the office
- Reputation of the company
- Relationship with the outsiders

Other Causes

- Nature and complexity of project
- Type of employer & his requirements
- Most of the QS works depend on others information/output
- Level of details and information available
- Unforeseeable events
- Nature of profession
- Type of procurement
- Position of construction industry
- Diversity of team members in work related aspects
- Mentality of Asian country people in relation to time management
- High number of parties involved
- Repetition of work
- Special procedure (procurement guideline)
- Government rules & standards
- Legislation actions
- Delay caused by the authorities

Figure 3: Potential Causes behind Poor Time Management

Finally some suggestions were proposed and listed under two headings (as given under Figure 4) as Personal Strategies and Organizational Improvements to overcome the above mentioned causes.

Personal Statergies

- Effective team work
- Proper planning well prior to the events
- Development in personal skills and attitude
- Proper division of tasks among team members
- Use of check lists
- Updating the knowledge
- Methodological & systematic working pattern
- Use of formats
- Continuous reviewing & updating of sequencing and prioritizing of activities
- Direct communication with the superior
- Improvement in psychological aspects
- Ascertain skills
- Systematically organized documentation
- Formalized procedures
- Development of brain to add value to the process
- Personal relationship/communication
- Sharing of information & knowledge with others
- Use of available software to its maximum usage
- Personal willingness to take opportunities
- Use of programmes for daily activities
- Writing internal memos
- Putting Provisional Sum
- Use of master specification, BOQ, preambles etc.
- Use of industry norms
- Use of guidelines

Organizational Improvements

- Continuous monitoring the actual activities against planned ones
- Time management training, CPD,
- Use of proper advanced technology/software
- Regular management meetings
- Key Performance Indicators (KPIs)
- Motivation & guidance by the top management/other staff
- Incentives/Bonus/Promotions etc.
- Quick communication methods
- Development in organizational standards in quantity surveying
- Providing required facilities
- Positive working environment
- Decentralization of powers
- Centralized database & ease of access
- Use of work studies, research & development etc.
- Reallocation & sharing of resources
- Availability & usage of alternatives
- Use of outsourcings resources
- Some kind of punishments
- Distribution of profit among team members

Figure 4: Practicable Time Management Initiatives

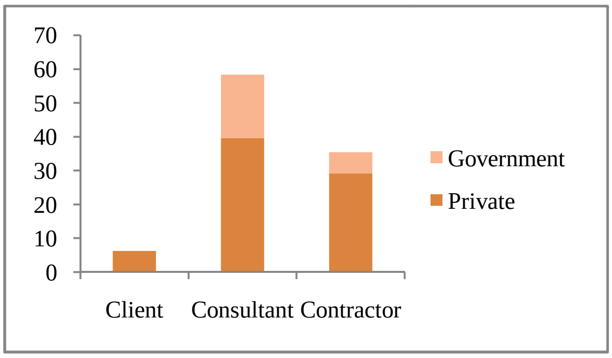
In addition to the solutions for the improvement in time management, the possible barriers that may arise when implementing those time management initiatives were identified through preliminary interviews. The compiled list of potential difficulties includes: Personal attitude to resist the change towards time management, Lack of awareness on time management, Lack of interest of top management, Fear on any issues that may arise after implementing time management initiatives from staff and management, Requirement of additional resources to implement, Requires a significant time to implement and Financial constraints of the employer to support time management initiatives.

5. DATA COLLECTION AND ANALYSIS

Quantitative data for this study were collected through Questionnaire survey conducted among Quantity Surveyors working worldwide. Subsequently the findings were verified through experts' interviews conducted among experts and the qualitative data obtained from interviews were analysed using NVIVO software. Initially the presented data was analysed from various perspectives to understand the inter relationships between variables in order to demonstrate a clear understanding on the research findings.

5.1. PROFILE OF RESPONDENTS

The profile of the respondents of the questionnaire survey are classified according to the type of organisation including the type of sector to which their firm belongs to and managerial position and their working experience and presented in Figures 5 and 6 respectively.



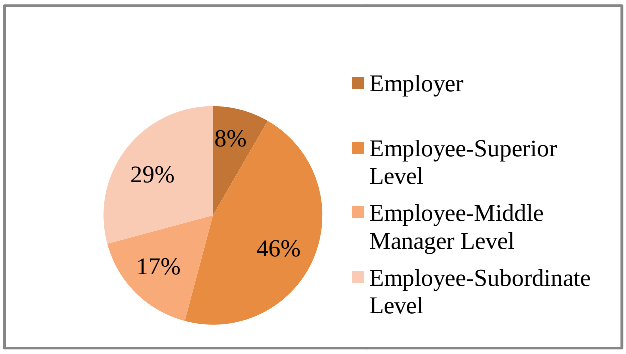


Figure 5: Respondents' Profile Based on Type of Firm and Managerial Position

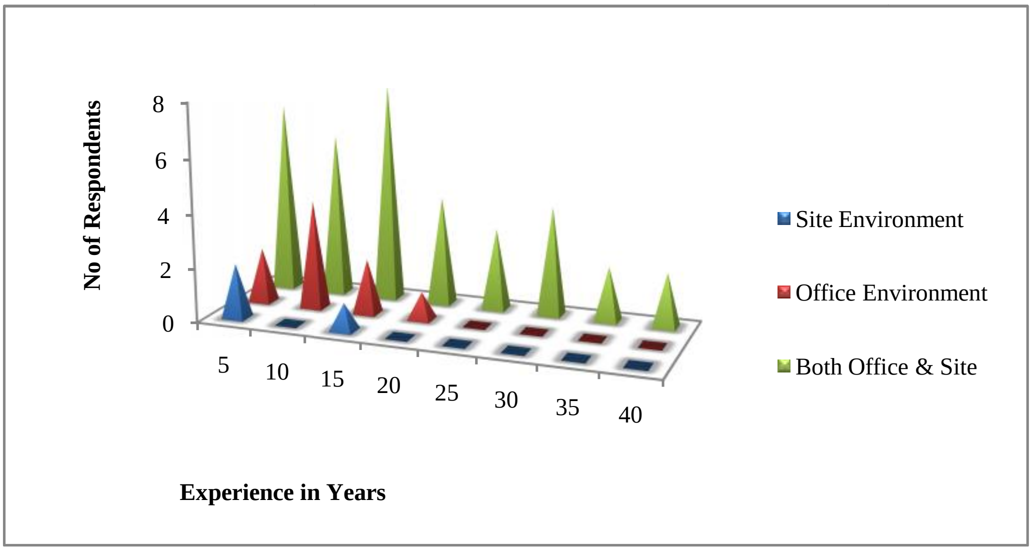


Figure 6: Respondents' Profile Based on Working Environment

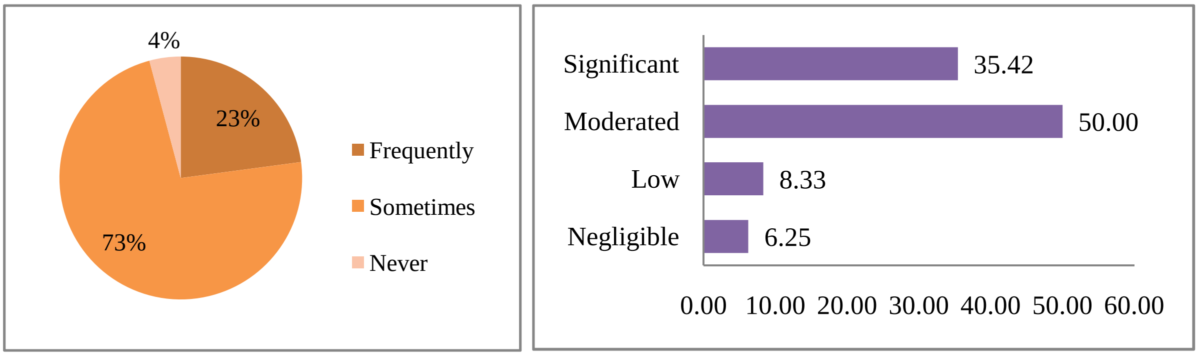


Figure 7: Frequency of Issues Faced by QSs on Time Management and Severity of Poor Time Management

The sample was verified to ascertain if the problem of poor time management is evident in the sample so that conclusions could be drawn for the population. The Figure 7 reports the perception of the Quantity Surveyors with regard to frequency of issues faced by QSs on time management and severity of poor time management in day to day life.

5.2. *ESTABLISHING THE PROBLEM OF POOR TIME MANAGEMENT*

It proves the existence of time management issues faced by QS to be substantial with 73% of respondents rating the level of existence to be at a sometimes and around 23% of respondents rated as frequently level. Also the severity of poor time management felt by QS has been rated 50% at moderated level followed by 35% of significant level. Therefore it can be concluded that majority of the respondents are experiencing considerable level of time management issues. Based on the results of sample, it can be interpreted that the population has a serious issue on poor time management. On the other hand the time management sessions, workshops, and CPDs on work performance and time management, importance of time management for professionals, scheduling techniques and ethical landscape in Quantity Surveying. conducted among the construction professionals in Sri Lanka were acknowledged.

Having established the problem of time management, the mode of communication was verified to recognize whether these issues are brought to light by Quantity Surveyors to their employers/superiors/top management, if time management issues exist. Figure 8 illustrates that most individuals have discovered time management issues through personal experience and the next majority being through discussion with peers, followed by a small percentage of people through observation. A significant point has to be emphasised on the absence of a proper organisational communication mechanism in Sri Lankan construction firms to report on time management issues.

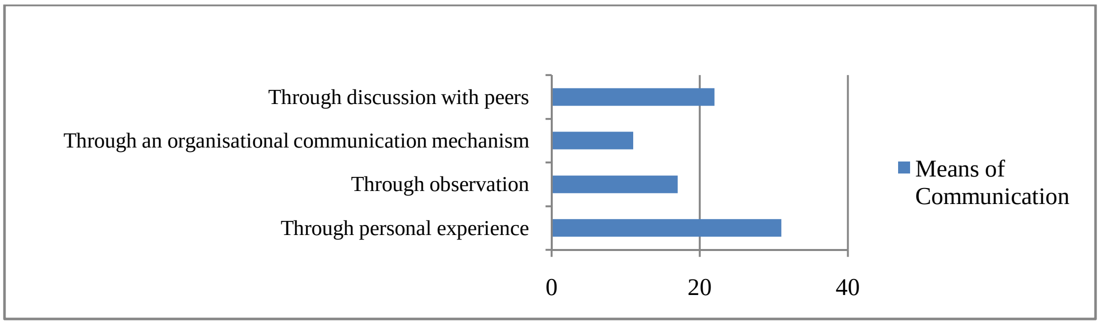


Figure 8: Mode of Communication Used to Identify Time Management Issues

5.3. *RESULTS OF MANOVA TEST*

MANOVA (Multivariate Analysis Of Variance) was used to explore outcomes from several parametric dependent variables, across more independent variables (each with two or more distinct groups). Since this study attempts to identify the statistically significant differences between and/or among more than one dependent variable (i.e. critical duties, causes, solutions and barriers) and more than one independent variable (i.e. type of organization, type of sector, country of practise and managerial position), MANOVA was the most appropriate tool among the others. For each MANOVA both the *multivariate effects* (how the independent variables have an impact upon the combination of dependent variables) and *univariate effects* (how the mean scores for each dependent variable differ across the independent variables groups) were explored to study them individually and as a whole.

Initially MANOVA performed the multivariate test and provided Wilks' Lambda value together with associated F value and significance value (p). Wilks' Lambda is a measure of the percent of variance in the dependent variables that is not explained by differences in the level of the independent variable. If the variance (Wilks' Lambda) is close to 1, it can be interpreted that no significant variance between dependent variables with associated F value. Further if the significance value (p) is greater than the benchmark value of p (0.05), there is no significant effect on the group of dependent variables from the independent variables. Subsequently it conducted an univariate test (F test) and offered an F ratio that was assessed against critical (cut-off) F value and statistical significance will be achieved when a F ratio of particular variable is greater than the critical F value. Similarly the level of significance (also known as *p* value for the test) was measured against the benchmarking significance value (also known as alpha (α) value) and statistical significance is attained when a *p*-value is less than the significance level (α). A confidence interval of 95% was adopted based on rule of thumb, which means the benchmarking significance level (α) is 5% (0.05). If the *p* value for a particular variable is less than 0.05 and F ratio is greater than critical F value, it means a significant effect is caused by the categorical variable and vice versa. Statistically this is known as rejecting the null hypothesis H_0: *the particular categorical variable does not have any significant effect on the dependent variable* or there is less than 5% chance that the result would have been due to random reasoning. Consequently the post hoc test was carried out to arrive at estimated marginal mean value for each dependent variable based on respondents' comments on a 6 point rating scale. This will resemble the Quantity Surveying populations' perception on each factor and rank them accordingly giving priority to the top priority factors. Results of the test on questionnaire survey are tabulated as follows. Data collected from interview are incorporated into the research findings.

6. RESEARCH FINDINGS

6.1. AN OVERVIEW OF TIME MANAGEMENT FOR QUANTITY SURVEYORS

A study was made by Waller *et al*. (2001 cited Wu and Passerini, 2013) that indicates different deadline perceptions and behaviours among construction team members affect the ability of teams to meet deadlines. Although among the construction professionals QSs are the ones who frequently appear to time pressure as argued by several authors. As a result this study attempts to examine the time management phenomenon among Quantity Surveyors. In addition, experts have stressed that QSs time management may be influenced by specified contractual time targets for each critical activity. The reason behind this is all of the Quantity Surveyor's duties are related to construction contracts. Therefore their time shall be proportionately allocated to several projects based on the scope of services they want to provide and nature and complexity of projects they are supposed to do. Despite the lack of awareness on time management, questionnaire survey and expert interview results acknowledged some trainings and workshops at organizational level related to time management. Further the questionnaire survey findings identified that majority of the individuals have discovered time management issues through personal experience while there is an absence of a proper organisational communication mechanism in Sri Lankan construction firms to report the time management issues to superiors.

6.2. KEY FUNCTIONS THAT CREATE TIME MANAGEMENT ISSUES

Literature findings offered a complete set of functions of QSs with reference to Willis *et al*. (2007) and O'Brien *et al*. (2014) for roles and duties respectively. However only less number of literatures has mentioned about critical roles and duties that consume more time compared to others. As a result preliminary survey was undertaken to disclose the critical duties in client, consultant and contractor organisation that consume more time.

However among the critical duties obtained from preliminary survey, only some activities (which satisfied the criteria for selection) have been taken for detailed analysis. Initially it was revealed that there is no influence between the duties in each type of sector and managerial position. Further each activity is not impacted by categorical variables (type of sector and managerial position). Accordingly the key functions that create time management issues include: Preparation of final accounts and agreements, Preparation of tender documents (especially BOQ), Estimating & tendering, Preparation of claim report, Checking final accounts, Procurement and coordination of stakeholders to the project, Value engineering, Turnaround documents, Preparation of cost value reconciliation and getting authorities' approvals. In addition to type of organization, the impact from range of sectors in QS's time management has been acknowledged through preliminary survey. Findings revealed that QSs working for both private and government clients may need performing additional jobs due to project and clients' requirements that may influence on their time management. Moreover preliminary survey has exposed that time pressure reduces from pre-construction to post construction.

6.3. FACTORS THAT CONTRIBUTE TO POOR TIME MANAGEMENT

The prevailing causes for poor time management were acknowledged through literature and preliminary survey. The research carried out by Guoqing and Yongxin (2000);Hassanzabeh and Ebadi (2007) have identified some of the potential causes that may impact on time management as; social activities, personal attitudes, several meetings and sudden crisis. Ultimately it implies that individual factors have a great effect on wasting time than organizational or natural factors. Rightfully majority of the solutions were acknowledged under personal improvements. In addition to the above principal causes for poor time management, some other causes were collected through preliminary survey and classified under three headings as, Personal Causes, Organizational Causes and Other Causes. Similar to the critical activities, the questionnaire survey findings revealed that there is no inner relationship between causes in respect to type of organization, type of sector, country of practise and managerial position. However it was identified that there is a significant impact on some causes from these categorical variables. As a result only those selected causes were analysed in detail and findings are listed as: Experience in Quantity Surveying practices, Lack of specialisation skills in Quantity Surveying, Improper allocation of tasks among team members, Personal competencies (especially time management skills), Type of Employer & his requirements, Diversity of team members in work related aspects, Inadequate education of subordinates and other commitments. Further finding revealed that office work is more time consuming, compared to site environment. Ultimately the findings revealed that these reasons require to be managed in a different manner, i.e. some unique techniques that involve a significant level of personal skills are essential to overcome these causes. As a result tactful techniques that vary from general time management principles are proposed to be adopted by QSs when managing their time due to those unrestrained factors.

6.4. PRACTICALITY OF TIME MANAGEMENT INITIATIVES

Time management is possible by understanding the theories, principles and techniques proposed by scholars and philosophers who have understood its significance. However these tools and techniques are dependent upon the work and the amount of time required for completion in personal and professional life. Moreover literature identified some time management tools as Personal Information Management (PIM) software and Personal Digital Assistants (PDAs) to facilitate the scheduling and prioritising of activities. Literature findings recognised a step by step approach to solve the time management issues as: Getting a clear understanding of the problem, Establishing goals and priorities, Making time to do planning, Delegating unnecessary work, Allocating and scheduling time for important and priority activities, Set yourself at least one major priority each day and achieve it, Frequently review and update the schedule, Eliminate one time waster from your routine each month, Review at the start of each day and make sure your first hour is productive, Try to finish what you start, Give yourself some quality time each week to network outside your business - perhaps attend a seminar, follow-up customers, introduce yourself to potential customers, or talk to business advisors and Take some time for yourself - time to learn, time to relax, and time to live. In addition to time management initiatives, the feedback mechanisms to evaluate the effectiveness of time management initiatives were revealed through preliminary survey as personnel evaluation and performance review. Moreover literature findings acknowledged that time management will be more difficult for QS in future and accordingly preliminary survey findings confirmed the above literature findings. In addition preliminary and questionnaire survey has attempted to distinguish the difference between QSs working in Sri Lanka and outside the country. Consequently the findings were highlighted that there are pros and cons in working Sri Lanka and overseas. Therefore it will not impact on the time management of individual QS.

6.5. DEVELOPING GUIDELINES

According to the definition given for tactful time management (under section 2.1), it is essential to consider the time management skills and attitudes when developing guidelines for tactful time management. Subsequently the collected data from preliminary survey were categorised under two headings as, Personal Strategies and Organizational Improvements. However among them, only some strategies (which satisfied the criteria for selection) were carried for further analysis using univariate test. Further it shall be noted that to practise tactful time management these guidelines need to be applied together with time management skills. Accordingly the following guidelines were developed based on those selected solutions to achieve tactful time management for QSs.

6.5.1. GUIDELINES TO ACHIEVE TACTFUL TIME MANAGEMENT FOR QUANTITY SURVEYORS

Effective team work, Development in personal skills and attitudes, Updating the knowledge, Use of formats, Proper division of tasks among team members, Continuous reviewing & updating of sequencing and prioritising of activities, sharing of information and knowledge with others, Personal willingness to take opportunities, Use of proper advanced technology, Key performance indicators (KPIs), Use of work studies, research & development etc., Direct communication with immediate superior, Use of master BOQ, specifications, preambles etc., Writing internal memos, letters etc. among the staff and Use of outsourcing resources.

6.6. BARRIERS TO TIME MANAGEMENT INITIATIVES

Literature findings, preliminary and questionnaire survey revealed some potential barriers that influence on time management initiatives as: Requirement of additional resources to implement and requires a significant time to implement. As a result it can be concluded that if QSs are able to prove this is an effective & productive initiative, then top management will approve and allocate the funds.

7. CONCLUSION

Analysis on research findings acknowledged the importance of time management for construction professionals; especially for QSs. Since time management is more towards to personal achievement the initial step has to come from individual level where each QS shall take necessary actions to apply and enhance the time management initiatives at personal level. However individual policies will not become successful unless the working environment or system is favourable to practise those strategies. Therefore top management of the organisation shall ensure that positive and corporative working environment is there to practise time management initiatives at individual levels. Superiors have a significant role to play in creating this culture by maintaining flexible relationships with subordinates, so that they can communicate the issues in achieving time targets. Further human resource division can introduce and execute time management techniques for the entire organisation while providing training and development on these initiatives if necessary. Moreover the professional institutions that govern the conduct of professionals registered under such bodies as members to incorporate relevant guidelines from the given list to enhance the time management behaviours among QSs at industry wide level. Accordingly Institute of Quantity Surveyors Sri Lanka (IQSSL), Royal Institution of Chartered Surveyors (RICS) and other professional institutions need to initiate and endorse the policies on time management to upgrade its members' professional standards to global level. In conclusion, all time management skills and strategies are learnable. With these time management skills and strategies, QSs need to select proper time management techniques that are most relevant for their situation.

The Figure 9 demonstrates the overview of this research that indicates the critical time consuming duties, causes behind them, practicable strategies to tactfully manage the time and possible barriers that may arise when implementing the given strategies.

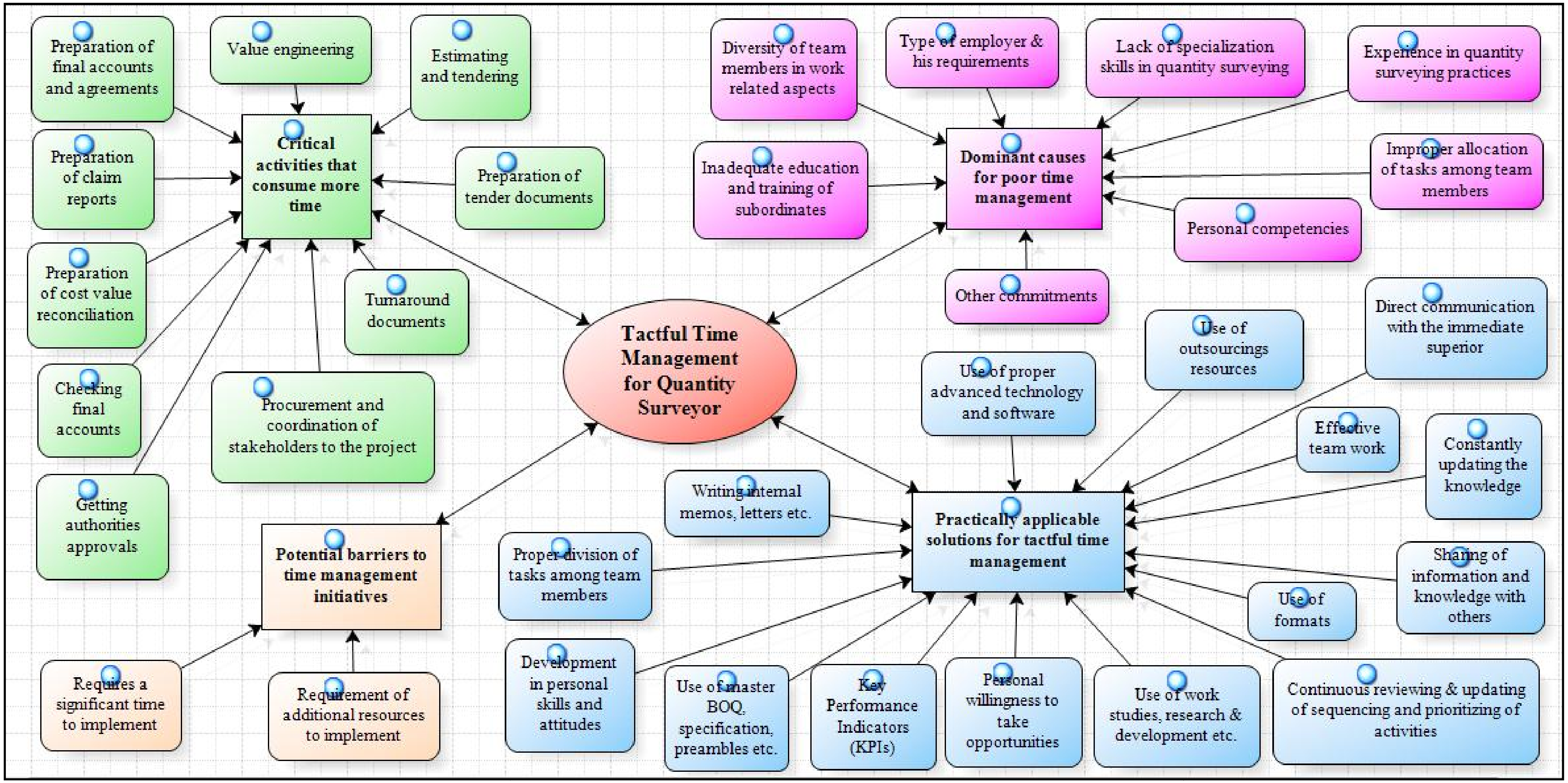


Figure 9: Cognitive Mapping

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SUITABILITY OF PACKAGE DEAL CONTRACTS FOR RESIDENTIAL BUILDING CONSTRUCTION

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ABSTRACT

Residential construction is becoming an increasingly important subdivision of construction industry, necessitating advanced procurement methods in order to accommodate changing requirements. Commonly, residential construction demand is met by the informal sector of construction industry. With the changing environments, a novel trend of package deal contracts is spreading in the context bringing in formalities to the residential construction projects. Package deal is a developed procurement method with unique characteristics. However, in selecting an appropriate procurement method for a specific housing construction project, proper understanding of characteristics of available procurement options are utmost of importance. Therefore, this research aimed to elucidate the suitability of package deal contracts for residential building construction, against time, cost and quality benefits.

Study identified 43 time, cost, and quality related expectations through a comprehensive literature survey, which residential construction clients would expect to be born of package deal contracts. The factors were ranked against industry experts' view and further, tested via a survey with a sample of clients with package deal and informal construction experience. Data were analysed for medians and standard deviations in to rank the factors considering the reliability. Consequently, experts appreciated time and cost benefits of package deal contracts over informal construction. Importantly, projects start quickly with known early commitments under package deal contracts. However, informal construction offers better quality with attractive finished products. Therefore, the package deal is suitable for the clients, who are concerned of time and cost benefits, while informal construction is suitable for the client's with prime concern of quality benefits.

Keywords: *Benefits; Informal Construction; Package Deal; Procurement; Residential Construction.*

1. INTRODUCTION

From the dawn of history, residential construction has been a necessity of mankind (Allen and Thaloon, 2011). Hence, residential construction has developed as a sub-division of construction industry with its unique characteristics to facilitate human needs of day today activities, leisure activities, studying, playing and relaxing, all in comfort with good level of privacy, while being with an attractive finish (Scutella and Heberel, 2005). However, increasing complexity of houses, use of innovative materials, technologies, and increasing population have created many challenges to the residential building construction industry (Turina, Radujkovic and Pusic, 2007).

Consequently, many residential construction clients face problems with delayed completions, wastage of resources, and low quality outputs, while wasting money without fulfilling the client's requirement due to poor pre-arrangements between the client and the contractor (Sambasivan and Soon, 2006). The procurement system of a project is a key determinant to successful achievement of objectives of any construction project. The choice of procurement system, therefore, severely influences the outcome of a project (Jayasena, 2009). Traditionally, majority of residential buildings were constructed by informal sector of construction industry. Yet, from the recent past a novel trend of package deal contracts for residential building construction is emerged replacing the informal approach to the residential constructions. Differently, according to Meikle (2011) formal approach to construction is more common

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in urban areas, which follow a proper procurement method allowing a pre-agreed construction procedure with fixed time scale. Yet, Ashworth (1996) advises client to choose the required building package and package deal contractor carefully, if deviating from informal approach.

It is further described that, if a client makes a wrong choice, the penalty may be time and cost overruns together with quality issues leading to general dissatisfaction. Therefore, the selection of the most suitable procurement method is critical for both clients and all project participants. Such background urges the need of proper guidance for clients in selecting procurement arrangements, being laymen to the construction industry. Hence, this research addressed the problem of guiding identification of a suitable procurement method for residential building construction in terms of time, cost, and quality benefits, aiming to explain the suitability of package deal contract arrangement for the residential building construction compared to informal approached construction. Since, the objectives were established as; understand the behaviour of residential construction procurement arrangements, identify time, cost and quality related benefits of package deal contracts compared to informal construction, and to develop a guideline to improve awareness of benefits in package deal compared to informal construction in terms of time, cost and quality for residential building construction clients.

Therefore a comprehensive literature survey was conducted in to understand the related research directions and depths of existing knowledge, as presented in the next section.

2. LITERATURE REVIEW

The literature survey of the study revealed many theories illuminating the significance of the research problem and assisted identifying number of benefits, which are expected by the residential construction clients to be arise via a procurement arrangement.

Accordingly, residential building construction is a major sub-division in the construction industry owing 30-35% construction output (Rhodes, 2015). Since, shelter has been recognized as a basic need, evolving human kind has created residential construction needs continuously complex. Consequently, residential construction demand urge for developed materials, and designs, for better time, cost, and quality advantages (Sherwood, 1996). In meeting such demands, proper management of construction process through an appropriate construction procurement arrangement is utmost importance (Ojo, Adeyemi and Fagbenle, 2006). If a client makes a wrong procurement choice, the penalty may be time and cost overruns, together with quality dissatisfaction (Jayasena, 2009).

Hence, the study suggests a proper procurement arrangement should able to offer a higher quality at a lower cost within a minimum period of construction time (Jayasena, 2009). However, in developing countries large portion of construction activity is executed by the informal sector (Hewage, 2009). According to Meikle (2011) informal building construction is narrow in scope and mostly, concerned about small scale buildings like houses, shops and storages. Normally, the informal approach to construction does not involve various professions and parties in the industry neither follow a proper procurement system. However, the informal sector involves with almost all construction projects in rural areas of developing countries and 50% of housing in urban areas (Hewage, 2009). Yet, it may have similarities with one or many of other procurement methods. According to Mitullah and Wachira (2003), informal sector operates unregistered according to the regulations of national or local governments, as a small proportion of the contractor body of a country, and operating with little capital, simple technology, using mostly local resources, and involved with buying and selling in unregulated and competitive markets. Yet, most of the residential clients seek the service of the informal sector of construction industry due to constraints aroused basically, due to unawareness (Silva, 2009). However, there are many negative impacts brought by the informal sector to the residential construction industry in terms of time, cost, and quality (Silva, 2009).

Recently, package deal is another popular procurement option available for residential construction contracts, which indicates the characteristics of a properly organized procurement system. 'In practice, the terms 'package deal' and 'design and build' are interchangeable. But, the package deal is strictly a special type of design and build project, where the employer chooses a suitable building, often from a catalogue' (Ashworth, 1996, p.112). Further, the option allows clients to view similar completed buildings from elsewhere, that he/she wishes to build. Package deal contractors regularly advertise of the services/products, they wish to offer in terms of building time and prices, rather than designs, and the clients may most probably required to find a site. Yet, the package deal contractors offer many other benefits starting from planning permissions, building regulation approval and many more (Franks, 1998).

Aftermath of the synthesis of the literature, in terms of expected benefits from a procurement option by residential construction clients, 43 factors were identified, as presented in Table 1, which were field tested for scrutiny in the practical context.

Table 1: Expected Benefits from a Procurement Arrangement

Time Benefits	**Cost Benefits**	**Quality Benefits**
▪ Less construction time duration (Meikle, 2011)	▪ Cost of the service is worthy(Franks, 1998)	▪ Flexibility for design alterations(Ashworth, 1996)
▪ Handed over at the expected time (Meikle, 2011)	▪ Applicability irrespective of the location of the site(Franks, 1998)	▪ Properly functioning building services (Franks, 1998)
▪ Less time spent on project management (Ojo et al., 2006)	▪ Model house can see before buying (Jayasena, 2009)	▪ Minimized wastage (Sambasivan and Soon, 2006)
▪ Construction can start quickly (Ashworth, 1996)	▪ Less cost overruns (Jayasena, 2009)	▪ Assurance of quality on the materials used (Sherwood, 1996)
▪ Less conflicts between contractor and client's representatives (Ashworth, 1996)	▪ Satisfaction on finished product in terms of investment (Ashworth, 1996)	▪ Adequacy of the builder's technical knowledge (Jayasena, 2009)
▪ Time taken to finding a builder is less (Franks, 1998)	▪ Disputes with the contractor is less (Hewage, 2009)	▪ Attractiveness of the finished product (Franks, 1998)
▪ Single point responsibility (Franks, 1998)	▪ Ease of payments (Jayasena, 2009)	▪ Work reviewed by experienced professionals (Jayasena, 2009)
▪ Good communication among construction team (Jayasena, 2009)	▪ Availability of workmen's compensation and insurance (Silva, 2009)	▪ Availability of range of designs with the contractor (Franks, 1998)
▪ Time taken for authority approvals is less (Meikle, 2011)	▪ Cost of procurement is less (Jayasena, 2009)	▪ Involvement of construction professionals (Sherwood, 1996)
▪ Simultaneous design and construction (Ashworth, 1996)	▪ Low contractor profit levels (Ojo et al., 2006)	▪ Efficiency in contract management (Ojo et al., 2006)
▪ Direct contact with the contractor (Ashworth, 1996)	▪ Commitment known early (Sherwood, 1996)	▪ Durability of fixtures (Turina *et al.*, 2007)
▪ Quick response to the client's needs (Scutella and Heberel, 2005)	▪ No tendering cost (Sambasivan and Soon, 2006)	▪ Authorized construction (Scutella and Heberel, 2005)
	▪ No fraudulent acts (Rhodes, 2015)	▪ No structural defects (Allen and Thaloon, 2011)
		▪ Final output is well-known from the beginning (Franks, 1998)
		▪ Proper documentation (Ashworth, 1996)
		▪ Contractor planning the work properly (Franks, 1998)
		▪ Availability of required materials and plant (Silva, 2009)
		▪ Concerned of safety regulations (Silva, 2009)

Hence, it was required to scientifically investigate the availability of time, cost, and quality related expected benefits with each package deal contracts and informal contracts. The next section presents the method followed in filling the identified knowledge gap scientifically.

3. THE RESEARCH METHOD

Research method section outlines the working plan of the study initiating from the research question development to arriving into scientific conclusions. Hence, the study has established the research questions as;

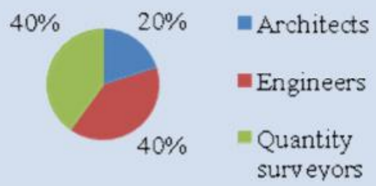
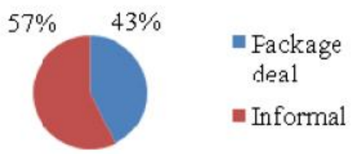
1. How different available procurement options behave in the context of residential construction?
2. What are the benefits of package deal contracts compared to informal construction?

Therefore, the initial literature review suggested many prepositions, which needed further analysis in order to develop context specific solutions for the research questions.

The research was conducted with a positivist philosophical stance accompanied by a quantitative approach since the methodology allows the end product to be generalised with higher degree of freedom (Remenyi *et al,. 1998)*. Further, the research was conducted as a cross-sectional study. Survey is considered to be the most appropriate strategy for this research study since a survey is a systematic way of primary data collection based on a sample, and assess information about the population. Therefore, it is not a method considering a specific case in depth, yet, captures main characteristics of a population. Moreover, survey is a quick and efficient strategy in collecting data comparative to other strategies such as; action research, grounded theory, experiments, ethnography and archival research (Tan, 2002). Hence, data were collected via two (02) questionnaires devised based on the literature findings separately, for experts and clients following a mono method (Saunders, Lewis and Thornhill, 2009). The questionnaires requested for demographic data of the respondents in order to evaluate the capacity of the respondents in contributing to knowledge creation via the study. Further, core data were collected from the industry experts based on their opinions on the importance of the benefits to be evaluated based on a 1-5 Likert scale, where; 1 represents strongly important, 2 - important, 3 - averagely important, 4 - less important, and 5 represents very less important. Similarly, the questionnaire designed for the residential building clients were inquired for satisfaction with their construction experience in terms of the suggested benefits, which were ranked using a similar scale.

Hence, two (02) different samples were used as sources in data collection process within the study, where the sources being industry experts and residential construction clients as mentioned above. The sample derived for the survey is representative portion of the population and the sample was selected as an unbiased and sufficient in size. The non-purposive quota sampling was used to select the samples. Table 2 presented the cross-section of the survey samples.

Table 2: Cross-Sectional View of the Survey Sample

Survey description	**Quota(s)**	**Response proportion**	**Response rate**
Pilot survey with industry experts	Architects		20%
	Engineers		40%
	Quantity Surveyors		40%
Context survey with residential building construction clients	Clients with package deal experience		40%
	Clients with informal construction experience		53%

Moreover, as per Stutely (2003) suggestion, a minimum number of 30 from each quota within overall sample as a rule of thumb for statistical analyses has been followed in this study. Hence, the sample for the pilot survey with industry experts comprised 30 units and the residential client sample comprised of 60 units. The overall response rate was 46.67%.

Data collected were analysed for median values since median represents the middle value of a data set (Glosser, 2014). Further to obtain better ranking process 3rd and 1st quartiles of the sample were calculated and standard deviations were calculated to check the consistency of data. Less standard deviation values indicate that the data have spread closely showing high consistency.

Therefore, the data analysis of the pilot survey allowed ranking time, cost and quality benefits in terms of importance. The data collected from the context survey allowed ranking the factors according to the availability with each of the procurement arrangements. Each benefit ranked in time, cost, and quality categories arose from expert survey analysis were weighted based on the rakings obtained. A total score for each of the procurement arrangement in front of top five (05) time, cost and quality benefits were calculated to compare the percentage achievement against the maximum score achievable to derive the final decisions on comparative performance between the considered two (02) procurement arrangements.

4. DATA ANALYSIS, FINDINGS AND DISCUSSIONS

From the 43 benefits identified at the literature review, twelve (12) were time related benefits, 13 were cost related benefits and 18 were quality related benefits. The factors were subjected to the initial expert survey and the data analysis allowed to rank the time, cost and quality benefits in terms of importance. Further, the context survey uncovered the presence of such benefits with each of the procurement arrangement concerned by this study.

According to the demographic data analysis, 100% of the selected industry experts sample was experienced more than five (05) years in the residential building construction industry. Specially, 90% of the sample is charter qualified. On the other hand, 95% of the clients selected for data collection were having recent experience [not over five (05) years from completion] in housing construction and occupied at the same buildings at the moment. Therefore, the samples showed calibre in contributing comprehensive data into the study.

This paper presents the analysis upon the top five (05) time, cost and quality benefits as per to views of experts and relevant clientele views of availability with each procurement arrangement considering the length limits of the paper submission.

4.1. ANALYSIS OF TIME RELATED BENEFITS

Time related benefits in the order of importance and availability according to each survey strata are present in the Table 4.1. Consequently, the two (02) benefits, less time spent on project management and handed over at the expected time, out of the top five (05) ‘time’ related benefits as identified by the experts, are highly available with the package deal contracts, yet, which are not highly available with the informal arrangements. In accordance with literature review, package deal contracts being a sub division of design and build procurement arrangement, designs and costing are already finished, when a client chooses his appropriate design (Ashworth, 1996).

However, less construction time duration is the most important ‘time’ related benefit, as per experts, yet, which is not offered highly at any of the two (02) procurement arrangements. However, the two (02) procurements arrangements commonly offer the benefits; construction can start quickly and less conflicts between contractor and client’s representatives to the clients, where the first mentioned benefit is the only ‘time’ related benefit offered by the informal contract arrangements in addition to the benefit, quick response to the client’s needs, out of the major time related benefits. In addition, package deal contracts offer clients, the benefit, time taken to finding a builder is less, whereas informal contracts offer the benefits; direct contact with the contractor and good communication among construction team.

Moreover, considering the weighted scores, package deal is capable of offering 54.67% of the total achievable score in offering time related benefits considering the top five (05) expected benefits whereas, informal contracts offer only 41.33%.

Table 3: Importance and Availability of Time Related Benefits

Score	Industry experts' view	Score	Package deal clients' view	Score	Informal clients' view
12	Less construction time duration	10	***Construction can start quickly***	8	*Quick response to the client's needs*
10	**Handed over at the expected time (10)**	8	**Less time spent on project management**	2	*Direct contact with the contractor*
10	***Construction can start quickly***	7	**Time taken to finding a builder is less**	5	*Good communication among construction team*
8	**Less time spent on project management**	10	**Handed over in the expected time period**	10	***Construction can start quickly***
8	*Quick response to the client's needs*	6	***Less conflicts between contractor and client's representatives***	6	***Less conflicts between contractor and client's representatives***
7	**Time taken to finding a builder is less**				
6	***Less conflicts between contractor and client's representatives***				
5	*Good communication among construction team*				
4	Single point responsibility				
2	Time taken for authority approvals is less				
2	*Direct contact with the contractor*				
1	Simultaneous design and construction				
75	**Total Score**	**41**	**(54.67%)**	**31**	**(41.33%)**

Hence, the analysis suggests higher capability in offering time related benefits to be with package deal procurements over informal construction arrangements.

4.2. *ANALYSIS OF COST RELATED BENEFITS*

Top five (05) 'cost' related benefits according to each survey strata are present in Table 4. Thus, none of the most important cost related benefits are present with the informal approach to residential construction**.** However, the 2nd important benefit; commitment known early is highly available with the package deal contracts. This is suggested as a top benefit in package deal construction as per literature as well. Clients favour to know their commitment before starting the construction. They normally check, whether the budget of the construction is suitable with his budgetary allocation (Sherwood, 1996).

However, the four (04) top benefits; cost of the service is worthy, satisfaction on finished product in terms of investment, less cost overruns, and model house can see before buying, are not highly offered by any of the two (02) prominent procurement arrangements for residential construction. Literature also suggests "client's satisfaction' as one of the most important concerns in the residential building construction (Jayasena, 2009). However, the two (02) procurements arrangements commonly offer the benefits; no tendering cost, no fraudulent acts, and applicability irrespective of the location of the site, to the clients. In addition, the package deal contracts offer the clients, the benefit, ease of payments, while informal construction arrangement offers clients the benefits of; disputes with the contractor is less and cost of procurement process is less.

Moreover, considering the weighted scores, package deal is capable of offering 31.58% of the total achievable score in offering cost related benefits considering the top five (05) factors, whereas informal contracts offer 24.21% of the top benefits expected. Hence, the analysis suggests higher capability in offering cost related benefits to be with package deal procurements over informal construction arrangements.

Table 4: Importance and Availability of Cost Related Benefits

Score	Industry experts' view	Score	Package deal clients' view	Score	Informal clients' view
13	Cost of the service is worthy	2	***No tendering cost***	2	***No tendering cost***
13	**Commitment known early**	13	**Commitment known early**	1	***Applicability irrespective of the location of the site***
13	Satisfaction on finished product in terms of investment	8	***No fraudulent acts***	8	***No fraudulent acts***
10	Less cost overruns	1	***Applicability irrespective of the location of the site***	7	*Disputes with the contractor is less*
10	Model house can see before buying	6	**Ease of payments**	5	*Cost of procurement process is less*
8	***No fraudulent acts***				
7	*Disputes with the contractor is less*				
6	**Ease of payments**				
5	*Cost of procurement is less*				
4	Low contractor profit levels				
3	Availability of workmen's compensation and insurance				
2	***No tendering cost***				
1	***Applicability irrespective of the location of the site***				
95	**Total Score**	**30**	**(31.58%)**	**23**	**(24.21%)**

However, the both the procurement arrangements offers lesser cost related benefits compared to time related benefits, whereas the metaphor occurs with a considerable margins.

4.3. ANALYSIS OF QUALITY RELATED BENEFITS

Top five (05) 'quality' related benefits according to each survey strata are present in Table 5. Therefore, out of the five (05) most important quality related benefits, adequacy of the builder's technical knowledge is present with both the approaches. Informal construction offer the most important quality benefit, attractiveness of the finished product. It is important, as finished house should be attractive for people. Clients always try to construct a unique house, which is exceptional and attractive (Franks, 1998).

However, the benefits; properly functioning building services, assurance of quality on the materials used, and minimized wastage are not highly offered by any of the arrangements. Yet, both the arrangements offer the benefits; authorized construction and no structural defects to residential construction clients. In addition, package deal contracts offer clients, the benefits of; final output is well-known from the beginning and availability of required materials and plant, whereas informal arrangements offer the benefit of flexibility for design alterations. Hence, according to Jayasena (2009), if client did not find the correct contractor, finally he will be dissatisfied with the construction. Selecting a suitable package deal contractor is more important in package deal construction.

Therefore, considering the weighted scores, package deal is only capable of offering 21.02% of the total achievable score in offering quality related benefits considering the top five (05) factors, whereas informal contracts offer 31.79%. Hence, the analysis suggests higher capability in offering quality related benefits to be with informal construction arrangements over package deal procurements.

Table 5: Importance and Availability of Quality Related Benefits

Score	Industry experts' view	Score	Package deal clients' view	Score	Informal clients' view
18	*Attractiveness of the finished product*	5	***Authorized construction***	14	*Flexibility for design alterations*
17	***Adequacy of the builder's technical knowledge***	6	**Final output is well-known from the beginning**	18	*Attractiveness of the finished product*
17	Properly functioning building services	8	***No structural defects***	5	***Authorized construction***
17	Assurance of quality on the materials used	17	***Adequacy of the builder's technical knowledge***	17	***Adequacy of the builder's technical knowledge***
14	Minimized wastage	5	**Availability of required materials and plant**	8	***No structural defects***
14	*Flexibility for design alterations*				
14	Durability of fixtures				
14	Work reviewed by experienced professionals				
14	Availability of range of designs with the contractor				
14	Involvement of construction professionals				
8	***No structural defects***				
7	Efficiency in contract management				
6	**Final output is well-known from the beginning**				
5	**Availability of required materials and plant**				
5	Proper documentation				
5	Contractor planning the work properly				
5	***Authorized construction***				
1	Concerned of safety regulations				
195	**Total Score**	**41**	**(21.02%)**	**62**	**(31.79%)**

Considering all facts discussed and identified, residential construction clients should consider their time, cost, and quality benefits requirements individually. When selecting a procurement system, requirements of an individual client should be matched with the characteristics of each construction method. Therefore, a guideline was developed to demonstrate the capacity of offering important time, cost and quality related benefits by the package deal and informal construction procurement arrangements. The developed guideline for residential building construction clients for procurement selection is presented as Table 6.

Hence, Table 6 illustrates the most important time, cost, and quality benefits available with package deal and informal construction, whereas the top expected benefits, as per experts are given in bold letters and common benefits are italicized. The factors are presented in the order of availability and font sizes are proportionate with the importance given by the industry experts. Hence, by referring the guideline, residential clients can decide the most suitable contract type for their construction according to their requirements.

Table 6: Guideline for Residential Building Construction Clients for Procurement Selection

	Package deal	Informal construction
Time	***Construction can start quickly***	**Quick response to the client's needs**
	Less time spent on project management	Direct contact with the contractor
	Time taken to finding a builder is less	Good communication among construction team
	Handed over in the expected time period	***Construction can start quickly***
	Less conflicts between contractor and client's representatives	Less conflicts between contractor and client's representatives
Cost	*No tendering cost*	*No tendering cost*
	Commitment known early	*Applicability irrespective of the location of the site*
	No fraudulent acts	*No fraudulent acts*
	Applicability irrespective of the location of the site	Disputes with the contractor is less
	Ease of payments	Cost of procurement process is less
Quality	*Authorized construction*	Flexibility for design alterations **Attractiveness of the finished product**
	Final output is well-known from the beginning	*Authorized construction*
	No structural defects	***Adequacy of the builder's technical knowledge***
	Adequacy of the builder's technical knowledge	*No structural defects*
	Availability of required materials and plant	

Therefore, if a client is interested in more of time and cost benefits over quality, the suitable procurement arrangement is package deal. Although informal construction has more quality benefits, package deal construction is a trustworthy contract type.

5. SUMMARY

The study revealed the availability of more of highly important time, and cost benefits in package deal construction over informal construction, whereas informal construction offers more of highly important quality related benefits. Further, package deal offers least of quality benefits compared to its time and cost benefits, yet, informal contract offer least cost related benefits compared to its time and quality related benefits.

Hence, the study is important, as it sheds the light on the strength of package deal construction in the context of Sri Lankan construction industry towards better residential construction procuring. It will be helpful for residential construction clients to select the most suitable procurement types, as well as to understand the novel systems of package deal construction. The clients, therefore, can select a suitable procurement system by comparing the benefits from each construction method. Further, the study will assist improved awareness upon key theories, characteristics and benefits of package deal construction and informal construction of the interested people in residential construction industry. In addition, the study lays the foundation for construction companies to direct their business towards package deal construction and to promote their business in residential construction sector. However, it is important for the package deal contractors to increase their attention upon the expected quality aspects of the building output.

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SUSTAINABLE CONSTRUCTION PRACTICES OF SRI LANKAN CONTRACTORS

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ABSTRACT

Construction industry is conversely depleting of natural resources. It impacts on the environment, economy and society, not only during a project's life cycle but also for coming generations. Adhering sustainable principles in construction industry brings the sustainable construction which ensures better quality of life for everyone. The contractor as a key player in the construction industry has to play an imperative role to promote sustainable construction by minimising their negative impact on the environment and society while maximising their economic contribution. Thus, this research intended to examine current sustainable construction practices and issues of contracting organisations to suggest a framework which can be used for the ultimate delivery of sustainable construction in Sri Lanka. Case study research approach was used to collect data among contracting organisations and eight semi-structured interviews were conducted. Four industry expert interviews were conducted to verify the gathered opinions and suggestions on enhancements of sustainable construction practices of contracting organisations. Cross-case analysis was used to analyse multiple cases using code based content analysis technique. Findings revealed that the organisations were at primary stage in sustainable construction practices, namely legal framework, standards, guidelines or policies, design, procurement, technologies, processes and innovations, organisational structure and people, education and training, measurements and reporting.

Keywords: *Construction Industry; Contracting Organisations; Sri Lanka; Sustainable Construction; Sustainable Practices.*

1. INTRODUCTION

The sustainable development includes three broad components; social, environmental and economic (Khalfan, 2002; Persson, 2009) often known as the 'triple bottom line', which brings environmental responsibility, social awareness and economic profitability objectives to the fore in the built environment and facilities for the wider community (Ali and Nsairat, 2009). Previous studies on sustainable materials (Emmanuel, 2004; Mora, 2007) and sustainable indicators (Ugwu and Haupt, 2007) emphasise the importance of national approach which unique to each country to deliver sustainability in their construction industry. Therefore, it is an inevitable need in the Sri Lankan construction industry to grant sustainability with the collaboration of all stakeholders. The contractor as a key player in the construction industry has to play a significant role in promoting sustainability in construction by minimising their negative impact on the environment and society while maximising their economic contribution (Tan *et al.*, 2011).

Accordingly, this study was to examine the current sustainable construction practices of contracting organization and their issues in order to suggest actions which can be taken into the enhancement of sustainable construction practices of contracting organisations to attain sustainable construction in Sri Lanka.

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2. LITERATURE REVIEW

2.1. SUSTAINABLE CONSTRUCTION PRACTICES

The first definition of sustainable construction was proposed by Charles Kibert during the first International Conference on Sustainable Construction in Tampa, 1994; *"sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles"* (Kibert cited in Murray and Cotgrave, 2007, p.13). Later Plessis came up with a straightforward definition on sustainable construction in 2002 in the discussion document of Agenda 21 for Sustainable Construction in Developing Countries by compelling entirety sustainability image as; "*sustainable construction is a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity*" (Plessis, 2002, p.8). Thus, this definition takes sustainability further than just reducing pessimistic impact, as implied in the earlier definitions, by introducing the idea of restoring the environment.

It may be perceived as a long term exercise carried out by various parties/industries to achieve a sustainable development within the parameters of economic, social and environmental cornerstones. Thus, construction industry, which traditionally focused on time, cost, and quality was shifted into the new paradigm by focusing economic, environmental and social aspects. Such construction would bring environmental responsibility, social awareness, and economic profitability to the fore in the built environment and facilities for the wider community. Sustainability in construction offers first-rate response to the present environmental and socio-economic problems as it is an application of the principles of sustainable development to the comprehensive construction cycle from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste (Yunus and Yang, 2011). The main challenge for the industry is to play an integral part in reducing the impacts of its activities on the environment and local communities. Hence, Owners/Developers who play an important role in developing and financing construction projects for implementation of sustainable construction (Gan *et al.*, 2015), Architects/ Engineers who are involved in designing sustainable infrastructures, Contractors as builders of the construction projects, have to take leadership in such transformation.

Tan *et al.* (2011) stated that contractors have to play significant role in promoting sustainable development within the context of the construction industry by assuming the responsibility to mitigate their negative impact on the environment and society while maximise their economic contribution which gives multiple benefits to contractors by implementing sustainable practices. Sustainability makes good business sense because it is increasing importance to the efficient, effective and responsible operation of business while such sustainable business practices in construction organisations give competitive advantage to their organisations (Ebner and Baumgartner, 2006). Thus, focus on sustainable construction practices of contracting organisations, where contractors play their role immensely, is very important to bring sustainability in the construction industry as it ultimately contributes to sustainable development in globally.

Table 1 summarized the previous studies which can be rehearsed to contribute sustainable development in the construction industry.

Table 1: Sustainable Construction Practices of Contracting Organisation

Sustainable practices	Principles
Sustainable legal framework	Organisation can comply with the legal frame work of the country which leads to sustainable construction, including the environmental requirement and social responsibility, to improve economic advancement (Pitt *et* al., 2009; Tan *et al.*, 2011).
Sustainable construction standards, guideline or policies	Organisation can proceed with establishing or their own sustainable standards, guideline or policies to minimising environmental, economic and social risk associated with construction practices (Krigsvoll *et al.*, 2010).

Sustainable design	Organisation can improve the project's whole life value through green design and ensure the buildability with efficient use of resources, sustainable materials, minimum wastage, resilient, adaptable and attractive (Tan *et al.*, 2011; Akadiri *et al.*, 2013).
Sustainable procurement	Organisation can promote green supply chain throughout the project life cycle to ensure the sustainability (Vanegas *et al.*, 1996; Tan *et al.*, 2011; Shaharudin and Ismail, 2015).
Sustainable technologies, processes and innovations	Organisation can increase the sustainability of both the construction process and its resultant assets via sustainable technologies, processes and innovations which includes lean principles (Tan *et al.*, 2011; Booth *et al.*, 2012; Liang *et al.*, 2014; Salifu-Asubay and Mensah, 2015).
People and organisational structure	Organisation can arrange the organisation and project structure to facilitate the implementation of sustainable policy and strategy and increase in organisations awareness and committing sustainable construction (Tan *et al*., 2011; Liang *et al.*, 2014).
Sustainable education and training	Organisation can increase organisation's commitment to sustainable construction through better education and training of every staff in the organisation or project (Tan *et al*., 2011; Liang *et al.*, 2014).
Sustainable measurement and reporting	Organisation can have measurement and reporting system or use existing benchmarks to evaluate environmental, economic and social performance and identify the areas to be improved (Persson, 2009; Pitt *et al*., 2009; Tan *et al.*, 2011; Liang *et al*., 2014).

2.2. SUSTAINABLE CONSTRUCTION IN SRI LANKA

Sri Lankan history shows how our forefathers built great cities, irrigation systems and religious monuments that coexisted with nature and yet provided a sustainable economy and lifestyle to the citizens (GBCSL, 2010). However, Sri Lanka suffers from not only the environmental but also economic and social issues due to unsustainable development happened during past decades and happening currently. This timely requirement has been identified, revealed and has acknowledged distinctive sustainable approach to meet its sustainable desires. The Ministry of Environment and Natural Resources (MENR) in Sri Lanka had put a step forward to contribute to sustainable development in Sri Lankan context by introducing a guideline. MENR (2007) declared that the guideline for establishing National Sustainable Development Strategies (NSDS) stated that NSDS is not just a document, but also a country based and country owned system. Further, Green Building Council established in 2010 as one of the humble steps to take our society to that glorious past which people are still proud of as Sri Lankans. In addition, Tsunami reconstruction projects were in line with after the Tsunami Sustainable Building Guideline for South-East Asia, which provides numerous environmental, safety and financial benefits through sustainable reconstruction management guideline (UNEP, 2007). There are few building projects which were recorded in the industry as sustainable buildings, for instance Kandalama Hotel which is one of the first Leadership in Energy and Environmental Design (LEED) Bronze rated hotels in the world (rated in year 2000), MAS Intimates Thurulie - Clothing Factory in Sri Lanka which is the first LEED Platinum rate newly built manufacturing factory in the world. Even though such preliminary steps were taken still there are gaps in sustainable construction practices to attain environmental, (The Sunday leader, 2014) economic and social sustainability in Sri Lanka. Studies of Abeysundara *et al.* (2009) identified that significant environmental impact in the Sri Lankan context due to unsustainable development as nutrient enrichment, acidification and global warming, while most of the impact on society and economy were silent in several studies.

3. RESEARCH METHODOLOGY

Under qualitative case study research approach, three contracting organizations were selected (refer Table 2) to appraise the current sustainable construction practices and issues of the contracting organisation in Sri Lanka. An organisation was selected as the unit of analysis among C1 grading contracting organisations that have been engaged in sustainable development up to a certain level in the Sri Lankan construction industry as them are mega scale contractors who are representing the voice of construction sector in Sri Lanka. Eight semi-structured interviews were conducted (refer Table 2) within the case studies by considering ‘individuals” as a unit of data collection. Individuals who have experience in sustainable construction have taken part in those semi-structured interviews and were conducted using interview guideline and tape-recorded (with permission of the interviewee) to secure an accurate account of the conversations and avoid losing data since everything cannot be written down during the interview. Those semi-structured interviews enable sufficient flexibility to approach different respondents, covering the same areas of data collection while enable to adapt the questions necessary, clarify doubts and ensure that the response is properly understood by repeating and rephrasing the questions. Ultimately, interview transcripts were developed to generate a sensible adaptation of interviewed data.

Since the research contained three case studies, during the analysis, broad themes and patterns were looked for, rather than narrow, precisely variables of qualitative research. Cross-case analysis was used as it is the most preferable method of analysing multiple cases (Yin, 2009). Code based content analysis was used to analysis large set of gathered data in the simplest way as it produced a uniform schema of categories (Flick, 2006), which facilitates comparison of different cases. The each individual case was analysed based on the main themes, namely; sustainable construction practices of contracting organisations and issues in order to identify actions which can be taken into enhancement of sustainable construction practices of contracting organisations to attain sustainable construction in Sri Lanka.

Table 2: Profile of the Case Interviews

Cases	Type of construction	Agent	Designation
Case A	Buildings, Roads, Infrastructures, Batching plants and quarries	A1	Head of HR/ Team Leader of Sustainability Committee
		A2	Engineer Progress Monitoring
		A3	Project Manager
Case B	Buildings, Roads, Infrastructures, Batching plants and quarries	B1	Director Engineering
		B 2	Project Coordinator
		B3	Director / Sustainability reporter
Case C	Buildings and Roads	C1	Project Manager
		C2	Engineer Design

In addition to that four interviews were conducted with industry experts who engaged in the development of sustainable construction in order to verify and gather opinions and suggestions on enhancements of sustainable construction practices of contracting organisation as illustrated in Table 3. Interviewees represented environmentalist, sustainability consultant, contractor/builder, designer, engineer, project manager. These high-ranked participants influenced a wealth of experience in varied of construction projects such as factories, roads and highways, buildings. On an average, the recorded open-minded interviews lasted for one and half hours each and were conducted.

Table 3: Profile of the Expert Interviews

Designation of expert	Agent	Sector	Experience on sustainable
Advisor	E1	Government sector	Have experience more than 5 years in sustainable construction
Senior lecturer	E2	Government sector	
Managing Director	E3	Private sector	
Managing Director	E4	Private sector	

Accordingly, next section discusses the findings of the research study.

4. RESEARCH FINDINGS AND DISCUSSION

4.1. CURRENT PRACTICES OF CONTRACTING ON SUSTAINABLE CONSTRUCTION

Findings reveal that organisations are at the primary stage of adopting sustainable practices. Contracting organisations are currently observed and strictly enforced the law of the country because of its significant impacts of construction activities on society and the environment (Tan *et al*., 2011). Similarly, in Sri Lanka, contractors are enforced to comply with the legal framework which ensures sustainable construction, unlikely not in the form of sustainable practices. The research study of Krigsvoll *et al*., (2010) revealed sustainability in construction has a short developing history in terms of guidelines, standardisations and policy making in world content. It can be a one of the reasons to have very few organisations who practicing inbuilt sustainable policies within their organisations. Ding (2008) revealed that sustainable design is a best practice to have at the very earliest project stages and this involves not just considering what is being built, but how it is being built, with which products and methods and which functions the project will perform or facilitate, once completed. Thus, as the current demand for sustainable design from all stakeholders is very important to have sustainable construction. However, unlikely in other countries, Sri Lankan demand for sustainable construction is very poor.

Not likely in developed countries, there is no proper organisational or institutional procedure for green supply chain, in Sri Lanka, where materials and equipment are supplied in a green manner (Vanegas *et al*., 1996). As sustainability is a key concept in the world, Booth *et al.* (2012) stated that the contracting organisations have increased their organisational capacity in terms of technologies, processes and innovations towards sustainable construction by identifying their vital responsibility. Anyhow contracting organisations in Sri Lanka, rarely follow when only client's demand. Tan *et al*. (2011) further explored the importance of having awareness of sustainable construction within the people and top management at contracting organisations to the positive contribution from contracting organisations towards sustainable construction. However, there is no sufficient awareness in Sri Lanka about sustainable construction which ultimately cause to no proper education and training on sustainable construction to employees in all levels unlikely in global content. Further, without necessary skill sets, construction will be ill-equipped to meet the challenge of the sustainable construction agenda. As a result, although there are several sustainable measurements and reporting tools available which critical to the development of corporate sustainability and to help organisations to manage towards sustainability, Sri Lankan practices on sustainable measurements and reporting at infancy level.

4.2. ISSUES ON SUSTAINABLE CONSTRUCTION PRACTICES OF CONTRACTING ORGANISATIONS

Issues in existing sustainable construction practices of selected contracting organisations were discussed in this section to enhance the current sustainable construction practices of contracting organisations. Five major issues were identified as below via the case studies, namely; Legal framework and enforcement, Institutional intervention and coordination, Commitment of the people, Cost Factor, Education and Experience.

The study of Abeynayake (2010) revealed that the Sri Lankan legal system has sufficient provisions to protect the environment as well as a good system procedure for physical planning. However, empirical investigations stated that there are several gaps in the legal system in Sri Lanka as it is not identified real concept of sustainable construction. Although there are provisions within the legal framework in Sri Lanka to accomplish environment sustainability, there are less provisions for economic and social aspects. However, outdated Acts and Ordinances are still governed by law without necessary amendments to suit sustainable construction. Furthermore, there is an immense problem with enforcement of the legal provisions which leads to sustainable construction due to political issues and the less awareness of the stakeholders. It indicates the levels of legal enforcements are varied from project to project.

There were several issues in the institutional intervention and the coordination of sustainable construction practices in Sri Lanka. Although, there were published national strategies for sustainable development, there are no any published national strategies which focus on the construction industry. At the same time there is neither national platform nor coordination committee to promote sustainable construction while even no coordination between organisations, government or the research and development units in Sri Lanka. There are very few social responsible organisations to take leadership to promote sustainable construction for an example Green Building Council and the Sustainable Energy Authority and they are started recently. Thus, current institutional intervention, even in the government level is fairly less and as a result of that, there is no any agenda or the setup to follow the contractors or other stakeholders.

The reasonable commitment of the stakeholders in the construction industry is an essential element in promoting sustainable construction. Empirical records showed that there are issues with the commitment of the people due to lack of aware of the significance of sustainable practices due to problem in their attitudes. Finding revealed that the client's demand is not sufficient and demand for the sustainable project should arise from the client side rather than conventional. The pointing figure is another problem as many stakeholders believe that the role of 'promoting' and 'encouraging' sustainable practices falls on other shoulders as well such as designers, consultants, contractors or the Government.

Cost of implementation of sustainable technologies is ridiculous. Thus, sustainable construction practices are believed to increase project cost as they need to have higher capital upfront. When the client does not demand the sustainable project, the contractor is not welcome in the sustainable construction as he is losing in the competitive bidding. The cost of sustainable approaches which are costly than the other conventional techniques (new technologies BIM, training cost) has to bear by the contractor which helps to minimise the impact to the environment.

Empirical data highlighted that there are many players in the construction industry and mostly are not professionally qualified. The implementation of sustainable construction practices can be improved if various construction players, including Engineers, Architect and Quantity Surveyors play their role in advising the developers on the merits of pursuing sustainable practices. If the consultants can come up with a good design within the project budget that can sustain the environment and give a good business return, then the developers will be inclined to accept the proposal. At the same time there is quite few educated and experienced construction professionals in sustainable construction and most of the employees are neither have the education nor experience on sustainable construction and even they are not looking to continuous development as requires in the industry time to time.

Achieving sustainability goals depends on how well these issues are well handled. Accordingly, next section discusses the suggestions which can be used to identify issues in current practices.

4.3. SUGGESTIONS TO OVERCOME ISSUES IN SUSTAINABLE CONSTRUCTION PRACTICES OF CONTRACTING ORGANISATIONS

There were several attributes highlighted through the literature synthesis and expert interviews which would be better to suggest for improvement of sustainable construction practices of the contracting organisation for the ultimate delivery of sustainable construction industry in Sri Lanka. The study emphasises the delivery, sustainability in the construction industry is a long term process which needs to address with the support of all stakeholders.

It is an essential to have an effective legal framework which ensures the sustainable construction within the country. Accordingly, the government has to directly intervene to the development of sustainable construction practices in the construction industry. Further, the studies of Majdalani *et al.* (2006) stated that the legislative body has an important role to play in preparing the necessary legal infrastructure to protect the interest of all parties and to prompt a wider adaptation of sustainable construction practices. This can only be achieved if the government takes a leadership role in this regard. However, all the stakeholders should participate and try to balance the long term benefits with the short-term resources. Accordingly, all the parties should abide these legislations and regulations by looking at the macro scale level of the industry and try to establish best practices that serve current and future interests of all. Both government and private sector contractors can be motivated by introducing intensives, low taxes, low interest rates, discounts for materials, for adhering of sustainable principles. Thus, responsible institutions must involve in helping the government to shape the construction industry.

Institutional intervention and coordination have heavily contributed to sustainable construction and can play a key role within the industry, it is needed to take leadership by responsible institutions and put step forward to promote sustainable construction via proper agenda by introducing , sustainable design criteria, Eco labelled materials, green supply chain, lean concepts, benchmarking, sustainable assessment and sustainable consulting. It requires to enhance research and development which brings sustainable technologies, processes and innovations. Thus, having proper coordination and collaboration among academic and technical institutions will speed up the achieving sustainable desire.

Stakeholders' awareness of the sustainable construction can improve via media as it assists in direct communication to the people while the awareness level of the employees enhance by giving awareness programme in each level of the employees with practical scenarios. Moreover, Pitt *et al.* (2008) revealed that this is crucial if sustainable practices are to be adopted over and above the requirements of building regulations. Thus, client's knowledge and awareness on sustainable construction is particularly important as they are the principal stakeholder in determining and committing sustainable construction practice.

The cost factor as far more highlighted issue within sustainable construction practices, findings avowed that to compete with this high cost associated with sustainable construction, it needs to well aware of these concepts by all the stakeholders in the construction industry. Further, it needs to change the mind-set of the people to think of the whole life cycle cost than current benefit. As the cost factor negatively, strongly affect to the sustainable construction, it can be managed by introducing evaluation criteria which gives high credits to sustainable contractors in the selection process of the contractors. It creates that the contractors naturally tend to practice sustainable construction where the cost of it is shared by the client.

Not only construction professionals, entire people need to have knowledge and awareness on sustainable construction practices from their childhood and should have a proper agenda to share the knowledge on sustainable construction within the organisations. Further, best solution for that is to cross training among the employees. It will be benefited to share the one's experience and the knowledge among many others. Therefore, empirical investigation, specially identified significant of having experience employees who positively contribute to sustainable development in the construction industry and rehearsing innovative technologies like BIM where all the stakeholders working on same platform and talk same langue which minimise construction waste, increase build ability and achieve stakeholder interest (Wu and Zhou, 2014).

Accordingly, sustainability in the Sri Lankan construction industry can be delivered effectively via contracting organisations by adopting and focusing following developed conceptual framework (refer Figure 1) namely; Legal framework, Standards, guidelines, Design, Procurement, Education and training, Measurement and reporting, People and organization structure, Technologies, process and innovation.

5. CONCLUSION

The impact caused by construction activities heavily affect to our environment, society and the economy. Thus, there is a big responsibility within all stakeholders in the construction industry to take part of this challenge, including contractors as a key player in the construction industry. Studies revealed that contracting organisations were at the primary stage of adopting sustainable construction practices such as Legal framework, Standards, guidelines, Design, Procurement, Education and training, Measurement and reporting, People and organization structure, Technologies, process and innovation.

Legal framework and enforcement, institutional intervention, commitment of the people, cost factor and education and experience, were identified as key issues in an existing sustainable construction practices of contracting organisation. Therefore, several aspects were captured through experts' opinions and literature synthesis which would be guided for better enhancement of sustainable construction practices of contracting organization in Sri Lanka.

Thus, it is required to rehearse identified sustainable construction practices and adopt made suggestions in the Figure 1, rather it becomes as future menace. Consequently, this research contributes on sustainable construction practices of contacting organisations related to the construction industry openings and broader view on the current practices and issues and suggestions to overcome. In such situation, all the stakeholders in the construction industry have great responsibility to contribute and make this into a competitive advantage in future by furnishing awareness to implement or the enhancement of sustainable practices.

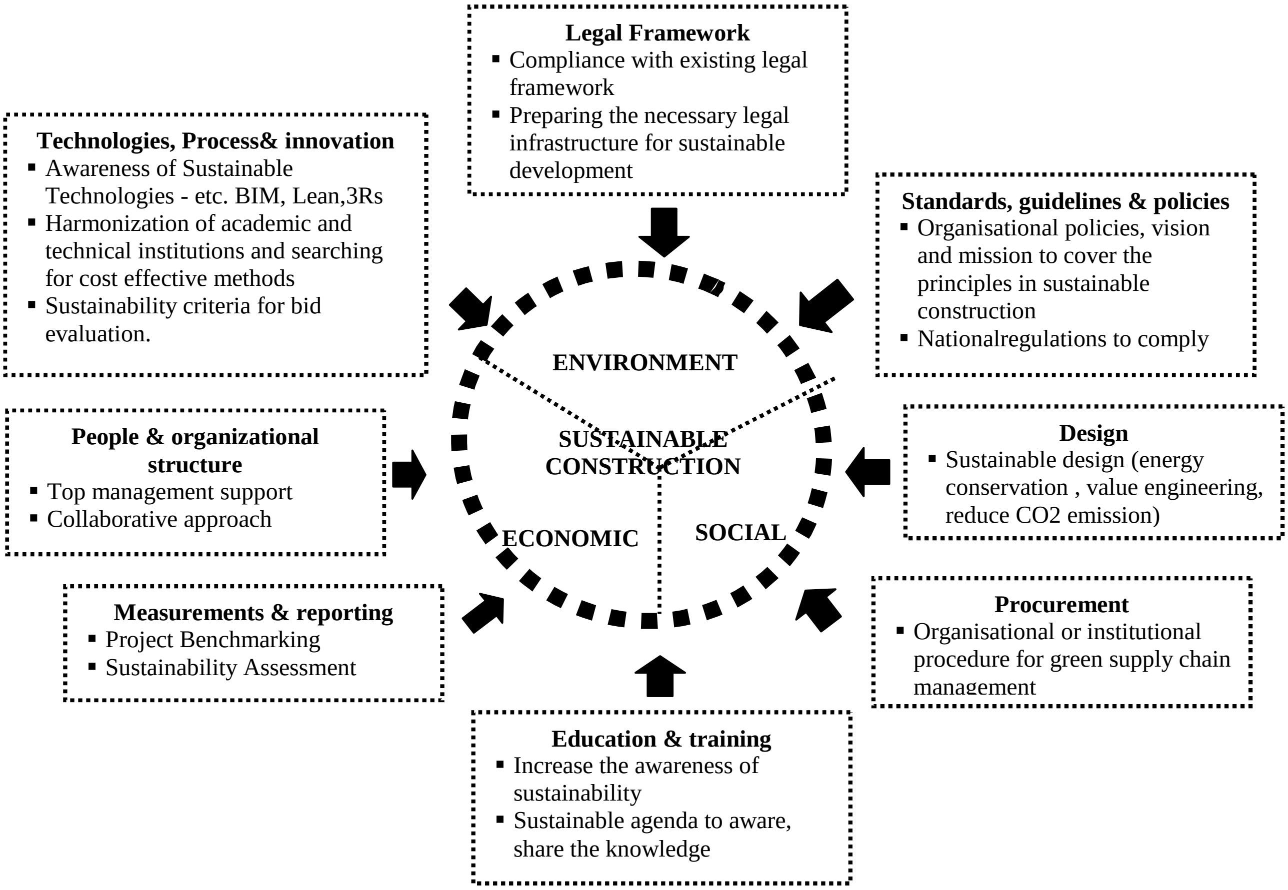

Figure 1: Developed Conceptual Framework

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SYNERGY BETWEEN LEAN AND VALUE ENGINEERING CONCEPTS: SRI LANKAN CONSTRUCTION INDUSTRY PERSPECTIVE

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ABSTRACT

The allied competitiveness and unpredictable nature of the construction industry forced to rethink on the performance enhancement tools in order to address the urgent matter of resource scarcity as a global dilemma. Hence, most of the construction firms highly concern about the customer's satisfaction by means of giving value for the client's money. The researchers established that Value Engineering (VE) and Lean concepts supersede all the other value achieving strategies since; both address the concept of Value in a greater extent. VE addresses the areas, which are not aligned with the methodological purview of Lean. In turn, Lean could enhance the effectiveness of VE efforts. Although there were some arguments on the above, there is lack of a research of investigating the synergy between Lean and VE concepts with related to the construction sector. Hence, this study investigates the synergy between Lean and VE concepts in order to explore the best value for client.

Accordingly, a qualitative research approach was followed to attain the research aim. A comprehensive literature review followed by expert opinion surveys were used to investigate the synergy between the concepts. The information gathered were subsequently subjected to a content analysis. This study revealed that, there is a synergy among customer value principle, pre study, information and presentation phases, value stream principle with functional analysis and presentation phases, flow principle with creativity, evaluation, development and presentation phases, pull principle with functional analysis, presentation and post study phases, perfection principle with presentation and post study phases. The findings would be very much effective for advanced value achieving strategy development purpose which achieve the best value for the client in the extremity.

Keywords: *Value for Client; Synergy; Construction Industry; Lean; Value Engineering.*

1. INTRODUCTION

A barrage of remedial reforms and revisions of construction practices have been recently targeting enhanced value, superior performance, overall satisfaction and harmony (Palaneeswaran *et al*., 2003). Hence, construction organisations are forced to rethink their construction for improving productivity, quality and efficiency in order to gain the best value for the client (Karna and Jonnonen, 2005).

Different researches have highlighted different value achieving strategies existing in the practice. Ismail *et al.* (2010) findings highlighted Value Engineering (VE) as a management tool that can be effectively used in the construction industry with an aim to produce innovative ideas and solutions for enhanced project value than in other value addressing techniques.

According to the findings of Perera *et al*. (2003), application of VE practices in Sri Lanka is relatively low. However, VE practices were done to the "World Trade Center" project during the project commencing and resulted energy saving and increased productivity in business etc. (Perera *et al*., 2003). Finally the researchers concluded by highlighting that the construction industry in Sri Lanka exacerbates the need of proper VE practice due to the absence of proper cost controlling mechanism allied with the industry.

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Aziz and Hafez (2013) mentioned that Lean concept and Lean-based tools can be successfully applied to simple and complex construction projects, which effort to deliver better value to owners while making real profits. Apparently, Lean is an immense in reducing cost and achieving project value compared to the other techniques/strategies (Madanayake, 2015).

According to the findings of Senaratne and Wijesiri (2008), even though Lean construction is still new to Sri Lanka, it can be used as a strategic option in construction projects. The research revealed that domestic construction industry workforce neglect the waste and their causes which tend to inefficiency and high cost. Hence, Sri Lankan construction industry make public an urgent need of Lean construction to address the construction wastes in a proper manner. Hence, it should be highlighted that VE and Lean address the value achieving scenario in a greater extent and there is an urgent need for the strategies from Sri Lankan context.

According to Arratia and Cell (2003), integration of VE and Lean thinking offers an organisation the continuous improvement while enhancing the value in manufacturing/production process. Although, Arratia and Cell have mentioned that Lean and VE can be used together in production/manufacturing industry, there is a lack of an evidence in research on such an integration with related to the construction industry. There is therefore a need to investigate the synergy between Lean and VE concepts in order to find out the probable integration and its benefits. Thus, the aim of the research is to investigate the synergy between Lean principles and VE stages.

The paper stucture begins with an introduction to the study and followed by a literature review on Lean and VE concepts in section 2. Section 3 presents the research methodology and section 4 presents the synergy betweeen Lean and VE strategies. The final section summarises conclusions derived from the research findings and present recommendations.

2. LITERATURE REVIEW

2.1. LEAN AS A VALUE ACHIEVING STRATEGY

The concept of Lean based on the Toyota Production System introduced by Japanese in 1950s (Spear and Bowen, 1999). Number of major companies in the world adopt Lean in order to remain competitive in rapidly globalised market (Perez and Sanchez, 2000). As per Arratia and Cell (2003), Lean tends to reduce cost, target customer wants, needs and finally improves the efficiency of production.

Lean Philosophy emerged to Lean Construction and Lean Project Management due to its strongest approach of achieving best performance, while maximising value and minimising waste (Ballard and Howell, 2003). Lean construction applies a new form of production management to construction sector which includes performance maximisation, concurrent design and construction and the proper project control throughout the project life cycle from design to delivery (Aziz and Hafez, 2013).

According to Madanayake (2015), there are five basic Lean principles in Lean implementation. The Lean Construction principles which were derived through the literature synthesis and used for this studyis shown in Table 1.

Table 1: Definition of Lean Construction Principles

Lean Principles		
No	**Principle**	**Description**
1	Customer Value	Specify the value from the perspective of ultimate customer. It is essential to meet the required specifications and to deliver the value desired to the end customer. By clearly defining value for product or service, customer value becomes the common focus for parties involved in the project.
2	Value Stream	Identify all the steps necessary to design and construction across the whole value stream to highlight non value adding activities
3	Flow	Make those actions that create value flow without interruption, detours, backflows, waiting or scrap
4	Pull	Only make/provide what is pulled by the customer
5	Perfection	The elimination of non-value-adding elements (waste/muda)

Source: Madanayake (2015)

Although Lean is effective, it does not answer to all the problems (Arratia and Cell, 2003). Hence, there can be both benefits and drawbacks associated with the Lean Construction approach. Ballard *et al.*, (2002) further explained the benefits achievable in Lean construction as improved management of demand, reduced cycle time, greater productivity, heightened work force involvement, and increased revenue and profitability. However, Garbie (2010) highlighted that although Lean provides the benefits, it is still need more effort to explore ways to overcome the drawbacks associated with Lean.

2.2. VALUE ENGINEERING AS A VALUE ACHIEVING STRATEGY

Lawrence D. Miles, who is an Electrical Engineer and also the pioneer of the VE has proposed some alternatives to overcome the issue of material shortage (Cheah and Ting, 2005). VE is another systematic approach which seeks to achieve value for money by providing all necessary functions at the lowest total cost (Male *et al*., 2007). According to Morgan (2003), VE is an intensive, interdisciplinary problem solving activity that focuses on improving the value of the goal objective functions in an organisation.

Value Management process involves three parts including pre-study, value-study and post-study (Shen et al., 2004). In contrast, Kelly et al. (2004) and Shen et al. (2004) proposed six stage job plan for the implementation of VE as information phase, functional analysis phase, creativity phase, evaluation phase, development phase and presentation phase as shown in Table 2, which is used for this study due to its selection as the most applicable job plan.

Table 2: Value Engineering Job Plan

Value Engineering Job Plan		
Phase	**Sub-phase**	**Related steps**
Pre-study		Collect user / customer attitude, complete data file, determine evaluation factors, scope the study, build data models, determine team composition
Value study	Information phase	Complete data package, modify scope
	Function analysis phase	Identify functions, classify functions, develop function models, establish function worth
	Creativity phase	Create large quantity of ideas to achieve the functions specified
	Evaluation phase	Rank and rate alternative ideas, select ideas for development
	Development phase	Conduct cost benefit analysis, complete technical data package, create implementation plan, prepare final proposals
	Presentation phase	Present oral report
Post study		Complete changes, implement changes, monitor status

VE facilitates creativity, innovative ideas, alternative solutions, and generally indulge in some ‘out-of-the-box’ thinking in introducing proper changes to the construction procedures (Ellis *et al.,* 2005). Further, VE facilitates sustainability to the construction industry and holds a strategic position (Abidin and Pasquire, 2007). However, VE is not effective in low value low risk projects (Kelly *et al.,* 2004). Significant cost and time consumption of the process can be considered as other drawbacks associated with Value Engineering implementation (Kelly *et al.,* 2004).Hence there is a need of proper implementation of the VE practices in order to achieve the target benefits.

2.3. COMPARISON BETWEEN LEAN AND VALUE ENGINEERING

Different researchers have defined VE and Lean in different ways. However, there are some specific characteristics, issues, problems and objectives associated with the concepts and the different researchers views on the facts are shown in Table 3.

Table 3: Comparison between Lean and Value Engineering

Characteristic/Issue/Problem/ Objective	**Lean**	**Value Engineering**
Excellent quality	Can be achieved by perfection	Enhance the value by achieving optimum quality
On time delivery	Obtains by reducing unnecessary flow activities	Propose alternatives which accelerate the project
Superior customer service	Identify and address the customer requirements in customer value phase Based on customer pull situation	Identify customer requirements in pre study phase and address them during job plan
Reduce variable overhead costs	Reduce non value added activity costs	Achieve optimum cost even in materials
Potential savings other than cost reduction	Limited by underlying design characteristics	Obtainable by making design changes
Waste elimination	Continuous waste reduction	Spontaneous and quick response to the wastes
Transforming operations into alternative forms of visual information	Achieve end user satisfaction and understanding	Achieve end user satisfaction and understanding
Use of visual analytical tools	Spaghetti diagrams, flow diagrams , bar charts, standard work sheets and production control boards	Function analysis and FAST diagrams.
Systematic approach for problem identification and solving	Mainly focus on waste reduction not problem solving	Proactive problem identification and solving mechanism
Provide consistency in application	Due to various definitions consistency is limited	Yes, Job plan facilitates the consistency
Promote creative thinking and innovations	Yes, but there is no room for creative process improvement	Yes, facilitates creative process improvements
Vigorous and analytic methodology	Is not an analytical approach	Yes, FAST diagrams etc. used as analytic tools
Reduce cost and increase value	Reduce costs of waste and increase the value	Achieve optimum cost and enhance value
Offers great flexibility to the approach	Less flexibility due to standardisation process	Not a standardisation process hence, the process is flexible
Most effective with processes that involve high dollar value	High cost reduction is possible in expensive projects	Can used in variety of situations but VE cost is significant
Works best with processes that have low variation and effective cost	Not effective for the projects with large nr of variations	No. can effectively implemented for higher number of variations.
Long term process which require strong and consistent management support	Yes, requires longer duration for perfection	40 hour workshop is required for implementing
Require large financial investment	Significant cost is there	Significant cost is there
Depends on the management	Yes, mostly	Depends on the VE team
Can work as isolated study event	No, operational management process	Yes, an isolated study event
Provide cohesive set of operating principles and practices	Number of principles to be followed	No, just the phases to be followed
Operator support	Operator support is required to achieve objectives	Operator support is required to achieve objectives
Team dynamics	Team based approach together with the management	VE team based approach

Sources: Dixon (2004); Wixon (2004); Arratia and Cell (2003)

Generally, the major difference between two concepts is; Lean is a philosophy whereas VE is an analytical tool. Lean expects to improve performance in direct manner whereas VE tries to achieve essential functions and improve the functional performance. VE is proactive process which provides an innovative ideas and solutions for problematic situations. However, Lean provides perusing perfection.

However, both strategies focus on enhancing customer value, reduce unnecessary cost or wastage in a great manner. Final objectives of two aspects would be achieving value for client's money and enhancing the project performance.

3. RESEARCH METHODOLOGY

Research design is a logical blueprint which can be explicit or implicit (Yin, 2013). The design of this research includes, literature survey, expert opinion survey, data analysis and validation of research findings respectively.

In depth expert opinion survey was used for the study since the research topic associated with detailed data requirement from the construction industry. On the other hand, the experts available with the specific knowledge related to Lean and VE were very less within the industry. Hence, obtainable sample size was less. Therefore, the research was conducted under the qualitative approach by considering its advantage over the quantitative approach. Further, the information gathered were mostly the opinion evidence and needed to be evaluated in a descriptive way. Hence, the research necessitated the qualitative research approach.

Unstructured interview was selected as the most appropriate method of data collection from experts for this research by considering above facts. Hence, six (06) experts were interviewed using unstructured interview guideline as the major data collection technique. The interviews were conducted until the data saturation among the industry experts who belong to consultant, contractor and client organizations. Content analysis, which is a qualitative data analysis technique was used in this research study to analyse the collected data by considering its merits over the other techniques. Further, unstructured interviewing method necessitated the tool content analysis for analysing its findings. There are several data analysis software to support the content analysis and this study selected NVivo (2010) for content analysis which contained graphical presentation of interpreting relationships.

Data validation facilitates the verification of the validity of research outcome. The final outcome developed under this research was validated by conducting two (02) expert interviews.

4. RESEARCH FINDINGS AND DISCUSSION

First question of the Interview Guideline was to identify the existing industry practices to achieve value for the money. All the six respondents have selected VE and Lean as value achieving strategies. However, they all explained that Lean and VE both are practicing in the industry in an ad-hoc manner, which they have derived, would limit the real benefits allied with the strategies. All the respondents agreed that Lean and Value Engineering can make significant contribution to the Sri Lankan context as separated strategies. Further, greater value achievement and unnecessary cost reduction is imaginable with both strategies. It has been showing the benefits for large number of years in Sri Lanka and become popular among the industry.

Both the strategies are with their own benefits and drawbacks. Hence, the industry is seeking for an advanced value achieving strategy where the drawbacks can be minimized. Experts suggest that the associated drawbacks could be overcome by synergising the concepts. The interview questions were prepared accordingly to find out the synergy of the concepts since the relevant findings of researches and applications are less in the industry.

Hence, third section of the interview guideline was developed accordingly to identify the synergy between Lean and VE. Five basic principles of Lean and eight stages of VE job plan were considered in finding out the synergy between the concepts. All respondents (R1-R6) presented their opinions and there were similarities in their answers. The synergies that respondents have mapped are shown in Table 4.

Table 4: Summary of Research Findings

VE JOB PLAN \ LEAN PRINCIPLES	CUSTOMER VALUE L1	VALUE STREAM L2	FLOW L3	PULL L4	PERFECTION L5
PRE STUDY PHASE V1	R1, R2, R3: These two phases can be mapped. R4, R6: There is a synergy R5: Identifying & Specifying the clients perception is achievable in pre study phase	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R2: Perfection can be defined here
INFORMATION PHASE V2	R1, R3: There is a link between these two phases R5: Value can be established with actual customer requirements at this phase R4: These phases can be mapped R6: There is a Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy
FUNCTIONAL ANALYSIS PHASE V3	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2: There is a synergy R3: An attempt to derive functionality of the value stream R6: It is possible to add functional requirements to Lean implementation in this stage	R1, R2, R3, R4, R5, R6: No Synergy	R1, R3, R4, R6: There is a synergy R2: Add the functional requirements for the pull	R1, R2, R3, R4, R5, R6: No Synergy
CREATIVITY PHASE V4	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R2: Adding innovations to the Flow is possible at creativity phase R3, R4: There is a synergy R5: Value flow can be sharpened by the creativity involvements	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy
EVALUATION PHASE V5	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R3: There is a synergy R2: Flow could be further evaluated for waste elimination in evaluation phase R5, R6: Value flow can be evaluated	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy
DEVELOPMENT PHASE V6	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R3: There is a synergy R2: Value flow can be further developed in development phase	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy
PRESENTATION PHASE V7	R1, R3: There is a synergy R2: An attempt to verify actual requirements of the customer R4: It can be checked weather the objectives are achieved or not R6: Findings can be presented to the client and can get confirmed	R1, R3: There is a synergy R2: An attempt to verify value stream R4: It can be checked weather the objectives are achieved or not R6: Findings can be presented to the client and can get confirmed	R1, R3: There is a synergy R2: An attempt to verify value flow R4: It can be checked weather the objectives are achieved or not R6: Findings can be presented to the client and can get confirmed	R1, R3: There is a synergy R2: An attempt to verify the things pulled by the customer R4: It can be checked weather the objectives are achieved or not R6: Findings can be presented to the client and can get confirmed	R1, R3: There is a synergy R2: An attempt to verification of perfection R4: It can be checked weather the objectives are achieved or not R6: Findings can be presented to the client and can get confirmed
POST STUDY PHASE V8	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R2, R3, R4, R5, R6: No Synergy	R1, R3: There is a synergy R4: These two phases can be mapped R5: Building end users perception which is always targeted. Can be achieved at post study phase R6: Pull can be further developed at post study phase	R1, R3: There is a synergy R4: Continuous improvement process is possible with post study phase R5: Continual focus on mitigating deficiencies while ensuring optimum usage is possible R6: It is providing a place to achieve perfection with a clear reviewing process
SUMMARY OF THE FINDINGS	**Value can be specified from the perspective of customer at Pre Study and Presentation stages**	**Value Stream and waste activities can be derived at the stages of Functional Analysis and Presentation stages.**	**Value Flow can be created with use of stage Creativity, Evaluation, Development & Presentation.**	**What is pulled by the customer can be provided within the stages of Functional Analysis, Presentation & Post Study.**	**Elimination of waste is achievable at the stages of Presentation & Post Study.**

Findings of literature review stated that combining Lean and VE would provide a better output. The respondents' opinion further reinforced the literature (as stated by Arratia and Cell, 2003) while stating these two concepts could be merged. Hence, as the first stage of synergising the concepts, experts were on their views by linking the five basic principles of Lean and all the Value Engineering stages. The final outcome of the research is shown in Figure 1 based on the data analysis, which explains the synergy between Lean and VE.

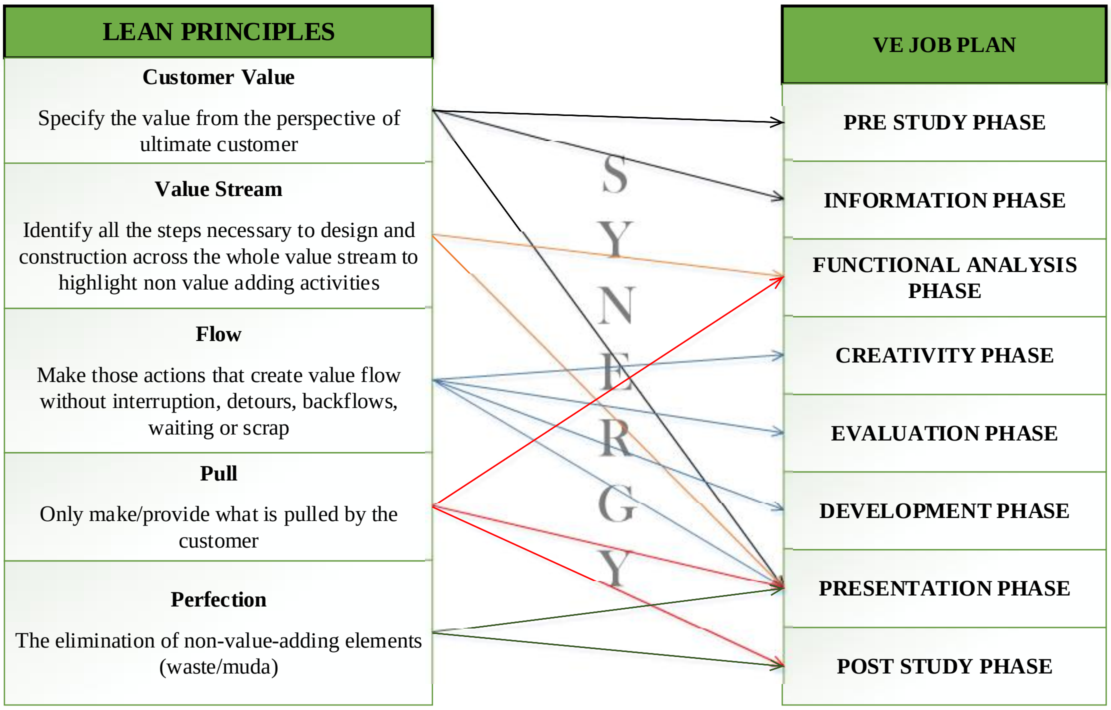

Figure 1: Synergy between Lean and Value Engineering

Customer value principle can be linked with pre study phase, information phase and presentation phase of the VE job plan where the principle can be realised. Value stream phase can be linked with functional analysis and presentation phases whereas flow can be linked with creativity, evaluation, development and presentation phases. There are links in between Pull principle and functional analysis, presentation, post study phases. Finally there is a synergy of perfection principle with presentation and post study phases. The synergy outcome was validated by two (02) industry and academic experts and thereby the synergy was accepted.

Therefore, five Lean principles can be achieved with the relevant phases of the VE job plan which finally provides Lean-Value Engineered outcome. Hence, the synergies can be used for further advanced value achieving strategy development purposes. The synergies may facilitate for a multiple value achieving strategy in time to come according to the views of the experts.

5. CONCLUSIONS

The dynamic nature of construction industry has forced the firms to find out relevant strategies in achieving best value for the client. The concept of value is not a novel concept which inherent a long history. Different researchers have defined value with related to their own points of views. However, value is not which measure the financial performance and value is depending on the interpreter who interprets it. Value is related to function, quality and cost by means of construction industry.

Many researches reveal the fact that construction industry is striving for construction process improvement in order to give best value to the client. Several holistic strategies being utilised in construction sector as the value achieving strategies. Initially the cost consideration was given prior concern whilst the modern era is rather concern over the value. Hence, the industry adhered to the value achieving strategies and the researchers exaggerated that VE and Lean supersede all the other strategies since, they address the concept value in a greater extent.

Although both the concepts are consisted with their own merits, they have their own drawbacks to overcome as separated strategies. Hence, the synergisation is the suggestion by the industry since the research findings facilitate a great synergy between the concepts. Basically, the industry entails a holistic multiple value achieving strategy apart from the rational single value achieving strategies. Since these two concepts supersede in the value arena, probably these two will address the concept in a greater manner. Therefore, there was a need of finding out the synergy and probable links between the strategies in order to develop an advanced strategy in time to come.

This research presents to the industry the basic synergy between Lean and VE as Customer value principle can be linked with pre study phase, information phase and presentation phase of the VE job plan, value stream phase can be linked with functional analysis and presentation phases whereas flow can be linked with creativity, evaluation, development and presentation phases. There are links in between pull principle and functional analysis, presentation, post study phases. Finally there is a synergy of perfection principle with presentation and post study phases in order to proceed further and finally realizing the best value for the client. Hence, the synergy findings could lead to a robust approach in enhancing the value of construction projects.

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THE ADOPTION OF INTEGRATED PROJECT DELIVERY IN PUBLIC SECTOR PROJECTS IN NEW ZEALAND: THE WAY FORWARD

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ABSTRACT

The construction industry in New Zealand is responsible for around 40% natural resources, 30% energy consumption, and 30% greenhouse gases. The increased costs in natural resources, and energy, together with environmental concerns have pushed the demand for green buildings. Integrated Project Delivery (IPD) process has emerged as an enabler for green buildings. Successful IPD combines the partnering concept and lean thinking, it addresses the participant's expectations, cuts costs, eliminates waste, reduces variability and generates value for all the participants. Yet many public sectors owners, do not have the authority to adopt features of IPD. However, owners can benefit from the IPD philosophy and features to take advantage of some key benefits. The purpose of paper is to examine the IPD tools and techniques appropriate for public sector organizations in New Zealand and to examine the barriers that public sectors organizations face in New Zealand while adopting those IPD features. A pilot study was conducted to examine these issues, semi structured interview were carried out with four public sector construction industry specialists. The interviews revealed that there is a gap between current and best practice in the New Zealand construction industry that is impacting on the adoption of IPD or IPD approaches. To improve the delivery of public sector projects a checklist of specific IPD tools and techniques appropriate for NZ public sector projects has been developed.

Keywords: *Integrated Project Delivery; IPD; Public Sector, Construction Industry.*

1. INTRODUCTION

The construction industry in New Zealand is responsible for around 40% natural resources, 30% energy consumption, and 30% greenhouse gases (Forsyth *et al.*, 2014). The increased costs in natural resources, and energy, together with environmental concerns have pushed the demand for green buildings. Integrated Project Delivery (IPD) process has emerged as an enabler for green buildings. Successful IPD combines the partnering concept and lean thinking, it addresses the participant's expectations, cuts costs, eliminates waste, reduces variability and generates value for all the participants. Yet many public sectors owners, do not have the authority to adopt features of IPD. However, owners can benefit from the IPD philosophy, its features and its key benefits.

The paper begins by exploring the nature of IPD, its key principles, the benefits of its implementation and the factors that are driving its adoption in construction industry, to provide a theoretical base for the study. This informs the research objectives, which suggested certain methodological constraints and avenues for the investigation. The results are summarised and discussed, a conclusion and suggestions for further research is also provided.

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2. LITERATURE REVIEW

2.1. THE DRIVERS OF IPD

The fragmented nature of the construction industry, particularly the separation between the design and construction, the uniqueness and complicated nature of building projects places great responsibility on the project team in setting up a comprehensive building process and successfully concluding a project (Sidwell, 1982). One fundamental aspect of the building process that requires particular and early attention is the selection of the most suitable organization for the design and construction of the project if success is to be achieved (Masterman *et al.*, 2003).

There are several limitations to traditional project delivery methods used in construction industry (Strickland, 2010). Over the years, construction project delivery methods have been evolving continuously (Kent and Becerik-Gerber, 2010). With time projects have become more complex in nature due to higher expectations of clients, advancement in technology, need for sustainability and energy efficiency (Kent and Becerik-Gerber, 2010). Clients have also become more aware of waste and productivity issues, technological advancements and are demanding change, it is suggested that the goal of everyone in the construction industry should be faster, better, more capable project delivery created by fully integrated, collaborative teams (NASFA *et al*., 2010).

IPD has emerged in response to this need (Nofera *et al.*, 2011) and to reduce inefficiencies that are a part of current design and construction practices (Kent and Becerik-Gerber, 2010). Frust (2010) stated that Integrated Project Delivery (IPD) process offers a way to organize the delivery of construction projects that uses the partnering concept and lean thinking, addresses participant's expectations, cuts costs, eliminates waste, reduces variability and generates value for all the participants through the procurement, design and construction process. IPD as a process embodies the principles of concurrent engineering. Anumba *et al*., (2002) stated that concurrent engineering facilitates the simultaneous consideration of all project-related issues and processes from the conception stage. Concurrent engineering uses systematic or parallel processes (rather than traditional sequential ones), and multi-disciplinary teams comprising all parties involved in the project, including the client and suppliers (Evbuomwan and Anumba, 1998).It seeks to improve project outcomes by using a collaborative approach to align the goals and incentives of project team through early involvement of all parties, shared risk and reward, and a multiparty agreement (Kent and Becerik-Gerber, 2010). The principles of IPD can be applied to a variety of contractual arrangements and requires highly effective collaboration between the client, designer and contractor, from the early design phase through to project handover (Azhar *et al.*, 2014). Usually, IPD teams include members beyond the basic triad of client, designer and contractor (AIA 2007a).

Waste and lack of productivity are also considered as an important driver of IPD. A Lean Construction Institute study (2004) suggests that as much as 57% of effort, time and material investment does not add value to the final product in construction projects, as compared to 26% in manufacturing industry (NASFA *et al*., 2010). It is suggested that to reduce this waste there is a need for change in the environment in which project teams are appointed and perform; and collaborative environments where all team members contribute to problem solving are required (ACIF *et al*., 2014). Perhaps this is why the biggest support for IPD is from within the Architecture/ Engineering/ Construction (A/E/C) industry that shares the owner's frustration about cost overruns, lack of coordination, change orders, poor communication and missed information (Sive, 2009).

IPD has the potential to revolutionize the construction industry as it focuses on overall improvement by integrating tools, processes and people into a system (Azhar *et al*., 2014). Several professional organizations support the advancement of IPD, however a relatively small number of projects are using IPD (Ghessemi and Becerick-Gerber, 2011; Kent and Becerik-Gerber, 2010; Sive, 2009).

2.2. BENEFITS OF IPD

Mihic *et al.* (2014) stated that, “IPD leverages early contributions of expertise and knowledge through utilization of new technology, allowing all team members to better realize their highest potential while expanding the value they provide throughout project life cycle.” Building upon early contributions of individual expertise, these teams are guided by principles of trust, transparent processes, effective collaboration, open information sharing, team success tied to project success, sharing risk and reward, value-based decision making and utilization of full technological capabilities and support (AIA, 2007b). The outcome is the opportunity to design, build and operate as efficiently as possible (Mihic *et al*., 2014).

According to AIA (2014), IPD is the key for proper consideration of many features, criteria and constraints of final design from the conceptual stage. Jones (2014) expressed that it offers a solution oriented approach as the planning is done at an early stage by a relevant and specialist team. Here the key participants work collaboratively on first defining the project goals and objectives including cost, time, quality and sustainability, and then analysing the satisfaction of the objectives through the use of local resources, opportunities presented by the site and selection of proper materials (Cleves and Gallo, 2012). In this kind of collaborative design environment, supported by responsive decision analysis tools, the possibilities of refining the design are wide- ranging (Jones, 2014). It is suggested that this leads to a high degree of confidence in the design in terms of component and material efficiencies; cost and time objectives and sustainability (Jones, 2014). Also, continuous efforts are made to reduce waste; use economical and environmentally sustainable materials; improve health and safety and reduce pollutant generation (Smith *et al*., 2011).

2.3. BARRIERS TO IPD

The project team and its members are the centre piece of integrated project delivery (AIA, 2007b). However, IPD presents challenges for the project team (Ghessemi *et al*., 2011). The implementation of IPD is not easy, especially in public sector projects (Azhar *et al*., 2014). According to Kent and Becerik-Gerber (2010), while new contract documents supporting IPD exists, they have not been tested properly and are not fully proven or understood. Construction industry firms are accustomed to traditional ways of responsibility, leadership and opportunity; and change is slow. Barriers faced by public sector organizations to implementing IPD can be categorized as legal and contractual barriers; cultural and organizational barriers; and technological barriers (Azhar *et al*., 2014; Ghessemi *et al.*, 2011).

Legal and Contractual Barriers

Legal and contractual barriers refer to issues of risk allocation, liability and insurance (Ghassemi *et al.*, 2011; Kent and Becerik-Gerber, 2010). Some IPD contracts reduce or eliminate the ability of parties to sue one another for better collaboration, but the current insurance products are designed to assign liability to each participant, and this makes the contractual arrangements more complicated (Cohen, 2010; Sive, 2009). According to Azhar *et al*., (2014) typically for public projects, architectural and engineering services are procured through negotiated contracts as a part of quality-based selection, whereas contractors are selected through open competition and lowest responsible bid (Ghassemi *et al*., 2011). In this kind of procurement selection, design is completed before involvement of the contractor in the process and this inhibits key aspects of IPD including multiparty agreements, shared risk and reward and early involvement of all key participants (Azhar *et al.*, 2014).

Cultural and Organizational Barriers

Cultural and organizational barriers within the construction industry refer to resistance to change; lack of leadership; lack of a widely accepted solution; size of project and type of project (Azhar *et al.*, 2014; Eadie *et al*., 2007). Since IPD projects require significant additional costs and design efforts, some critics believe that IPD should be reserved for large and complex projects (Tucker *et al.*, 2013; Lichtig, 2005). Others believe that IPD is more beneficial in repetitive facilities rather than unique one-time projects (Cleves *et al*., 2012). Lichtig (2006) expressed that the real challenge is to overcome the inertia and change the mindset built on traditional practices. Organizations are accustomed to ‘tried and tested’ methods and they show resistance to change, which can be aggravated by lack of awareness of new processes; improper communication and information transfer; and concern related to liability and risk in new processes (Zipf, 2000).

Technological Barriers

Technological barriers can cause concern while implementing IPD and are related to legal challenges of ownership, interoperability concerns and liability in the integrated use of technology (Ghessemi *et al.*, 2011; Kent and Becerik-Gerber, 2010). It is essential to establish information management protocols from the beginning that include ownership information, format of representation, responsibility, access and accountability in respect to project information (Azhar *et al.*, 2014) Availability of adequate IT infrastructure is not mandatory for IPD implementation, but experts strongly believe that it is necessary for the level of integration and collaboration required for IPD projects (Eastman *et al.*, 2011). Since, different organizations use different IT systems, interoperability issues arise when these organizations form a project team (Moses *et al.*, 2008). Some other barriers, according to Eadie *et al.* (2007) are high costs of IT systems, lack of technical expertise, IT security issues and in some cases, no business benefit being directly realized.

2.4. IPD IN NEW ZEALAND

The New Zealand government has set a target to improve construction sector productivity by 20% from year 2010 to 2020 (Fuemana *et al*., 2013). Gillies (2013) expressed that the government seems to recognize this to some extent and proposes IPD, but it is unclear how it might be recorded in a contract and what it would actually mean in practice. A report by New Zealand Productivity Commission (2012) noted that project delivery issues in New Zealand's construction industry could be minimized through better upfront planning and greater collaboration between clients, builders, designers and sub-trades, and suggested adoption of IPD to better facilitate project delivery. However According to Ryan *et al.* (2013) the New Zealand construction industry is not completely familiar with IPD.

This paper aims to investigate the following issues for public sector organizations in New Zealand:-

1. Identify in what form, if any, IPD is being utilized in the New Zealand Construction Industry.
2. Investigate the barriers that are faced by public sector organizations when employing IPD.
3. Examine the IPD tools and techniques applicable for public sector construction projects in New Zealand.

3. METHOD

The purpose of the research was to gain deep insights into the elements of IPD and the reality of its uptake. The nature of the research problem meant that an inductive approach was appropriate. This was exploratory in nature and a qualitative approach was taken as this would help to develop knowledge and understanding.

The sample size is limited and focuses on exclusivity of text and that the focus of the research should be transferability rather than generalizability (Marsh and White, 2006). Four construction industry specialists took part in the pilot study. The sample was selected based on the industry specialists experience in terms of their professional role, nature of work and projects they had undertaken in the construction industry. All of the industry specialists were all working for or closely with public sector organizations in New Zealand to deliver construction projects and had participated in at least 2 or more public sector construction projects in New Zealand. They were identified through personal networking, social media and company websites and selected on the basis of a homogeneous purposeful sampling technique (Patton, 1990) this ensured that all participants were selected based on specific criteria. A brief summary of each construction industry specialist is outlined below (see Table 1).

Table 1: Demographic Information of Participants

Interviewee	Role in Construction Industry	Years of Experience in role	Years of experience in Construction Industry	Level of Academic Qualification
1	Architect (Private Consultancy)	7	12	Bachelors of Architectural Studies
2	Project Manager (Contractor)	3	8	Graduate Diploma in Construction Management
3	Project Manager (Local Council)	9	25	Bachelors of Engineering
4	Project Director (Private Consultancy)	16	36	Bachelors of Engineering

As the interviews were semi-structured they were neither a completely open conversation nor were they highly structured (Kvale, 1996). Semi structured interviews were conducted, it is well suited for exploration of opinions and perceptions of respondents regarding complex and sometimes sensitive issues, and also enable probing for more information and clarification of answers (Barriball and White, 1994). The interviews followed suggested themes and questions which were formed from the literature. Face to face interviews were conducted lasting approximately 30 minutes in duration, this method was preferred over other formats because it generates a more effective interaction and motivates the participants to spend more time and put in extra effort (Ramanayaka, 2013). Notes were taken by the interviewer during the interview.

The interview data was analysed using content analysis as it allows the researcher to make valid inferences form the data to the context with the aim to provide new knowledge, insights and facts that can be tested at a future date (Krippendorff, 1980; Elo and Kynga, 2008). The analysis allowed the commonalities and differences that existed between each interviewee to emerge. The dominant themes are summarised below.

4. FINDINGS AND DISCUSSION

Based on the interpretation of the data the findings can be categorized into a number of themes including the definition of IPD, benefits of IPD, type of projects most appropriate for IPD implementation and the potential barriers to IPD implementation in New Zealand's public sector construction projects.

A general understanding of IPD was communicated, the participants confirmed that IPD is a project delivery method where clients, contractors, designers and consultants work collaboratively as an integrated team, with their commercial interests aligned with actual project outcomes.

All the participants appreciated the intent of IPD, they believed that the IPD framework helps in establishing right relationships among project participants to achieve success, especially in complex and large-scale projects. A general consensus among the participants related to the benefits associated with the use of IPD or IPD type delivery which supports the work of Azhar *et al.* (2014). They stated that companies can improve their competitive positions, gain entry into new markets, supplement critical skills and share the risk and cost of major developments which is in line with the AIA findings (AIA, 2007b).

The information collected from interviews revealed that IPD or IPD type delivery is particularly suitable for projects that are: large, complex and high cost; need high flexibility; face significant or undefined risks; have scope for innovation; have a tight time schedule to carry out; and involve significant stakeholder, environmental and/or political implications. The participants' views support the literature and suggest that IPD is suitable for large and complex projects that require flexibility, enhanced communication, innovation, enhanced quality and effective risk management (Frust, 2010; Azhar *et al.*, 2014).

The participants suggested that the IPD approach can be fundamental in achieving target outcomes and sharing risk for high profile public sector projects. They also expressed that public sector organizations in

New Zealand are increasing their use of IPD type delivery for construction projects methods similar to IPD are also being utilized on large infrastructure, public sector projects including 'Project Alliancing' and Design and Build project delivery with increased collaboration and integration. Public sector organizations are also adopting collaborative and integrated practices like early involvement of participants, shared risk and reward, organizing workshops with stakeholder involvement and no litigation.

The participants went on to confirm that the adoption of IPD can immensely benefit and transform the construction industry in New Zealand from a traditional 'best for organization' practice to 'best for project' practice (Azhar *et al.*, 2014). Also, since public sector organizations are the largest procurers of construction in New Zealand, the adoption of IPD approaches could transform the practices throughout the industry, especially in large private organizations that work closely with public sector organizations, which in New Zealand's case is true for most large private sector organizations.

The participants revealed that there is a gap between current and best practices in the New Zealand construction industry that is impacting the adoption of IPD or IPD type approaches. A wide range of barriers to IPD were discussed and support the literature presented. Legal and contractual issues were raised by the participants. For the adoption of IPD in particular, there is a lack of suitable form of contract in New Zealand that is consistent with both IPD methodology and the Construction Contracts Act 2002. This supports the work of Cohen (2010) and Siva (2009) who confirmed a lack of proper contract form as an important barrier to IPD implementation. The New Engineering Contract x12 was suggested a solution for this by one of the participants as it is specifically designed for multi- party agreements. Other contractual challenges that could be faced while implementing IPD in New Zealand's public sector construction projects include lack of insurance policies and bonding arrangements; complications with job costing and accounting; assigning project leadership; and deciding framework for contractual renegotiations.

Cultural and organizational barriers discussed by the participants included: resistance to change, lack of leadership and uncertainty of risk involved (Azhar *et al.*, 2014; Eadie *et al.*, 2007). Participants suggested that one of the most significant challenges to IPD suggested is the client's resistance to change, primarily due to lack of knowledge and experienced personnel that could lead the change in their organization. Participants also confirmed the challenging cultural paradigms that exist in the construction industry which can act as a barrier to the successful implementation of IPD on public sector construction projects (Lichtig, 2006; Zipf, 2000).

Another factor that demotivates the clients from spending resources on IPD developments is the uncertainty of risk involved in multi-party contracts and collaborative arrangements where the client loses a degree of control in decision-making. The issue of risk allocation which supports the work of (Ghassemi *et al.*, 2011; Kent and Becerik-Gerber, 2010).

A further barrier to IPD is that of other key project participants, who traditionally have an adversarial 'control-based' approach to contract management, and changing this behaviour and attitude of people in the construction industry towards 'trust-based approach' is also a key issue.

Participants confirmed technological barriers to the implementation of IPD. They stated that the availability of adequate IT infrastructure is critical for the level of integration and collaboration required during implementation of IPD, especially on large and complex public sector projects this supports the work of Eastman *et al.* (2008). Although large organizations in New Zealand can deliver on the IT infrastructure requirements for IPD implementation, small and medium enterprises that play crucial roles as sub-contractors and suppliers for public sector projects are still lagging behind in their technological capabilities. Some of the reasons identified for this lack of technological capabilities among small and medium enterprises are high upfront and maintenance cost of technological developments; lack of trained professionals and lack of awareness of how technological advancements will impact these firms (Ghessemi *et al.*, 2011; Kent and Becerik-Gerber, 2010; Eadie *et al.*, 2007). Participants also raised concerns over the interoperability issues since different organizations involved in a project can have different type and level of complexity of technology available to them which supports the work of Moses *et al.*, (2008).

The findings also support the suggestions that, project delivery issues in New Zealand public sector construction can be minimized by using IPD which can offer better upfront planning, collaboration and integration. Public sector organizations in New Zealand recognize this and are adopting project delivery tools and techniques that are quite similar to IPD (New Zealand Productivity Commission, 2012).

The third and final objective of the paper is creating a list of IPD tools and techniques that are appropriate for implemented on public sector construction projects in New Zealand. Table 2 demonstrates the IPD tools and techniques, with their benefits, which could be adopted for delivery of public sector construction projects in New Zealand. The recommendation for adoption of these tools and techniques is based on the synthesis of the literature and analysis of the data.

Table 2: IPD Tools and Techniques appropriate for NZ Public Sector Projects

IPD Tool or Technique	Benefits
Multi-party Agreement	Maximizes collaboration, builds trust, single point of responsibility on project team
Shared Risk & Reward	Confidence to project participants, best for project attitude, promotes innovation
Early involvement of all parties	Minimize fragmentation, improved and informed decisions during design phase, optimize the whole project
Integrated Teams	No blame culture, high performance, continuous improvement, flexibility, optimize the whole project, enhanced communication
Integrated Governance	Collaborative and innovative decision making, flexibility, mutual trust and respect, optimize the whole project
Transparency	Mutual trust and respect, accurate information for all participants, prevents contingency hiding
Contingency Pool	Safety for project participants, encourages teamwork, prevents contingency stacking
Lean Construction	Maximize efficiency, minimize waste, value for client, promotes sustainability
Incentive Pool	Promotes high performance
Building Information Modelling (BI M)	Easy access to project information for all participants, current and accurate information for all participants, process quality, increased productivity, better collaboration and information sharing

According to the literature review, multi-party agreements are a key aspect of IPD. Even though there is no specific contract form for IPD in NZ, the qualitative analysis revealed that the New Engineering Contract x12 is designed specifically for multi- party agreements and can be used by public sector organizations in NZ. Therefore, multi-party agreements could be adopted by public sector organizations while implementing IPD or IPD type project delivery.

Both, literature review and qualitative analysis revealed that public sector organizations are already adopting techniques including early involvement of all parties and shared risk and reward due to various benefits offered by both these techniques, therefore, both these techniques should also be adopted for IPD or IPD type delivery. To successfully deliver a project that contains tools and techniques like multi-party agreement, shared risk and reward, and early involvement of all parties, it is important to formulate integrated teams and practice integrated governance to ensure success (AIA, 2007b; Mihic *et al.*, 2014). Transparency is essential to build trust in a collaborative and integrated setting and a contingency pool provides safety for project participants that in turn motivates the project participants and prevents contingency stacking. An incentive pool is another tool that motivates the project participants to perform better and has proved to be quite beneficial in IPD or IPD delivery. Finally, lean construction and BIM are two features of IPD whose importance cannot be stressed enough in delivering large and complex public sector construction projects in NZ.

5. CONCLUSIONS

The importance of the right project delivery system in a construction project cannot be overstressed, but historically, very few attempts have been made to improve these systems. IPD is an attempt at improving project delivery, and as this paper has examined how the implementation of IPD can successfully improve public construction project delivery and add value to projects and organizations involved.

These exploratory findings are consistent with the literature regarding the fundamental features of IPD, the level of uptake of IPD in New Zealand, as well as the barriers and benefits of IPD for Public Sector Construction Projects. In summary the benefits of IPD for Public Sector Projects in the New Zealand Construction industry include that IPD is suitable for large and complex projects that require flexibility, enhanced communication, innovation, enhanced quality and effective risk management and project delivery issues in New Zealand public sector construction can be minimized by using IPD which can offer better upfront planning, collaboration and integration. In contrast there a wide number of barriers to the implementation IPD for Public Sector Projects in the New Zealand Construction industry. These include legal and contractual issues, cultural and organizational and technological constraints. The most appropriate IPD tools to encourage IPD implementation on Public Sector projects in New Zealand are the use of multi part agreements, a system that accommodates shared risk and reward, facilitates integrated team and governance and champions' transparency throughout the project.

Given that the study is based on a small number of industry expert opinions, it would be useful to conduct a more in depth study focusing on the key results presented. One specific area that a wider study should focus on is the relationship between IPD and Building Information Modeling (BIM). BIM offers easy access to project information, current and accurate information for all participants. It also offers process quality, increased productivity, better collaboration and information sharing and has the potential to improve the uptake of IPD. The research provides insights into IPD uptake and barriers to IPD for public sector projects in the New Zealand context. This is a pilot study and the results should be used cautiously as they are not generalizable due to the small sample size. However they are transferable and these findings could form part of a wider study. This would contribute to the exploration of a well refined and calibrated IPD decision making tool for construction project owners. For this to occur a detailed statistical analysis of the cost and benefit of implementing IPD on public sector construction projects in NZ is needed as well as further validation of the findings presented in this paper.

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THE LOOPHOLES OF EVACUATION PROCESS IN THE SRI LANKAN HEALTHCARE SECTOR

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ABSTRACT

Healthcare facilities are traditionally seen as places of sanctuary and safety by the general public. The fire hazard is one of the challenges faced by any healthcare organization. Therefore, in order to save lives and reduce injuries, well-designed evacuation process is significant. Thus, this research investigates the loopholes of the evacuation process in the Sri Lankan healthcare sector which, would be helped to improve the evacuation process in hospital buildings in Sri Lanka near future. The research study was initiated with a comprehensive literature review and subsequently adopted a qualitative research approach to investigate the research phenomena. Semi-structured interviews were conducted with fire safety professionals to investigate the requirements and parameters of the evacuation process and the loopholes of fire evacuation process in Sri Lankan healthcare sector. The collected data was analysed through content analysis by manual. The research findings revealed that the fire safety door, evacuation assembly point, compartmentation, fire detection and alarm system and closings of high risk rooms' doors are engaged with some loopholes which need to be improved. Loopholes contributing to evacuation process are; inadequate space in assembly points, lack of inspection by fire wardens etc. The research therefore suggests that regular maintenance, involvement of space planner from the initial construction stage, conducting training programs to staffs including managerial level, would help to improve the existing evacuation process in the Sri Lankan healthcare sector.

Keywords: *Healthcare Sector; Evacuation; Loopholes Fire Safety.*

1. INTRODUCTION

Building fire accidents result in significant life and economic losses. It is considered as one of the biggest threats to both the building occupants and its contents (Salleh and Ahmad, 2009). For an example, Ramachandran (1999) indicated that in the UK nearly 800 people were killed in the fire accidents annually, whereas direct material damage reaches to £1,200 million each year. According to Ahrens (2002) fire caused by smoking materials, heating equipment, electrical or lighting equipment in 2006-2010 were 6,240. Further, Ahrens (2012) indicated fire caused an average of six civilian deaths, 171 civilian injuries and $52.1 million in direct property damage annually. Fire safety design in a building is expected to provide a safe environment for occupants while inside the building during their safe evacuation to a place of safety where outside the building (Furness and Muckett, 2007). Obviously, the process of evacuation is significant, and therefore effective evacuation helps to save lives, reduce injuries, bound property loss and minimize all sorts of troubles that caused by the fire as wells as during the evacuation (Mileti, 1999).

There are several serious disputes when considering the evacuation of a hospital (Taaffe *et al*., 2005). For example, previous studies had acknowledged the challenges with evacuation plan, such as emergency planning and preparedness of hospital evacuation (Schultz *et al*., 2003; Manesh *et al*., 2013). As well as Taaffe *et al*., (2005) identified the issues and complexities of hospital buildings in the USA. Moreover, Schultz *et al.* (2003) and Manesh *et al*. (2013) merely described emergency planning and preparedness of hospital evacuation. Tayfur and Taaffe (2007) argued that when considering the evacuation of a hospital there are numerous critical issues identified, such as the nature of the threat, risk to patients and staff, continuing care, resource demands and threat probabilities and timing. Further, Tayfur and Taaffe (2007)

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subjected inefficient and ineffective evacuation may result in terrible loss of life. For an example, in Kolkata AMRI hospital fire killed 86 people due the lack of fire safety equipment in the hospital and also when the fire took place the windows and doors were locked (Paul, 2011). The comprehensive evacuation of hospital buildings involves different considerations (New York Centers for Terrorism Preparedness and Planning [NYCTP], 2006). Consequently, hospital premises consist with many elderly people, young people, teenagers, children, infants, handicaps and women who need both mental and physical care and medications (Bierster, 2010). The way an individual occupant in a hospital will behave to a fire danger is complex (Furness and Muckett, 2007). Evacuation of hospital is a difficult process that requires an effective strategy and careful execution, however, there is still no stable approach to tackle this problem (Tafee *et al*., 2005).

In the context of Sri Lanka, Carballo *et al*., (2005) mentioned, during an event of fire in healthcare organization, evacuation of badly injured patients were done easily because of the safety procedures which were prepared by the hospital in case of fire. However, the same researchers also argued, when hospital proposed the advanced planning and instruction for emergencies, they did not accurately and widely known about evacuation procedures. Moreover, Fazulhaq (2014) stated that although fire safety equipment is installed in Sri Lankan hospitals, sometimes there are no service contracts for the maintenance of that equipment. This conflicting nature of the evacuation process in the Sri Lankan healthcare sector identifies a research gap. The current research therefore investigates the loopholes of the evacuation process in the Sri Lankan healthcare sector, which would help to improve the evacuation process in hospital buildings in Sri Lanka.

2. LITERATURE REVIEW

Generally in the event of emergencies, a healthcare sector is a place where large number of patients need to be immediately secured (Federal Emergency Management Agency, 2007). Complete evacuation of healthcare sector requires special considerations, because a significant percentage of patients in hospitals are incapable of self-evacuation; they may be medically unstable and dependent on mechanical support equipment (Loria *et al*., 2012).

Malhotra (1993) explained that evacuation process is a vital part of any building fire protection system and generally hospital design must follow the regulation of national as well as international. Hospital building evacuation standards of the American Institute of Architects [AIA] (2006) specified about fire safety actions such as compartmenting, exits, fire alarms, automatic switch off systems, and other fire protection methods, including those within present facilities. National Fire Protection Agency [NFPA] (2006) introduced the NFPA-101 standards and declared that fire protection is based on “defend-in-place” principle. Defend-in-place principle means if evacuation becomes impossible, an alternative is to defend in place, simply most appropriate location for refuge, where it is totally enclosed. The fire evacuation requirements and the parameters for each requirement are guided by those standards. According to the literature review following evacuation requirements and parameters are identified as the requirements and parameters for an effective evacuation process.

2.1. MEANS OF EXIT

Exit route is an uninterrupted and unobstructed path of exit, which use to travel to a safe area from any emergency place and it includes exit access, horizontal and vertical exits and exit discharge (Geren, 2005). The vertical evacuation is very complex, also consuming large amount of waiting time due to the significant percentage of patients who cannot evacuate without assistances of mechanical equipment in the event of an emergency. Thus, the horizontal movement of patients is one of the most important considerations in the healthcare organizations (NFPA, 2006). Horizontal exit of the hospital should have at least two smoke free areas on each floor.

2.2. *SITE ACCESS*

In general, ground and air transportation are mentioned as the two types of transportations that evacuate patients to the outside the hospitals. In the healthcare sector, allocating sufficient spaces for parking is the main consideration in site access for all occupiers. Hospitals should have a separate and additional area for ambulance entrance (AIA, 2006). The size of parking lots and ambulance entrance depends on location, type and size of hospital facilities. Lee, Lim, and Anantharaman (2004) indicated that helicopter access is one of the most significant accesses which transports patients directly and rapidly from the helipad without interference from other hospital functions.

2.3. *EVACUATION ASSEMBLY POINT*

NYCTP (2006) stated that the evacuation assembly area is the last resort and safe point to accommodate all personnel of the building, after an evacuation. In hospitals, inside assembly area acts as the prime staging safe space and also all occupants can assemble together inside the hospital (Burgun, 1994; NYCTP, 2006). At the final stage of evacuation, all patients, staff, or visitors can assemble in the outside assembly area which is a safe open area outside the building. Healthcare sector may have more than one assembly point, depending on the size of the building. It should be out of the way of responding emergency personnel (Drabek, 1999; Burgun, 1994).

2.4. *VERTICAL TRANSPORTATION*

A hospital may have three types of vertical transportation. They are staircases, lifts, and ramps. In healthcare organizations, the evacuation exit stairs should be designed to please the principles for internal staircases. In hospital building only staff, visitors and ambulatory patients can evacuate through the stairs (NFPA, 2006). Non ambulatory occupants are expected to remain in the building under the defend-in-place concept which those patients on the floor of fire origin being moved horizontally to an area of refuge (NFPA, 2006). A significant amount of patients critically ill in the hospitals and patients in body casts who difficult to evacuate, elevators provide the practical vertical evacuation (Bukowski, 2011).

2.5. *FIRE EVACUATION DRILL*

Normally in hospitals a large amount of people is occupied daily. All of them may not be familiar with the stairways and alternative exits; sometimes it may not be familiar,even for those who are working in the same building. So they enter and exit using the same entrance. In the event of an emergency, occupants might travel past to that particular entrance or exit to evacuate the building (Jones and Demers, 2001). So the use of fire drills becomes more important in situations like these, where conducting fire drills will provide an opportunity for occupants to locate and use alternative routes under non-threatening conditions.

2.6. *FIRE SAFETY DOORS*

In a hospital, A fire door set should be designed as self-closing and latching devices, because they have to provide more than simply fire resistance as possible to contain the spread of fire, smoke and toxic gases especially in a high-occupancy building (Chiltern International Fire, 2000). Department of the Environment, Heritage and Local Government (2006) specified that high risk rooms should be located in close position.

2.7. *FIRE DETECTION AND ALARM SYSTEMS*

A fire alarm system is designed to detect a fire at a sufficiently initial stage, with the aim of people who are at risk can be made safe either by escaping from the fire (Goh and Kwek, 2005). Detectors must be coupled with alarms. Alarm systems provide notice to at least the building occupants and usually transmit a signal to a staffed monitoring station either on or off site. Further maintenance of fire detection and alarm systems should be carried out monthly basis (The Electrical Safety Council, 2008).

2.8. CLOSING OF FIRE DOORS TO HIGH RISK ROOMS

Department of the Environment, Heritage and Local Government (2006) specified high fire risk rooms should be taken special care of, and thus they can be identified as laundry rooms, kitchens and store rooms. If the high risk rooms are held in open position, then there is a major chance of the fire to be spread to other areas. Thus, three levels can be divided as low, medium and high as follows.

- Low - If all the doors to the high fire risk rooms are kept in the open position
- Medium - If some of the doors to the high fire risk rooms are maintained in the open positions
- High - If all of the doors to the high fire risk rooms are closed

2.9. COMMUNICATION SYSTEM

There should be an integral process to communicate with the occupants in the building (Muszynski, 2010). In the building both occupants and facility personnel must keep copies of the plan and as well as need to learn and practice the plan. It is also useful if the details of the person who is authorized to communicate with fire brigades, the person who operates the public addressing systems for directing the occupants to move to a safe location in the building and to do necessary things when the fire brigade arrives are also added in the evacuation plan. In high rise buildings which have these protection strategies are frequently equipped with voice communication fire alarm systems that allow either a live or recorded voice announcement, or both, to provide direction to occupants. The communication method may direct the occupants about the emergency, if they have to remain in the place and await for further instructions, or to evacuate the building (Muszynski, 2010).

2.10. COMPARTMENTATION

Compartmentation is the subdivision of the building into compartments. Each compartment separated from, either by walls or floors, thereby restricting the growth and spread of fires in buildings (Furness and Muckett, 2007). As NFPA - 101 (2006) stated, the building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period. In particular, walls common to two or more buildings must resist the spread of fire. To inhibit the spread of fire all buildings must be subdivided with fire resisting construction appropriate to the size and intended use of the building. In addition, all buildings must be protected against the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited.

3. RESEARCH METHODOLOGY

A qualitative research approach was adopted as the research requires an in-depth knowledge of the evacuation process in the Sri Lankan healthcare sector. Semi-structured interviews were conducted to assess the requirements of evacuation and to identify the loopholes in each requirement and their parameters. A total of ten numbers of private hospitals was selected and interviewed thirteen professionals in the healthcare sector, which included fire safety engineers, fire safety consultants, facilities managers, maintenance engineers and intensive commanders. The organizations were considered particularly due to those hospitals covers varieties of healthcare, including primary and acute care and constraints in collecting data from government hospitals. The number of hospitals was limited to ten due to the data saturation of semi-structured interviews. The interviewees were first asked to comment on what are the requirements and parameters of evacuation that they have fulfilled at the hospital building. A framework developed according to requirements and parameters identified through literature review, was given to the each interviewee. Then the interviewees were asked to comment on the loopholes in the evacuation process of the particular building. The views of the interviews were analysed using content analysis.

4. DATA ANALYSIS AND FINDINGS

The data for the analysis was collected using semi-structured interviews from ten hospital buildings H1-H10 through a purposeful sampling technique. Table 1 represents the profile of the participants. Participants were limited to thirteen and more than one professional who engaged in occupational health and safety activities in selected hospitals were considered where necessary. Interviewees represent the different professional backgrounds such as fire safety engineering, maintenance engineering, maintenance management, facilities management, safety consultancy, and intensive commanding. 38% of the participants represent fire safety engineering, while remaining 23% and 15% of participants are from maintenance engineering, and maintenance management respectively. An equal percentage of participants 12.5% belong to field of facilities management, safety consultancy and intensive commanding.

Table 1: Profile of Participants

Building	Interviewee	Designation	Years of Work Experience
H1	I01	Maintenance Manager	10
		Facilities Manager	6
H2	I02	Maintenance Engineer	12
H3	I03	Fire Safety Engineer	30
H4	I04	Fire Safety Consultant	28
		Assistant Maintenance Engineer	7
H5	I05	Intensive Commander	5
H6	I06	Fire Safety Engineer	17
H7	I07	Fire Safety Engineer	30
		Maintenance Engineer	7
H8	I08	Fire Safety Engineer	16
H9	I09	Maintenance Manager	6
H10	I10	Fire Safety Engineer	9

4.1. *REQUIREMENTS IN EVACUATION PROCESS OF HEALTHCARE SECTOR*

The review of literature indicated that there exists ten different evacuation requirements for the effective functioning of the evacuation process. However, evacuation requirements used to evaluate the evacuation process in healthcare sector in Sri Lanka were limited to eight requirements and 39 parameters which almost cover the ten critical requirements identified under the literature review. The interviewees were asked to indicate "Yes" for the requirements and parameters which currently available at the evacuation process of a particular hospital, and if not asked to indicate as "No". Only three parameters are given with a three point Likert scale which ranges from 'Low to High' as stated in the literature review and obtained the response. The Table 2 indicates the framework with requirements and the parameters of evacuation with their percentage of availability within the selected hospital buildings.

Table 2: The Developed Framework for Requirements and Parameters of Evacuation Process and Their Representation in Hospital Buildings

Requirements	Yes (%)	No (%)
Evacuation Drill		
Educating the building occupants about alarm sound	100	-
Educating to building occupants to about using fire extinguishers	100	-
Notifying the building occupants to location of fire exit routes	80	20
Notifying the building occupants to location of the fire assembly point	60	40
Familiarizing new occupants with fire evacuation drill procedure	60	40
Identifying the weakness in communication system when evacuation	40	60
Arrangement for disabled people are checked	30	70
Fire drill is carried out at night times	20	80
Means of Exit		
Fire exit routes are directly connected to the last resort	100	-
Handrails are at a height not less than 100 cm	100	-

Existence of at least two exit routes in a workplace	100	-
Unobstructed fire escape routes	80	20
Fire escape stairs have straight flight not less than 125 cm wide with 25 cm treads and risers not more than 19 cm	80	20
Fire escape entrance is separate and remote from internal staircase	40	60
Existence of emergency lighting system	04	60
Communication System		
Radios have backup direct current power source (battery)	100	-
Facilities have presence of a backup communications system	100	-
Fire brigades visit and inspection for evacuation plan	100	-
Copy of the evacuation plan kept by the security center or telephone operators	80	20
Facilities have adequacy of fire brigade access	40	60
Facilities have the provision of "action in the event of fire" notices in the healthcare sector	20	80
Facilities have the provision of "calling fire brigade procedure" notices	20	80
Fire Safety Doors		
Door materials are wind- and fire-resistant	100	-
Doors of rooms for less than 50 people and more than 50 people are respectively 112cm and 122cm wide, located from each other in distance and swing out	60	40
Provision of residents bedrooms with minimum 30 minutes fire resistance door	40	60
Main doors is double swing; bathroom door is swing out; emergency room doors are swing in and out	30	70
Door designed to be kept closed have indicated sign such as: fire exit, keep door closed	30	70
Evacuation Assembly Point		
Assembly point have sufficient spaces for assemble the large number of occupants at a time	70	30
Route from the building to the assembly point contains illumination and sign-posting	70	30
Final exits lead directly to a place of safety	40	60
An outside location at least 50 feet from the building and away from roads	40	60
Safety once away from the building	20	80
Compartmentation		
Exterior walls meet the fire resistance rating of two hours	30	70
Compartments enclosed consist of both floor-to-floor and wall to- wall fire-resistant	30	70
Room partitions made of fire resistant construction material	20	80
Automatic fire detection and alarm system		
Regular Maintenance (monthly)	40	60
Closing of fire doors in high risk rooms		
If the all the doors in the high fire risk rooms are kept in the open position	Low	30
If some of the doors to the high fire risk rooms are maintained in the open positions	Medium	70
If all of the doors to the high fire risk rooms are closed	High	-

Considering the % response regarding the each parameter of evacuation, the research findings imply, only 9 parameters (25%) are available at all the selected hospitals (100%)among the given 36 number of parameters. Consequently, 6 parameters (16.6%) from the rest of the parameters are available at the hospitals in a 70-80%. Other 17 parameters (58.3%) are available at the hospitals in a 60 or less than 60%. The last evacuation requirement is closing doors in high risk rooms. It includes three parameters and tested using a three point Likert scale. According to the interviewees' opinion, 70% of selected hospitals maintain medium risks if some of the doors of higher fire risk rooms are maintained in open positions. The remaining 30% maintains low risks if all doors in the higher fire risk rooms are kept in the open position.

4.2. LOOPHOLES IN THE EVACUATION PROCESS IN HEALTHCARE SECTOR

The next stage of the data analysis includes the analysis of interviewees' responses on loopholes in the evacuation. The interviewees' responses on the loopholes were weighted according to the parameters which have 60 or less than 60% of availability of requirements and parameters of the evacuation. According to the interviewees' opinion, this includes the loopholes in fire safety doors, evacuation assembly point, compartmentation, automatic fire detection and alarm system, and fire doors in high risk rooms.

FIRE SAFETY DOORS

Overall, two loopholes are identified in the provision of the resident’s bedrooms with minimum 30 minutes fire resistance door. The loopholes include absence of conducting inspections to check the ability of 30 minute fire resistance and lack of knowledge and skills of management personnel relating to fire safety. Most of the interviewees (60%) opined that there are no any inspections to check the ability of 30 minute fire resistance. Considering the loopholes in the parameter; the main door double swings, bathroom doors is swinging out, emergency room doors are swinging in and out, and there are two loopholes responsible. 60% of the views expressed that fire safety engineers do not consider the fire door standards in selecting the door types. Another 50% of the research participants are of the opinion, lack of knowledge about the requirement of different types of doors. As the loopholes in the parameter; door designed to be kept closed has indicated sign, most of the interviewees (80%) opined that there seemed a lack of regular inspection of door whether the signs are properly displayed. And 50% of the interviewees pointed out that fire wardens are not instructed to inspect the fire doors by the hospital management.

EVACUATION ASSEMBLY POINT

The analysis indicated that the absence of fire safety engineers in the design stage, inadequate space to accumulate whole occupants in final resort and lack of awareness of fire safety standards are the most prominent loopholes for the parameter; exits lead directly to a place of safety. Approximately, 50% of interviewees were agreed on these factors. Considering the next parameter with loopholes, the parameter; an outside location at least 50 feet from the building, and safety once away from the building mainly depends on car park close to the hospital, inadequate space to design the assembly point 50 feet away from building, absence of fire safety engineers in the design stage, lack of awareness of fire safety standards, and design standards. Among those factors, 40% of the interviewees depicted that hospitals with the car park close to the building may increase the probability of accidents when evacuate the building. In terms of safety once away from the building, 60% of the interviewees indicated that inadequate space to design the assembly points inside the hospital premises is more challenging. 40% of the interviewees specified that the unawareness of the designers about the level of danger faced with placing the assembly point outside.

COMPARTMENTATION

Most of the interviewees (60%) opined that the exterior walls constructed by non-fire resistant materials, but the high initial cost of fire resistant material is challenging. Other 40% of the interviewees are of the opinion that lack of the safety tests being conducted according to the fire safety standards and lack of consideration by management in fire rating hours in exterior walls are most challenging. Considering the parameter; compartments enclosed consist of both floor-to-floor and wall-to-wall fire-resistant, the loophole is the lack of consideration of fire safety standards during early stage of the design and construction stage. This was opined by approximately 50% of the interviewees. The analysis also found out that room partitions with non-fire resistance material, lack of advice from quality consultants is more challenging on the room partitions made of fire resistant construction material.

AUTOMATIC FIRE DETECTION AND ALARM SYSTEM

In the automatic fire detection and alarm system, there are three loopholes; a few maintenance staff to carry out the inspection every month, lack of awareness of proper maintenances and testing system and failure to maintain records relating to the fire detection and fire alarm test as per the standard. Most of the interviewees (60%) are of the opinion, that there are few staffs to carry out the inspection every month. Another 40% of the interviewees stated that there is a lack of awareness on proper maintenance and testing system.

FIRE DOORS OF HIGH RISK ROOMS

Considering the fire doors of high risk rooms, 60% of the interviewees indicated that unawareness of management and fire wardens about the importance of maintaining high risk rooms closed as a loophole in the evacuation process. Another 30% of the interviewees in the opinion that high frequency of usage of high risk rooms such as store room, kitchen and laundry and lack of daily inspection by fire wardens in high risk rooms are also contributing to the loopholes in the fire evacuation process in the Sri Lankan Healthcare Sector.

5. DISCUSSION

Building fire safety can be divided into five major steps, those are minimizing the chance of fire, early discovery, restricting the fire spread, extinguishing the fire, and evacuating the building (Smariga, 1965). Accordingly, the research identified eight evacuation requirements for the better functioning of building fire safety. The evacuation requirements are evacuation drills, means of exits, communication system, fire safety door, evacuation assembly point, compartmentation, fire detection and alarm system and closings of high risk rooms' doors. Loria *et al*. (2012) explained that a complete evacuation of healthcare sector requires special considerations, because a significant percentage of patients in hospitals are incapable of self-evacuation; they may be medically unstable and dependent on mechanical support equipment. However, research findings indicated that most of the evacuation requirements (5 out of 8) are with loopholes in the Sri Lankan healthcare sector. Those requirements include: fire safety door, evacuation assembly point, compartmentation, fire detection and alarm system and closings of high risk rooms' doors.

Evacuation aims at a continuous path of travel to move massive victims from any point within a building or structure to another open space (fire assembly point) which should be secured from danger (Lathrop, 1997). Therefore, the fire assembly point should be away from roads, walkways and 50 feet from the building. The interviews revealed that the assembly points are located even within 50 feet of building and also closed to car parks. This is because of inadequate space of hospitals. Fire safety is a process that should start at the beginning of the design of a building and it should address issues such as means of escape, smoke control and other life safety provisions (Hoffmann and Steenbakkers, 2005). This seems that the fire safety engineers and space planners need to involve from the initial stage of the design. However, the view of the interviewees (30%) indicated that the hospitals are lacking in appointing such professionals from the initial stage. A fire door set should be designed as self-closing and latching devices, with fire resistance because they have to provide more than simply fire resistance as possible to contain the spread of fire, smoke and toxic gases especially in a high-occupancy building (Chiltern International Fire, 2000). According to interviewees, the fire doors are having some loopholes like; signs are not displayed properly on fire safety doors, lack of inspections by fire wardens, and lack of knowledge of fire safety standards. Department of the Environment, Heritage and Local Government (2006), specified high fire risk rooms of laundry rooms, kitchens and store rooms, should be taken special care and need to keep in closed condition as the chance of getting fire is high. However, the research found that closing of high risk room engages following loopholes; the frequency of using those rooms per day is high, therefore it is not possible to keep closed position.

Thus, the research identifies that the fire evacuation of hospitals in Sri Lanka is engaged with some loopholes and intends to suggest ways to improve the evacuation process in hospital buildings in Sri Lanka. The next section concludes the research and provide recommendations for the enhancement of the evacuation process of hospitals in Sri Lanka.

6. CONCLUSIONS AND RECOMMENDATIONS

According to the research findings, the evacuation requirements like fire safety doors, evacuation assembly point, compartmentation, fire detection and alarm system and closings of high risk rooms' doors are engaged with some loopholes. Those loopholes need to be improved for a better functioning of the evacuation parameters. Loopholes contributing to evacuation process are; inadequate space for assembly points, lack of inspections by fire wardens and high cost involvement for fire resistance materials. The research also found that regular maintenance (monthly) of fire detection and alarm system is necessary for the best performance. However, because of the allocation of few staffs, the maintenance is not done regularly. The research recommends the strategies to improve the evacuation process through identifying the ways of minimizing loopholes. Steps need to be taken to carryout proper maintenance to fire detection and alarm system, communication system and emergency lighting system in an accepted time interval. Adequate staffs need to be allocated throughout the evacuation process. Further, the research found that record keeping of evacuation drill, maintenance of fire detection and alarm system need to be done in a systematic way. The space planner and fire safety engineers need to be involved from the design stage of the building. This could allow the building to have separate staircases for common use and in the event of fire; providing assembly point inside the building premises; and designing the parking area with sufficient width. The most significant suggestion made by the interviewees was to make the management aware of the important aspects of the evacuation process in healthcare organizations. This includes the importance of designing a fire staircase separately, regular inspection by the fire brigades regularly and use of fire resistant materials in the construction of buildings.

Finally, the research suggests that conducting workshops, training programs and brainstorming sessions regarding evacuation process and its maintenance to relevant staffs including managerial level could enhance the evacuation process. In addition, staffs from senior management levels need to undertake comprehensive training and instruction in relevant fire safety legislation and associated fire safety technical guidance. This could secure organizations from any legal problems. Thus, the healthcare sector could be seen as a place of sanctuary and safety by the general public.

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TOWARDS FACILITIES INFORMATION MANAGEMENT THROUGH BIM

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ABSTRACT

Information plays a significant role in managing built environment facilities. These information are generated at different life cycle stages, by different parties, which also provide different values to a variety of stakeholders. The acquisition of appropriate information efficiently and effectively is two of highly important considerations in facilities management because of the nature of information flows, number of information providers and users. Building Information Modelling (BIM) is one of the popular mechanisms, which has adopted in construction sector to manage its information. This preliminary paper investigates how construction information is valued in facilities management. This is an initial step of understanding the possibilities and hindrance of using BIM as an effective vehicle to manage information during the facilities management stage.

To achieve this aim, data were collected through literature review and 13 semi-structured interviews among construction professionals. Data were analysed thematically. The literature reveals BIM is an efficient mechanism to manage construction information. However, there is a difficulty of transferring appropriate information from construction stage to facility management. The study further identified the types of construction information that are highly usable for completing FM tasks, their uses and value attached to them.

Keywords: *Building Information Modelling; Construction Information; Facilities Management; Information Flows; Information Value.*

1. INTRODUCTION

The success of facilities management highly depends upon the correct practices of information management (NBS, 2015). The data flows (in - out) during the lifecycle of a facility is frequent and are significant to manage the overall facility. On the other hand, the UK construction industry is highly depend on sub-contracting (HM Government, 2013) and the information related to the built asset is provided by several parties. Hence, BIM is identified as an effective solution to minimise such deficiencies as it provides robust platform for collaboration. Although BIM is meant to provide benefits throughout the building life cycle, current literature has been unbalanced in focusing on the application of BIM in post-construction stages (Codinhoto *et al*., 2013). Also from the practitioners' perspective, the primary attention of project owners / stakeholders are more towards the built facility (end product) rather its operational and maintenance considerations (Becerik-Gerber *et al*., 2012).

Therefore BIM enabled Facilities Management (FM) is been promoted within construction industry in the recent past. However, the pre-identified benefits of BIM is merely based on the information it holds. Therefore, this study attempts to investigate how construction information is valued in facilities management in deciding which information to be passed down through BIM.

2. BUILDING INFORMATION MODELLING (BIM)

BIM is identified as "a novel approach to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format" (Eastman, 2011). It is a process rather than a tool (British Institute of Facilities Management, 2012). At construction stage, it appears as an AEC (Architectural, Engineering

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and Construction) digital modelling process (McGraw-Hill, 2009). Looking beyond construction, BIM is considered as a technology based process used to enhance the performance of a built asset through each phase of its life cycle (Love *et al.*, 2013). Being nourished by different views, this paper considers BIM as the process of data acquiring, storing, integrating and management through the building life cycle with graphical modelling. It provides number of advantages to project stakeholders through apposite coordination, waste reduction, informed decision making and also contributing correct information at the correct time (Love *et al.*, 2013). However, the overall benefits of BIM is not completely realised and construction project stakeholders are facing difficulties to make the decision on adopting BIM in their project execution plan (Barlish and Sullivan, 2012). On the other hand, BIM is a complication as it continues expanding from a software to an asset management information system (Love *et al.*, 2013).

Moreover, BIM should not only be seen as a mere technology used at the design and construction stage but also its impact on the future of the organisation as an information tool for operation and maintenance of the built asset. To be an effective tool at the facilities management (FM) stage of a building, BIM should contain FM information (NBS, 2014).

FM is dealing with enormous amount of building information; acquiring, updating and analysing (Wang *et al.*, 2013). BIM as a platform coming from the early stages of a building is a perfect solution for FM data management. BIM allows to communicate FM needs in early stages (British Institute of Facilities Management, 2012). The positive contribution of adopting BIM in facilities information management is identified as a significant value addition associates with BIM (Gu and London, 2010). Eadie et al. (2013) highlight that facilities managers and client benefit the most out of BIM implementation. From clients perspective, a considerable effort should be given to define client's FM needs at the early construction stages (Becerik-Gerber *et al.*, 2012). Above that, most of the projects do not hand over the 3D model and Construction Operations Building Information Exchange (COBie) dataset at the commissioning and this prevents grasping of BIM advantages in FM (Eadie *et al.*, 2013).

COBie and IFC (Industry Foundation Classes) are currently available standard formats for data exchange with BIM. In terms of facilities management, COBie is a neutral spreadsheet format which allows data exchange in a structured manner for commissioning, operation and maintenance of an asset (British Standards Institute, 2012). IFC is another common language for information sharing (Abanda *et al.*, 2015), which provides a standard form of data sharing between construction, operations and maintenance stages of a built asset (International Standard Organisation, 2013). IFC itself does not give a detail explanation to decide what information is required by any specific task under the given scope (East et al., 2013). On the other hand, information overloading and poor understanding on information needs of FM, and level of details of those information drive towards the low implementation of BIM within FM (Parsanezhad and Dimyadi, 2014). This indicates the niche for robust mechanism to acquire necessary information for facilities management. Correct identification of the value that attached to facilities information is a key mechanism to filter necessary information (Zhao *et al.*, 2008).

3. FACILITIES INFORMATION MANAGEMENT

Facilities Management (FM) is the centre point of responsibility which ensures services of an organisation perform up to the agreed standards to support the core business performance to achieve business objectives (British Institute of Facilities Management, 2015). To be successful, a business should understand the impact of rising cost on building occupancy, services and workplace management over the business life cycle (Codinhoto and Kiviniemi, 2014). FM is dealing with large amount of building information including acquiring, updating and analysing (Wang *et al.*, 2013). On the other hand. facilities managers' spend lot of time in searching the required information (Jylha and Suvanto, 2015). Therefore, acquiring and storing required information related to the building is the initial success factor for a well-planned facility management (Akcamete *et al.*, 2011).

In order to be successful in continuously growing, complex built environment, FM requires to manage the information produced by different stakeholders throughout building life cycle (Pittet *et al.*, 2014). This task has become much complex and challenging due to increasing volume, continuous changes take place in information and variety of parties interested or using the same information (Zhao *et al.*, 2008). As a solution, Wang *et al.* (2013) suggest that the early engagement of FM in construction process will help to overcome such challenges. Yet, the early engagement of FM is rarely practiced and depends upon the type of procurement arrangement. BIM as a platform coming from the early stages of a building is therefore a practical solution for FM data management.

However, this fascinating solution brought in through BIM for FM is highly depended on how building owner explains his information requirements (Giel and Issa, 2016). Therefore, the question of what information to be transferred through BIM still remains unanswered. Due to the complexity and difficulties in transferring information from construction stage to facilities management it is necessary to use a means of measurement to filter the necessary information from the least important information. Identifying the economic value of information which is based on cost over benefit equation is the most common method of capturing value of information (Neal and Strauss, 2008). On the other hand value-in-use is another mechanism to capture value of information in user perspective (Repo, 1986). Certain characteristics in the construction industry such as contractual liability to fulfil client requirements and the responsibility on client to prepare the Employer Information Requirement (EIR) document impose on the value-in-use. Therefore, value-in-use is the most appropriate measurement for construction information. Value is something more "adjectival rather substantive" hence, it should be found with along the considered object and interest (Perry, 1914). Also the value of information differs based on the kind of information and context of use (Repo, 1986). Accordingly, value is considered as usefulness of information (Norton, 2010).

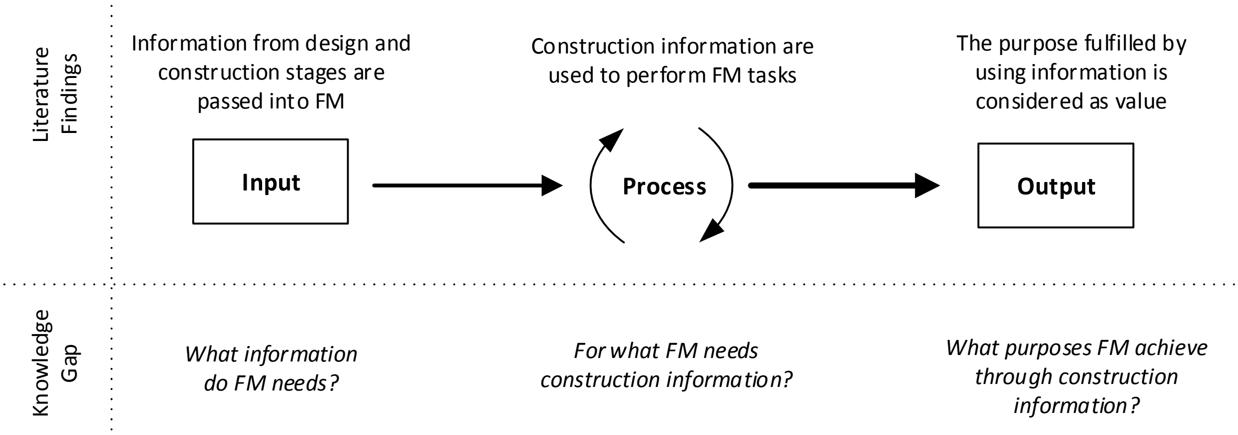

Figure 1: Information Value Process

Having studied the existing knowledge on facilities management information requirements and value-in-use, information value process is developed summarising the essence of literature (Figure 1).Accordingly, it is evident that information is an input for FM from the design and construction stages. These construction information are then used to perform different tasks during facilities management (process). Finally, information users at the FM stage perceive a sense of value by processing information during their job tasks. This conceptual model developed based on literature is needed to be taken forward to explore its applicability in facilities management context and to study further to bridge the knowledge gap by finding answers to the above questions (Figure 1).

4. METHODOLOGY

This paper aims to investigate how construction information is valued during facility management. Literature review was undertaken to identify the application of BIM in facilities management. Having identified the magnitude of information flows from construction stage to FM stage, 13 interviews were undertaken among the construction industry professionals(5 facility managers, 2 estate managers, 2 contractors, an architect, surveyor, BIM manager and a CAFM service provider) to understand the information requirements. It was evident that information requirements are made based on the usability and value of information. The study further noted that the term 'value' is multi-faceted and the information value depends upon for what and by whom it's being used. Data was analysed through coding.

5. DATA COLLECTION AND ANALYSIS

The interview transcripts were analysed through coding process adopted from grounded theory research methodology. The first step of analysis engaged with Open Coding where the researcher looked for the themes generated from the data with an open mind. All possible themes were captured and categories were made grouping the similar themes together. These categories were coded by giving a name which represents the similarity in the themes (Figure 2). In Axial Coding, the properties and dimensions of categories were defined and relationship among categories were realised by going through the data once more. Memos were written during the analysis. Figure 2 is an extract from the first two steps of the analysis explaining the development of “Types of information” category.

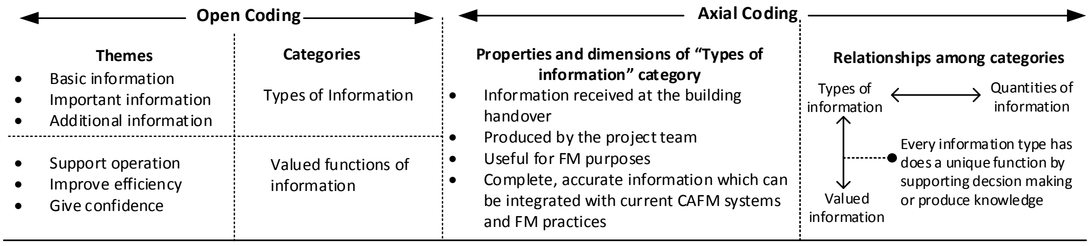

Figure 2: Extract from Data Analysis - Open and Axial Coding

Three kinds of information were highlighted by the respondents when referring to the construction information. A category named “types of information” was developed grouping these 3 types of information. Going through the interview transcript and memos highlighted the common and extreme characteristics such "the lead contractor is liable to provide necessary documents in softcopies at the handover" as stated by a facilities manager was used to determine the properties and dimensions of the category. For example, this quotation emphasise a dimension of the "types of information" category through the code "at the handover" by limiting the amount of factors falls under the category. Another example for a characteristic of the category was derived from a surveyor's statement "not all information is accurate most of the time" which made the point that information should be accurate to perceive its value. Once the categories were structured, key relationships were noted such as each type of information has a predictable quantity and a function. Then at the selective coding, "information" was selected as the core category and the relationship of this to other categories was formed to explain the developed concept.

6. RESULT AND DISCUSSION

Based on the research aim, “construction information” was selected as the core category. The other categories related to construction information builds the properties and dimensions of the concept. Base on the literature, the term value refers to the ultimate output of the information (Norton, 2010). Accordingly, the role of construction information is developed in three sectors (Figure 3).

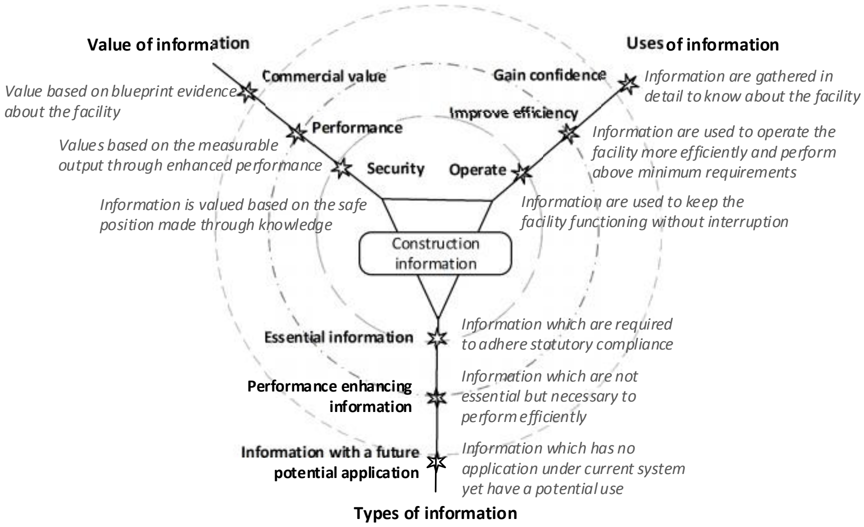

Figure 3: Role of Construction Information in FM
Source: Norton (2010)

The construction information was detailed in three aspects. They are; types of information, the uses of these information and their values. The category “types of information” consists with three sub categories namely; essential, performance enhancement and potential application. The “essential” category identifies the information which are highly necessary to run the facility. For example as-built drawings, safety manuals and operation manuals. These information are collected to adhere to the statutory compliances. Second category under types of information coded as “performance enhancement” is the group of information which are not essential to have with to operate the facility but having this additional information will help to provide an efficient service. The third category is “future potential”. This includes the “nice to know” information as explained by an information provider and also by the BIM manager. This does not have any practical application under current system but may have a potential contribution in the future with the system and technology changes. For example; this category answers the question, if any change of use occurs in the existing facility which information may be required?

The uses of construction information is also identified as key aspect. Here, the applications of construction information to facilities management tasks were identified and noted under ‘uses of information’ category. Facilities managers prefer to have as-built information about the facility as it helps the operation of the building. This is the most basic but most important use of information. The expectation of gathering information at this stage was to understand the features and characteristics of the facility in order to operate the building with minimum disruption. It guides the user on how to operate the facility including the equipment handling, maintenance requirements and possible precautions to be taken for any failure. Information are also used to make the FM functions efficient and effective. Having more detailed information tend to avoid time spend on physical inspection to collect necessary details about the built asset. Therefore, information are used to improve the efficiency of the FM performance. Then, information are gathered to retain knowledge and gain confidence by knowing more about the facility. This is very subjective therefore, no practical application is visible. In other words, more additional information are gathered about the facility although they have no practical application but merely to satisfy a psychological condition of information users.

Once the types and uses of information are formed, value of construction information was considered with related to facilities management. The term “value” refers to the final output of having construction information at the operation and maintenance stage of a building. Accordingly, information is valued in three different perspectives. The most valued output of information is secure environment it builds through knowledge. When the people are informed about the procedures, risks and characteristics of the built environment they tend to be familiar with work place and the work they do. Next, information is valued for the measurable output it brings through performance enhancement. The visible contribution of information such as time savings, support on decision making and risks avoided falls under this value group. Finally, information gains a commercial value when it is in a formal structure. This refers to benefits which could be gained at the reselling point or working on receiving accreditation for best practices. At such instances information acts as a visible proof giving evidence to the services provided by the FM team.

The proposed construction information framework will be assisting laying the input, process and out of construction information in FM. The three outlooks of the construction information also show a relationship between each category. The scattered lined on the framework explain the inter-relationships between three categories. Accordingly, it revealed that the majority of the construction information are the least valued at the facilities management (the largest circle). Therefore, this indicates that economical point of construction information for facilities management should be considered when choosing the information to be stored on BIM platform for long term purposes rather being guided by information management software capabilities.

7. CONCLUSION

It is evident that information carry a value with or without BIM. With the capabilities of BIM, this traditional situation of gaining advantages through information has become business as usual. BIM practitioners hold evidence for the value addition gained through BIM. If the same amount of information is handed over through BIM, building operators are capable of overcoming the basic problems faced in traditional method. It will bring in many opportunities by having digitized information. It will enable the long term use of information, inter-operability within CAFM systems and make it easy to update and manage information. However, value of information through BIM exceeds more as it is capable of handling more information and brings value through graphical demonstrations. Also, with the future expectations of linking BIM with internet enhances its capabilities. This takes the value of information to the next level as this one way information feeding loop will become a cycle going beyond feeding information to BIM but also generating information through BIM.

Having identified this fact, it is necessary to choose the right information to be taken forward with BIM through the building life cycle. Facilities managers play a vital role at this point by contributing to the decision on selecting information which has a value addition beyond design and construction. Having knowledge on the role of construction information is therefore the base for the success of BIM in FM. Not only to the information users but, the model introduced through this paper is also beneficial for the information suppliers such as contractor, architects, etc. to understand the user perspective of the information they generate. This will promote to produce information with a lifelong application by informing both supply and demand sides. However, as a preliminary output of an ongoing research, detail development of the model is yet to be made.

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USE OF PROVISIONAL SUMS IN THE UAE CONSTRUCTION INDUSTRY: AN EMPIRICAL STUDY

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ABSTRACT

Provisional sums are widely used in the FIDIC (Red Book) forms of contract in the UAE construction industry. The practices on dealing with provisional sums have exposed the contracting parties to a number of risks. Therefore, this research aimed at identifying such risks and mitigation measures to limit such risks in using provisional sums in the UAE. The research started with a comprehensive literature review followed by a questionnaire survey among the UAE construction industry professionals. Based on the survey findings, six semi-structured interviews were conducted with expertise in the construction industry to verify the survey findings and close any gaps in the data. The study found that provisional sums are mainly used in the FIDIC (Red Book) forms of contract in the UAE for special works, contingencies, the works which can be only defined in the site, facilitating the appointment of nominated subcontractors and overlapping design and construction. The most common risks of using provisional sums are related to claims, variations and conflicts among the contracting parties. Defining the scope of provisional sums before tendering, incorporating the provisional sums into the project programme and limit the value of provisional sums in the contract are suggested as the key measures to minimize the risk of provisional measures.

***Keywords**: Provisional Sum Uses; Advantages; Risks; Mitigation Measures; FIDIC; UAE.*

1. INTRODUCTION

Provisional sums are mainly used for the works still under design or when their costs are unknown at the time of signing the construction contract. Their existence in the contract however, does not necessarily suggest any obligation on the employer to spend them. According to Murdoch and Hughes (2000), they are simply a method for the employer to express part of the budget of the project in the main contract. Okuwoga (1998), finds that provisional sums make 25% of contract sum and according to Ameer (2013), in some projects the value of provisional sums increased up to 50% of the project contract value. With this increased use of provisional sums and due to their uncertain nature, the risks related to cost uncertainty, schedule incorporation, quality and scope control are significant. Therefore, it is worth to identify the risks of using provisional sums in the construction contracts in order to develop strategies to mitigate such risks.

Use of provisional sums is a common practice in the UAE construction industry and Skaik and Al-Hajj (2013) indicate that the use was increased by the economic crisis in 2008 and this furthers the associated risks. However, there is a lack of research carried out in this area and therefore, this study intended to fill this gap through identification of the risks of using provisional sums in the UAE construction industry. As the International Federation of Consulting Engineers (FIDIC) standard forms of contract are mostly used internationally including in the UAE, this study is focused on FIDIC in general and FIDIC Redbook (1987 and 1999 editions) in particular. The research aim was to enhance the management of risks related to provisional sums through identification of such risks in the UAE construction industry. This aim was achieved through following objectives:

- Identify of the use of provisional sums in FIDIC (Red Book) form of contract
- Discover the purpose of using provisional sums

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- Examine the risks of using provisional sums
- Develop strategies to minimize the risks of provisional sums

2. PROVISIONAL SUMS

Provisional Sums are classified as ‘defined and undefined. Defined provisional sums deemed to be accounted within the contract sum and the contractor’s baseline program and usually have sufficient information about the related works (Ross and Williams, 2013). In contrast, undefined provisional sums do not provide enough technical details for the contractor to incorporate them in the financial and schedule planning (Ross and Williams, 2013). Provisional Sums allow the employer to deal with some construction works that are not feasible to finalize during the tender stage or in the absence of clear scope at the time of tendering. Unlike prime cost sums, which obligate the contractor to execute them, provisional sums may or may not be carried out by the contractor (Jenkins and Stebbings, 2006). According to Ross and Williams (2013), provisional sums can also be included in the contract as contingency for the works that are unexpected.

Despite the advantages, provisional sums add uncertainty to the construction contracts. According to Robinson (2013) their inclusion indicates that the main contractor is not required to take the risk of pricing part of the scope of work. Provisional sums are also considered as one of the main factors leading to cost overruns (Omoniyi, 1996). Ipko (2008) identified that provisional sums increase in an average of 40%. This is mainly due to the non-preparation of the technical drawings (Ogunsemi, 2007) and the inclusion of arbitrary figures for provisional sums (Olusegun, 2010). Ameer (2013) indicates that inflation leads to increase the provisional sums at least by 10%. Projects with fixed budget would choose lump-sum contacts to achieve the required cost certainty. However, if major parts of these contracts are made up of provisional sums, the actual cost for executing the provisional sums might be more than the estimated and included in the lump-sum. Engineers tend to include part of project scope as provisional sums either to satisfy their employers by enabling early project construction or to collect their design fees earlier than scheduled in their consultancy contracts. According to Ameer (2013), this leads to increase the overall contract value by 5%. Though this is acceptable to some employers as early completion would guarantee them early collection of the profit to compensate such loss, many, incur a loss.

Inadequate definition of provisional sums and the poor coordination of their scope with the main contractor’s scope may cause variations and claims from the main contractor. Inaccurate estimation and cost uncertainty of provisional sums lead to adversarial relationship between the client and contractor creating conflicts, disputes and legal proceedings. Such conflicts are related to the subcontractor nomination and signing contracts between main contractor and sub-contractors, not providing the required workmen and not coordinating with main contractors to overlap the work activities by the sub-contractors (Akintan and Morledge, 2013). In addition to the conflicts between the employer, contractor and subcontractors, use of provisional sums also leads to conflicts between employer and engineer. For example, when the engineer causes a delay in issuing the required information or instruction to the main contractor to execute the provisional sum works or delays the nominating of the subcontractors, engineer usually grants an extension of time to the contractor. This avoids deducting the associated liquidate damages from the contractor and benefiting the engineer from the additional supervision fees related to this extension. Thus, the employer incurs a loss on supervision fees and forgoing delay penalties. FIDIC (2000) emphasizes that the provisional sums can be used in whole or part but cannot exceed their value nor can the engineer or the employer add new ones. As Robinson (2013), indicates, enforcing such increase also leads to conflict between contracting parties.

As the expenditure of provisional sums controlled by the engineer’s instructions to the contractor, they are often not included or not properly accounted in the program. This creates difficulties to the contractor to justify any delay in the construction or a claim for extension of time. When the provisional sums are executed by the nominated subcontractors, the complexity of the nomination procedure also causes project delays. Skaik and Al-Hajj (2013), comments that the greater the percentage of the nominated packages, the greater the impact on the project program.

Since the provisional sums are often not detailed enough or estimated accurately at the time of the tendering (Ogunsemi, 2007; Olusegun, 2010), once the construction contract is signed, the engineer finalizes the design of the works related to the provisional sums under pressure of any claim from the main contractor on delay of issuing the expenditure instruction of provisional sums. In this context, the engineer may not be able to ensure the proper technical coordination between the different technical packages (Skaik and Al-Hajj, 2013), or may choose to trim the scope or the design of the provisional sums not to exceed their inaccurate estimated value, reducing the quality of the works.

The risk associated with the increase or decrease of the project value can be absorbed by the contracting parties when the provisional sums form a limited percentage of the contract. When the provisional sums form a considerable percentage of the contact value the risk can also be higher (Chan and Yeong, 1995). Olusegun (2010) confirmed that the more provisional sums are included in the contract, the less precise and realistic the initial contract sums will be if compared to the final cost. Accuracy of the provisional sums can be increased through adequate detailed drawings used in estimating the provisional sums (Olusegun, 2010). This conflicts with the time and stage at which they are prepared.

3. FIDIC Red Book and Provisional Sums

Both versions of FIDIC (1987); FIDIC (1999) provide two options for provisional sums execution: requesting the contractor to undertake the works or through a nominated subcontractor. When provisional sums are executed by the contractor, both versions of FIDIC Red Book refer to the variation clause, obligating the contracting parties to evaluate the cost of this item as a variation. When provisional sums are executed by a nominated subcontractor, selected by the employer, both versions refer to the nominated subcontractors clause obligating the contracting parties to evaluate the actual amount to be paid to the nominated subcontractor while the overhead and profit to be paid to the main contractor. One of the main advantages of executing provisional sums by nominated subcontractors' is that it provides better control over the time, cost and quality (Murdoch and Hughes, 2000). Skaik and Al-Hajj (2013) confirmed that the subcontracting not only satisfy the employer, but also the contractor by improving the efficiency of construction program through releasing him from the procurement of such works.

4. Research Methodology

Followed by a literature review on provisional sums and the use of provisional sums in the context of FIDIC Redbook in the UAE, a questionnaire survey was developed to identify the relative importance of the factors identified through the literature. Comprised questions were related to the respondents' profile, use of provisional sums in FIDIC Redbook, purpose of provisional sums, risks of provisional sums and strategies to minimize the risks. The questionnaire survey was administered among 150 construction professionals in the UAE. Professionals are purposively selected based on their knowledge and experience on subject area. Out of 150 questionnaires distributed, 72 responses were received. Of these, 10 responses were excluded due to the inadequate knowledge and experience in the subject area. From the remaining 62, 7 were incomplete and excluded from the analysis. Thus, 55 questionnaires were finally analyzed representing 36.67% response rate. Table 1 presents the profile of the survey respondents, which represented developers, consultants, contractors, sub-contractors and project managers. Of the respondents 83% had more than 5 years of experience and majority of the respondents held senior or manager positions.

Table 1: Profile of the Survey Respondents

Discipline	**Developer**	**Consultant**	**Contractor**	**Sub-contractor**	**Project Manager**	**Other**
	15%	33.33%	23.33%	15%	10%	3.33%
Years of experience	0-5	6-10	11-15	16-20	More than 20	-
	16.67%	31.67%	33.33%	10%	8.33%	-
Current position	Junior	Senior	Manager	Senior Manager	Director	-
	10%	35%	31.67%	15%	8.33%	-

Followed by the questionnaire survey, semi-structured interviews were conducted with 6 experts to validate the questionnaire survey findings and to derive explanations. the interviews were conducted in November 2014. As presented in Table 2, the experts were managers and directors who had 12 - 25 years of relevant experience. Interviews last for 45 - 90 minutes and all the interviews are digitally voice recorded upon the consent of the interviewees. Interview guideline comprised questions related to the interviewees' profile, use of provisional sums in FIDIC Red Book, purpose of provisional sums, risks of provisional sums and strategies to minimize the risks.

Table 2: Profile of the Interview Respondents

	Interviewee 1	**Interviewee 2**	**Interviewee 3**	**Interviewee 4**	**Interviewee 5**	**Interviewee 6**
Position	Contracts Manager	Director	Senior Manager	Contracts Engineer	Manager	Manager
Experience	22 years	25 years	14 years	21 years	20 years	12 years

5. QUESTIONNAIRE SURVEY DATA ANALYSIS AND RESULTS

Relative importance and purpose of using provisional sums, risks and strategies to minimize the risks were identified based on the Likert scale questions with a five point scale ranging from 'strongly disagree', 'disagree', 'neither disagree nor agree', 'agree' and 'strongly disagree'. Factors are ranked using the mean and the questionnaire leads to the following findings.

5.1. USE OF PROVISIONAL SUMS IN FIDIC RED BOOK

Before the specific questions on the use of provisional sums in FIDIC Red Book, some questions were asked to verify the mostly used standard form of contract in the UAE and their knowledge on it. Survey respondents' data revealed that FIDIC standard forms of contract were the most used forms of contracts and significant percentage of the respondents has a good knowledge on them (see Figures 1 and 2). This is in accordance with Kerr *et al*. (2013), who indicate that FIDIC forms of contract is considered as the most used forms internationally and in the UAE.

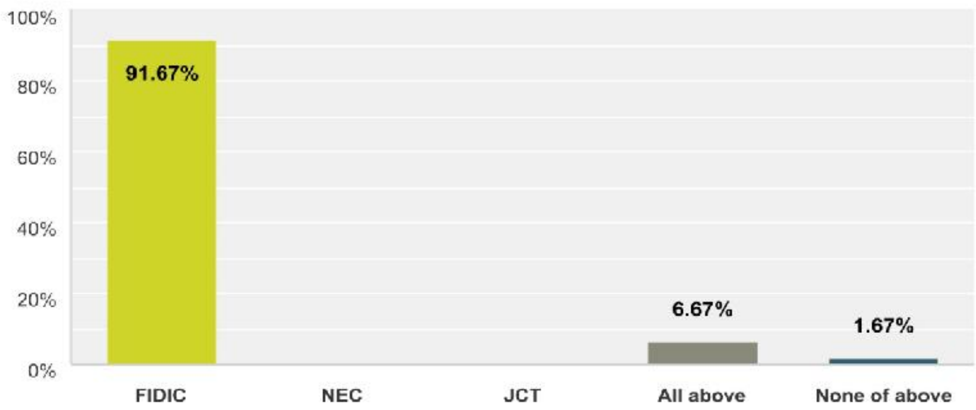

Figure 1: Use of Standard Forms of Contract

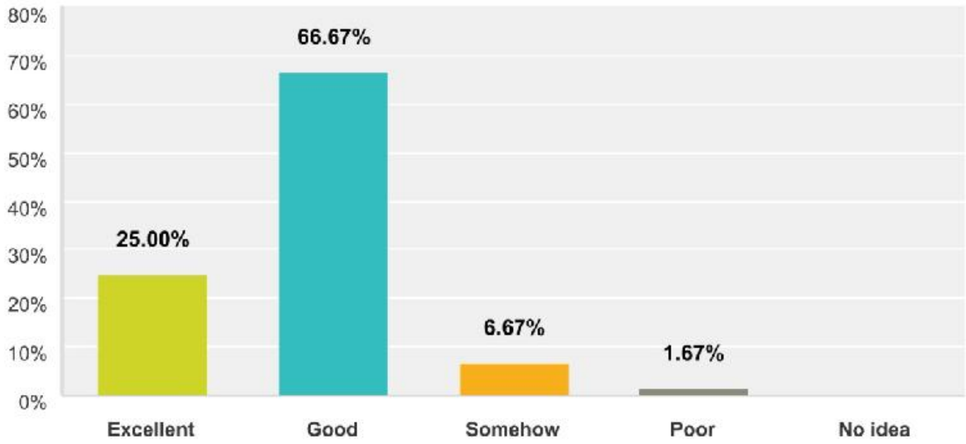

Figure 2: Respondents' Knowledge on FIDIC Forms of Contract

Among the FIDIC standard forms of contracts, over 90% of the respondents use FIDIC Red Book (see Figure 3) and half of them use its 1987 fourth edition while the other half use the 1999 edition. This ensures the reliability of the survey responses.

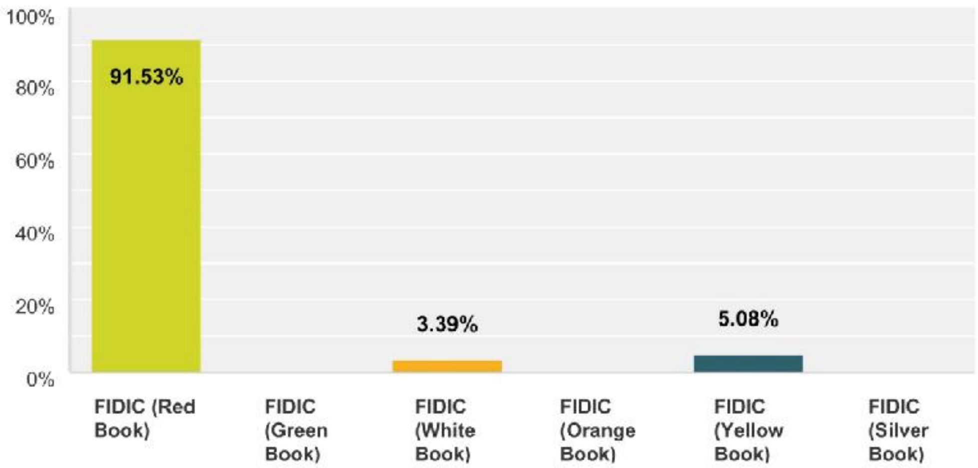

Figure 3: Use of FIDIC Red Book

Survey respondents indicated that the provisional sums are used in many contracts based on FIDIC Redbook. As shown in Figure 4, 72% agreed that 80%-100% of contracts use provisional sums while over 95% agreed that 60% - 80% of contracts use provisional sums. In comparing the value of provisional sums over the contract value, 34.55% of respondents suggested a 40% - 50% value of provisional sums (see Figure 5). Over 70% suggested that the value of provisional sums is more than 30% of the contract value. Furthermore, over 96% of respondents confirmed that the employers use provisional sums to include main components such as MEP works, aluminum and glazing, lifts etc. Though the majority of interview respondents indicated that the FIDIC Redbook is not clear on whether the employer has the right to increase the value of existing provisional sums or to add new sums, over 80% of the survey respondents indicated that the employer has the right to increase the value of provisional sums while about 60% of them indicated that the employer has the right to add new provisional sums. These findings however, justify the significance of evaluating the extensive use of provisional sums in contracts.

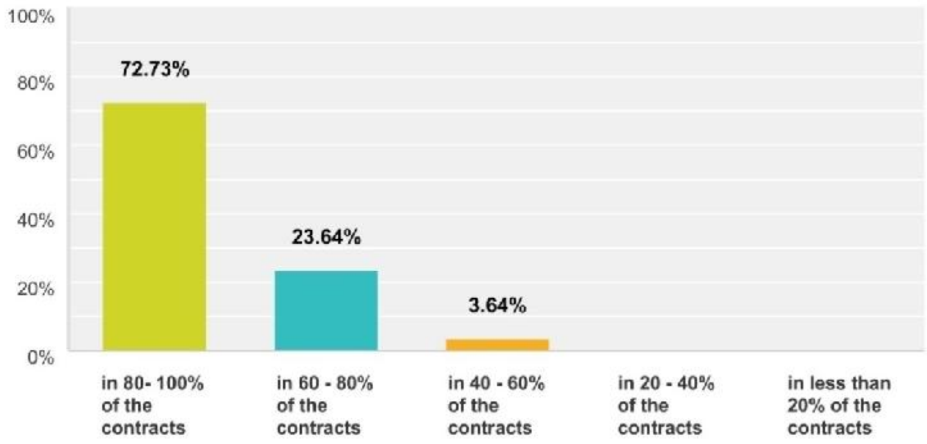

Figure 4: Use of Provisional Sums in Contracts Based on FIDIC Redbook

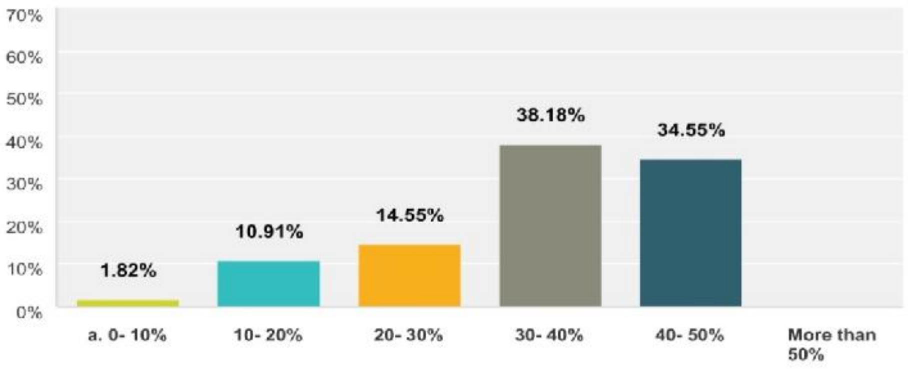

Figure 5: Value of Provisional Sums Used as a Percentage to the Contract Value

Regarding the clarity of FIDIC Redbook clauses in dealing with provisional sums, 60% of the survey respondents indicated that it is clear. In responding to the clarity of FIDIC Redbook on the responsibilities and obligations of contracting parties with regard to the provisional sums 50% of respondents agreed that it is clear while 41% stated otherwise.

5.2. PURPOSE OF USING PROVISIONAL SUMS

As presented in Table 3, inclusion of un-traditional packages such as supply of materials, goods, plant and services in the main contract, facilitating the nomination and appointment of sub-contractors, inclusion of works under design at the time of tendering, inclusion of the works of which the scope can be defined during the construction and expedite tendering and commencement of construction were the main reasons for using provisional sums. Least chosen reasons by the respondents were the reasons related to the budget control and contingency. While the literature (Emmitt and Yeomans, 2008) identifies the main use of provisional sums as to cover the cost of a work of which there is no enough details available at the tender stage to calculate its cost accurately, to cover the cost of work under design and to cover the cost of specialist sub-contractor works, research reveals more uses. Nominating and appointing sub-contractors are to enhance the quality of works while the inclusion of works under design at the time of tendering, inclusion of works that the scope can be defined during the construction are intended to shorten the project duration. A common practice in the UAE is to overlap the design and construction as much as possible to allow early construction and save time. This forces the consultant to rush the preparation of tender documents and identification of incomplete design packages as provisional sums so that the tendering can start. This practice not only save time in the design development process but also the tendering as the bidders are required only to include their attendance rates for these sums without reviewing their details, calculating the quantities or providing detailed pricing for them. This is followed by the project cost control.

Table 3: Survey Respondents' Perceptions of the Relative Importance of Purpose of Using Provisional Sums

Purpose	Mean	Rank
To include un-traditional packages such as supply materials, goods, plant and services in the main contract	4.27	1
To facilitate the nomination and appointment of sub-contractors	4.22	2
To include some works in the tender, which are under design or of which the cost is not known at the time of tendering	4.20	3
To include some works in the tender, of which the scope can be defined during construction	4.13	4
To expedite the tendering and construction commencement	4.07	5
To have a contingency sum	2.93	6
To control the project budget	2.84	7

5.3. RISKS OF PROVISIONAL SUMS

More than 80% of the survey respondents agreed that provisional sums add risks to the construction contracts. Meanwhile, 80% of the respondents agreed that the Employer caries the risk of provisional sums in relation to the delay of expenditure of the provisional sums and the cost increase resulted by inaccurate estimation or market inflation. 20% agreed the contractor caries the risk and this suggests that the parties share some risks related to the project.

Survey response data analysis produced mean importance values for the risks ranging from 3.93 to 2.65 as presented in Table 5. Risk of claims, variations and conflicts among the parties ranked first in the survey analysis (mean value 3.93), which is shared among all contract parties. The second ranked risk is the added cost uncertainty to the contract (mean value 3.80) and drive for scope conflicts and coordination issues is ranked as the third important risk in using provisional sums (mean value 3.65). Uncertainty added to the scope and contract are also identified as a main risks of provisional sums in the literature (Ashworth *et al*., 2013). As most of provisional sums are not fully detailed during the tendering stage or even after signing the construction contract, once the detailed designs for these sums are available there will be a need for some coordination between the main contractor and consultant in adopting the scope of the provisional sums into the ongoing construction works with minimum variations to the main contract. Coordination would be more complicated when provisional sums are subcontracted to a larger number of parties with totally different priorities and interests. Increased final contract sum (mean value 3.56) and expose the contract to the market inflation (mean value 3.47) are also a risk of using provisional sums. These factors together with added cost uncertainty to the contract assert the need to develop recommendations in dealing with Provisional Sums in the FIDIC Red Book to ensure good cost control of these sums. Second lowest risk of using provisional sums is delaying the construction and project completion (mean value 3.22). Reduce the quality of works (mean value 2.65) ranked the lowest. This indicates that the respondents perceive that the provisional sums enhance the value and quality of the project.

Table 4: Perceptions of the Relative Importance of Provisional Sum Risk Factors

Risks of provisional sums	Mean	Rank
Drive for claims, variations and conflicts among contracting parties	3.93	1
Added cost uncertainty to the contract	3.80	2
Drive for scope conflicts and coordination issues	3.65	3
Increase the final contract sum	3.56	4
Expose the contract to the market inflation	3.47	5
Delay construction and project completion	3.22	6
Reduce the quality of works	2.65	7

5.4. STRATEGIES TO MINIMIZE THE RISK OF PROVISIONAL SUMS

Nine strategies identified through the literature review were presented to the respondents to identify the relative importance of them. Defining the scope of provisional sums before tendering ranked first in the survey analysis (mean value 4.27). This complies with the FIDIC (2000), which indicates to avoid the use of undefined provisional sums as it increases the risk of inaccurate estimates, scope conflicts and variations. Incorporating the provisional sums into the project programme ranked second (mean value 3.98) as this avoids the project delay by controlling their scope delivery, expenditure instructions, subcontractor nominations and execution. Limiting the value (mean value .93) as a strategy minimizes the associated uncertainties. As respondents identified, training and education of the staff also help to limit the risks (mean value 3.87). A list of approved subcontractors (mean value 3.82) would allow the main contractor to choose a suitable sub-contractor in executing the works collaboratively and allowing the bidders to price the provisional sums would verify the accuracy of estimates and provide more control in executing these sums either by themselves or through subcontractors. Followed by this was avoiding provisional sums for main components of the projects. The least scored strategies are reducing the number of provisional sums and adding particular conditions. Similarly, Okuwoga (1998), suggests that cost overruns resulted by provisional sums could be reduced through better pre-contract documentation.

Table 5: Perceptions of the Relative Importance of Strategies to Minimize the Risk of Provisional Sums

Strategies	Mean	Rank
Tendering only once the scope of the provisional sums are defined	4.27	1
Incorporating the provisional sums into the project programme	3.98	2
Limit the value of provisional sums in the contract	3.93	3
Training and education of the staff on dealing provisional sums	3.87	4
Introduce list of sub-contractors to execute provisional sums	3.82	5
Allow the bidders to price provisional sums	3.69	6
Avoid the inclusion of main components of the projects as provisional sums	3.67	7
Reduce the number of provisional sums	3.40	8
Improve provisional sum clauses on obligations and responsibilities of parties through particular conditions	3.40	8

To explore the recommended range of percentage of provisional sums by the respondents, they were asked to choose a range and as illustrated in Figure 6, 10-20% was the most recommended range followed by the 0-10% and 20-30%.

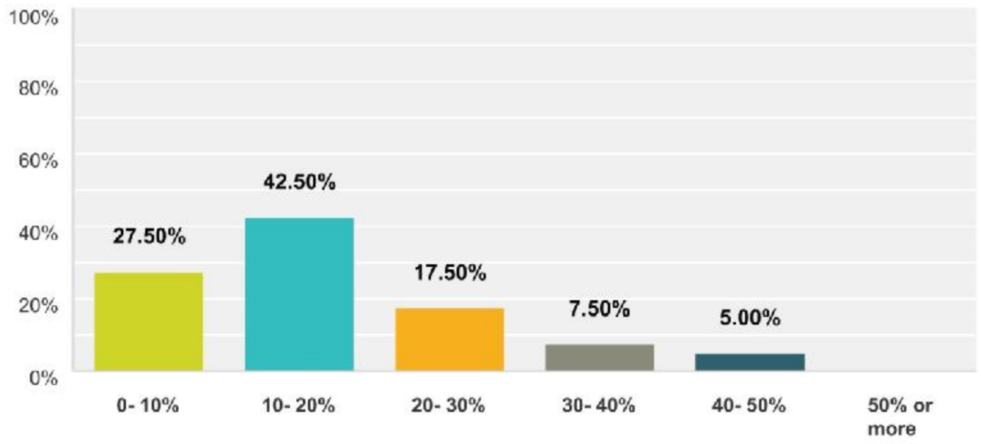

Figure 6: Respondents' Recommended Range of Percentage of Provisional Sums

6. INTERVIEW DATA ANALYSIS AND RESULTS

Interview data was analyzed through content analysis and following presents a summary of the findings. Interviewees agreed that the provisional sums are used in 70 – 90% of FIDIC Redbook based contracts and the average value of provisional sums is around 40 – 50% of contract value. They indicated that provisional sums are used in specialist works such as MEP, aluminum and glazing, lifts etc. Interviewees generally viewed that the FIDIC Redbook clauses are clear on dealing with provisional sums. Majority of them suggested the clauses related to increasing the value of provisional sums, payments and programme need enhancement though some were in the view that the form of contract allows increasing or decreasing the value of provisional sums.

As perceived by the interviewees, provisional sums overcome the tightness of lump-sum contracts based on the FIDIC Redbook and provide flexibility in dealing with variations. This was considered as significant when there are changes to the original scope. Interviewees were in the view that provisional sums are mainly used for incomplete designs intended to be completed by specialist sub-contractors during construction. They also agreed that the inclusion of provisional sums enables time saving through integrating design and construction. Another benefit highlighted by the interviewees is achieving better quality through nominated sub-contractors and suppliers.

Interviewees admitted that provisional sums are not detailed sufficiently by the consultants and not studied by the tenderers leaving them to finalize during construction. This mainly led to cost issues and contractual complications, which affected the timely completion of projects. Some un-defined provisional sums were sub-contracted as design and built agreements, in particular for specialist works such as lifts and escalators. Undefined provisional sums however, added more risk to the contract. Inaccurate estimation of provisional sums is another issue, which leads to inflation and quality issues etc. Though some companies estimated the provisional sums based on similar past projects and make necessary adjustments, this was not the practice in most of the companies. Lack of experience of the staff also led to poor estimates. Provisional sums also created scope conflicts and coordination issues between the main contractor and sub-contractors.

Interviewees highlighted that the value of provisional sums must be lower than 20% of the contract value to minimize the risks and the scope must be defined before tendering. Agreeing a list of sub-contractors with the main contractor also helps to minimize the scope conflicts. They also suggested the possibility of enhancing the clarity of the standard clauses through particular conditions.

7. CONCLUSIONS

Provisional sums are used in the FIDIC (Red Book) forms of contract in the UAE mainly for un-traditional packages, special works, contingencies and the works which can be only defined in the site. They are also used to facilitate the appointment of nominated subcontractors, overlap design and construction in the fast-track projects, expedite tendering and construction commencement and controlling the quality, cost or scope of some packages due to certain requirements by the employer.

In general, inclusion of provisional sums save time through expediting construction commencement, give flexibility to the employer to subcontract some packages to meet certain requirements in the quality or scope, enhance the cost control of the project if they are used as contingencies to mitigate some risks in the project. Provisional sums also help save cost mainly in the cases of untraditional packages as the main contractors tend to overprice these packages, reduce the claims, variations and conflicts in some cases specially if the main contractor has no interest to handle some untraditional or complicated packages. Similarly, the risks depend on the nature of the project and use. The most common risks of using provisional sums in the FIDIC (Red Book) forms of contract in the UAE are related to claims, variations and conflicts among the contracting parties. Besides there are risks related to the cost uncertainty, the projects delay and in some cases the poor quality due to scope conflicts, management and coordination issues. Defining the scope of provisional sums before tendering, incorporating the provisional sums into the project programme and limiting the value of provisional sums in the contract are suggested as the key measures to minimize the risk of provisional measures. The maximum percentage recommended by the majority of survey and interview respondents was 20%. Some recommendations in using provisional sums in the FIDIC (Red Book) forms of contract are included in Appendix A.

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APPENDIX A: RECOMMENDATIONS IN USING PROVISIONAL SUMS IN THE FIDIC (RED BOOK) FORMS OF CONTRACT

- Limit the maximum value of provisional sums in the construction contracts to maximum 20% of the initial main contracts value.
- Avoid the use of provisional sums for the main components of the project as much as possible.
- Estimate the value of provisional sums as accurately as possible during the tender stage.
- Include only the defined provisional sums in the tender documents to avoid scope conflicts and incorporate the provisional sums in the main contractor program to ensure proper accounting for their related works.
- To request the bidders to include their attendance rate for each provisional sum in the BOQs to avoid the contractual complications.
- To agree with the bidder a list of approved subcontractors who may undertake the execution of provisional sums.
- To train the staff on contractual framework of dealing with provisional sums and raise the awareness about the best use, benefits and risks of these sums.
- Clarify the terms and conditions in the case of increase of contract value due to value adjustment of the provisional sums and increase of a provisional sum value.
- Clarify the obligations and responsibilities of the contracting parties toward the inclusion of provisional sum items in the project program.
- Establish a link between granting the project building permit and the satisfactory design completion of all main project components to reduce the misuse of provisional sums and avoid the scope conflicts.
- Develop and maintain a national construction cost database to enhance construction cost estimate in the UAE.

USING SAFETY CLIMATE AS A TOOL FOR IMPROVEMENT OF SAFETY PERFORMANCE IN CONSTRUCTION ORGANIZATIONS

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ABSTRACT

Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries, and in Oman it accounts for approximately 10% of the total GDP. Statistics indicate that a total of 723,243 residents including 91% foreigners were working in 100,000 construction organizations in 2014 and was having second larger rate of occupational injuries after manufacturing industry with an estimated cost of 3,700,000 US$ per year. Construction workers are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, and therefore more closer to occupational accidents. In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate is an aspect of organizational climate, and offers a route for safety management, complementing the often predominant engineering approach. Safety climate investigations are more sensitive and proactive bases for developing safety, rather than reactive information from accident rates and accident and incident reports. Based on a thorough literature review, relevant safety climate dimensions including (1) management safety priority, commitment and competence; (2) management safety empowerment; (3) management safety justice; (4) workers' safety commitment; (5) workers' safety priority and risk non-acceptance; (6) safety communication, learning, and trust in co-workers' safety competence; and (7) workers' trust in the efficacy of safety systems, are identified and discussed. This paper further describes how construction organizations in Oman can improve their safety performance by using and assessing leading safety climate dimensions/ factors among their workers.

***Keywords**: Construction Safety, Safety Climate Dimensions, Safety Performance, Construction Organisations, UAE.*

1. INTRODUCTION

Statistics published by the International Labor Organization (2015) indicate that at least 108,000 workers are killed on construction sites every year, a figure which represents about 30% of all occupational fatal injuries. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work. In the developing world, the risks associated with construction work may be 3 to 6 times greater. Many more workers suffer and die from occupational diseases arising from past exposure to dangerous substances, such as asbestos. Construction is one of the world's biggest industrial sectors, including the building, civil engineering, demolition and maintenance industries. It accounts for a large proportion of GDP for many countries for example, 10 percent in the UK, 17% in Japan, and 10% in Oman. Statistics published in the daily Times of Oman dated June 09, 2014, a total of 723,243.00 residents were working in the construction industry. In most developing countries, construction is among the fastest growing areas of the labor market, continuing to provide a traditional entry point for labourers. It is, however, one of the most dangerous industries. Construction workers build, repair, maintain, renovate and demolish houses, office buildings,

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factories, hospitals, roads, bridges, tunnels, stadiums, docks, airports and more. During the course of their work they are exposed to a wide variety of hazards on the job, including dusts and vapours, asbestos, awkward working positions, heavy loads, adverse weather conditions, work at heights, noise, vibration from tools, among many others. The causes of accidents and ill-health in the sector are well known and almost all are preventable. A report published in daily Times of Oman dated February 28, 2015 states that there is no official statistics of how many company workers get hurt in the course of their duties but according to the individual Health and Safety Environment's (HSE) records of top 10 contractors, more than 3,700 of them needed medical treatment in 2014. The injured workers who get hospitalized made up nearly 10% of the total workers on this list. Sadly, about 18 per cent of them died either at the sites or in hospitals in 2015. In comparison to the previous year, 246 more workers got injured in 2014 but for obvious reason, company directors do not want this part of the record to be made public. The Public Authority of Social Insurance (2014) which registered only Omani nationals' reports shows that 401 cases of work related injuries were disbursed which cost a total amount of 406,000 OMR (105,1540 US$). The number of active insurees in the Social Insurance System was 197,510 in 2014; which gives a ratio of number of insurees and injuries cost as 1:0.49. If this is applied to the total workers working in the construction industry of Oman to get an idea of the cost involved in construction safety, gives a figure of 1,428,571 OMR (3,700,000 US$) per year. In construction organizations most of the workers are foreigners (92% of total work force) and as such they are not insured under the government authority. As per law of the country, construction organizations required to seek private insurance for their workers, however as the risk associated with construction workers is high their insurance premium is comparatively more. Construction organizations further bear high cost at the time of recruitment and pay for repatriation, compensation and replacement in case of accidents involving injuries and death. There is high potential for construction organizations to reduce the cost associated with accidents by improving safety culture through safety climate.

In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, have increased. Safety climate is a subset of organizational climate, and offers a route for safety management, complementing the often predominant engineering approach. An understanding of the safety climate dimensions can be useful in improving the safety performance of an organization. In addition, safety climate investigations are more sensitive (e.g. multi-faceted) and proactive bases for developing safety, rather than reactive (after the fact) information from accident rates and accident and incident reports (Seo *et al*., 2004). Over the past century focus concerning factors influencing safety and safety improvements within industries has changed and expanded. Hale and Hovden (1998) describe three ages of safety: the technical age (1920's), the human factor age (1970's) and the management system age (1980's). The third wave or age of safety expanded the focus to include safety culture, and the concept of safety culture was first truly introduced and defined after the Chernobyl accident in 1986 (INSAG, 1992). Safety culture and safety climate are concepts that today attract much attention across a broad number of industries and sectors (Clarke, 2000). One of the reasons for this is that a rich safety culture and a mature safety climate are some of the most important factors in achieving a safe workplace. In order to improve the level of safety culture and safety climate it is important to: a) determine the current level of safety culture and safety climate, b) decide what level of safety culture and safety climate is needed, attainable and wanted, and c) to create a plan to achieve the safety culture and safety climate that is wanted (AICHE, 2012). Safety climate may be defined as shared perceptions among the members of a social unit, of policies, procedures and practices related to safety in the organization. Researchers and practitioners have identified safety culture and safety climate as key to reducing injuries, illnesses and fatalities on construction worksites. Many construction contractors are trying to improve these indicators as a way to move closer to a goal of achieving zero injury worksites. This paper presents the initial research of how different safety climate could be used by construction organizations to improve their safety performance.

2. DEFINING SAFETY CLIMATE

Although there are several definitions suggested by different researchers from different thought and background, however recently in a workshop on ''safety culture and climate: bridging the gap between research and practice, held in Washington DC on 11-12 June 2013; Organizers distributed a handout containing 10 safety climate definitions obtained from both the peer-reviewed academic literature and from interviews recently conducted with contractors and safety practitioners. Seventy-two invited construction stakeholders representing the following constituency groups participated in the construction track (table No.1). Workgroups reviewed and discussed each definition and were asked to select one for safety climate and one for safety culture that they thought was most relevant for construction. Table No.2 shows the reported favourite definitions of safety climate from the workgroup.

Table 1: Composition of Participants of Workshop from Different Construction Stakeholders

Contractors	25 %
Employer Associations	12 %
Labor Organizations	14 %
Researchers/Academics	40 %
Consultants	6 %
Insurance Companies	4 %

Table 2: Top Most Favorite Definitions of Safety Climate from Different Construction Stakeholders

Safety climate is a leading indicator. It reflects how well the espoused safety program is ultimately integrated into the organization to support safe effective practices at the point of operation.	33 %
Safety climate reflects shared perceptions of the relative priority of safety compared to other competing organizational priorities.	23 %
The safety climate is the environment in which a company puts its safety culture to work. Like providing the tools and equipment necessary, maybe the resources on our job sites to create that environment in which people are allowed to work safely.	19 %
Safety climate is the shared perceptions of organizational members about their work environment and, more precisely, about their organizational safety policies.	16 %
Safety climate is a subset of organizational climate that measures through members' perceptions the degree of congruence between an organization's espoused values and policies and enacted practices.	9 %

3. Safety Climate Dimensions/Factors

Based on theory and empirical results from different sources, it is mandatory to consider different dimensions of safety climate based on the perceptions of conditions contributing to individual motivation, as well as conditions influential to relational aspects of occupational safety. From the literature review, the leading safety climate dimensions are: Management safety priority and commitment to safety; Workgroup safety priority and commitment; Learning, communication and innovativeness; Management safety justice; Trust in management; Trust in co-worker safety competence; Trust in the general efficacy of safety systems; and Safety empowerment.

3.1. Management Safety Priority and Commitment to Safety

As the organizational priorities are largely communicated through the managers, manager behavior would be a main source of information. If managers are perceived to be committed to safety and to prioritize safety in relation to other goals, safe behavior would be expected to be rewarded, and thereby reinforced. From this it may be inferred that safety climate informs the individual on how to behave in order to maximize individual benefit. In this respect, it may be viewed to represent an individualistic perspective.

Top management involvement in safety, and the priority of safety matters, were two of the themes identified by Zohar (1980) in the literature review undertaken to define the first safety climate scale. Brown and Holmes (1986) tested the safety climate questionnaire developed by Zohar (1980), and identified management concerns for employee well-being, and management activity in responding to this concern as two of three factors. Perceptions of management safety commitment and priority have been found to be the most commonly assessed themes in safety climate research (Flin *et al*., 2000). As a design criterion for the safety climate questionnaire that it should assess management safety priority as well as management commitment to safety.

3.2. WORKGROUP SAFETY PRIORITY AND COMMITMENT

Since being in equilibrium with the social environment contributes to a sense of security and reduces stress, shared perceptions of safety being valued and expected in the organization would also contribute to the development of workgroup norms favoring safety. Such norms would cue individual safety behavior, since individuals may expect safe behavior to be socially rewarded by the group. Clarke (2006), in discussing the results of her meta-analysis of 19 safety climate studies, suggested that individuals feel more committed to the workgroup than to the organization, and hence that the workgroup is most powerful in the socialization of new members. Clarke suggested perceptions of workgroup norms to be highly decisive for group safety climate. The results of Dedobbeleer and Beland (1991) indicated that safety climate measures should cover conditions regarding management as well as the workgroup. Andriessen (1978) found Safety motivation to be strongly determined by leadership and safety standards of the leader, but also by group standards and group cohesion. Results by Watson *et al*. (2005) showed that an index of co-worker safety norms was negatively correlated with at risk behavior. Tucker *et al.* (2008) found that the effect of perceived organizational support for safety, on employee safety voice, i.e. the degree to which employees speak out in an attempt to change unsafe workplace conditions, was mediated through perceived co-worker support for safety. Support for specifying safety climate dimensions regarding not only managerial policies, procedures and practices, but also workgroup ditto, has also been presented by Melia *et al.* (2008). Seo *et al*. (2004), in their scrutiny of 16 safety climate scales, identified perceptions of co-worker safety support as one of five major dimensions of safety climate covered in previous research. As a design criterion for the assessment that it should evaluate safety climate dimensions regarding both, but separately, management and workgroup policies, procedures, and practice. Safety priority and safety commitment should be assessed regarding both these levels. Norms of risk acceptance may play a negative role in relation to safety priority, and have been claimed to counteract active safety work (Murray and Dolomount, 1994; Pollnac and Poggie, 1989; Torner et al., 2000). Therefore the safety climate Questionnaire must have an assessment of workgroup risk acceptance.

3.3. LEARNING, COMMUNICATION AND INNOVATIVENESS

Communication and social interaction are necessary means for the creation of social constructs such as organizational climate. Hofmann and Stetzer (1998) suggested that management encouraging open communication on safety, sends a strong signal on how safety is valued. Jeffcott *et al*. (2006) stressed the importance of learning for a positive safety culture, i.e. continuously gathering, analyzing and disseminating information in an environment valuing expertise and being based on trust, where operators can identify and are willing to report abnormal events and errors. Communication is thus not merely an exchange of information, but also a prerequisite for learning and for new, innovative ideas to emerge. Open and frequent communication between management and employees was one of the important safety themes identified by Zohar (1980) in his literature review. Perceived management openness, including a willingness to share ideas and information freely and accurately, is often put forth as an aspect or facet of management quality necessary for the development of trust in management (Clark and Payne 1997), a dimension of safety climate discussed further below. Communication should, to be effective, take place not only as an interaction between management and employees but also between employees. As a design criterion for the questionnaire that safety related communication (open and rich), learning, and innovativeness should be assessed.

3.4. MANAGEMENT SAFETY JUSTICE

Organizational citizenship behavior (OCB) has been defined as "individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate promotes the effective functioning of the organization" (Organ 1997). Actively taking responsibility for the safety of oneself and others and engaging in safety activities, could well be regarded as an expression of OCB. Organ (1997) suggested the antecedents of OCB to be "dispositions related to conscientiousness" and "any dispositions that can be confidently and empirically tied to a characteristic level of morale in the workplace" (p. 94). Fassina *et al*. (2008) based on a meta-analysis of 34 studies on the relationship between distributive, interactional and procedural justice on one hand, and OCB on the other, stated that all three justice dimensions correlated with OCB, but that the correlations with interactional (fair treatment by superiors) and procedural justice (fair procedures) were the strongest. It could thus be argued that employee safety responsibility and safety behavior would be positively influenced by management procedural and interactional safety justice, i.e. just treatment and procedures when handling accidents and near-accidents. As a questionnaire design criterion that perceptions of management interactional and procedural justice in regards to safety should be included.

3.5 . TRUST IN MANAGEMENT

The theory of social exchange (Blau 1986) further emphasizes the relational component of safety climate. According to this theory, behavior from one party benefitting a second party creates a mutual expectation that this will be reciprocated at some future time by the second party performing behavior that benefits the initiator. Another theoretical concept of relevance here is that of Perceived Organizational Support (POS) (Eisenberger *et al*. 1986). POS is based on the assumption that "employees in an organization form global beliefs concerning the extent to which the organization values their contributions and cares about their well-being" (Eisenberger *et al*. 1986), and that such beliefs would increase the employees' affective attachment to the organization. As this demonstrates caring for workers' health, it may be assumed that POS would also have a positive effect on safety climate which there is empirical support for. POS and high-quality leader member relations have been shown to have an impact on workers' safety commitment and safety communication (Hofmann and Morgeson 1999), on safety climate (Wallace *et al*. 2006) as well as on lower accident rates (Hofmann and Morgeson 1999; Wallace *et al*. 2006). Mayer *et al*. (1995) stated that trust encompasses a willingness to take a risk in a relationship, and to be vulnerable to the other party. Cox *et al. (*2006) discussing trust in high reliability organizations, concluded that low trust relations can have negative impacts on an effective safety culture. Zacharatos *et al*. (2005) found trust in management, and safety climate to predict safety knowledge, safety motivation and safety behavior, as well as a lower rate of safety incidents. Burns *et al*. (2006) suggested that trust and distrust may be viewed as different constructs, both of which may have a positive impact on safety. It was concluded as a design criterion that the questionnaire should assess the employees' trust in management, and trust in management competence was chosen to represent it. However, the complex nature of trust in relation to safety, further stresses the importance of simultaneously measuring safety communication.

3.6 . TRUST IN CO-WORKER SAFETY COMPETENCE

The workforce's perceptions of the general standard of workers' qualifications, skills and knowledge, was one of the six most common themes in safety climate research found by Flin *et al*. (2000). Co-worker safety competence was also one of the five dimensions of safety climate identified by Seo *et al*. (2004). As stated above, perception of competence is often suggested as one of the dimensions of trust. The complexity of trust should, however, be kept in mind. As Conchie and Donald (2008) pointed out, if there is blind trust in co-workers, double checking of safety critical tasks may be overlooked, and mistakes may pass undetected. The questionnaire should be designed to contain items assessing perceptions of trust in co-worker competence, but once again, the importance of open and rich communication, participation and empowerment, in order to counteract the development of blind trust, should be emphasized.

3.7. TRUST IN THE GENERAL EFFICACY OF SAFETY SYSTEMS

The importance of well-functioning safety systems was confirmed in an interview study with first-line supervisors and worker safety representatives in construction work (Torner and Pousette 2009). It should be emphasized that safety climate is a social construct, and a climate measure of perceptions of safety systems should not be an "audit" on how such systems are implemented in the workplace under study (Hale 2000), but rather aim at capturing perceptions of the efficacy for attaining a high standard of safety of a systematic approach to safety through well-developed safety management systems. Pidgeon (1998) expanded on this and stated that organizational culture plays an important role for how we structure our understanding of the world, and these understandings help us to acknowledge certain safety issues. At the same time they may turn our attention away from other equally important issues, so that hazards may "incubate" in the organization. In addition, trying to anticipate all possible risks, and trying to prevent them through elaborate safety management systems, may lead to rigid responses rather than resilience when non-anticipated events occur (Conchie *et al.* 2006; Pidgeon 1998). This once again points to the importance of learning (e.g. Pidgeon and O'Leary 2000) and open and rich communication in the organization. Hale (2000) advocated a creative mistrust in the risk control systems, as one of the dimensions of a good safety culture. He stated that believing that you have the ideal safety culture should be a warning that you don't, and instead it is sound to constantly question the quality of the safety culture. Hale stressed the importance of open communication and reflexivity. As a design criterion for the safety climate questionnaire that it should assess perceptions of the efficacy of safety systems, but that this should be assessed together with other aspects of safety climate.

3.8. SAFETY EMPOWERMENT

One way for managers to convey trust is by empowering the employees. Empowerment is a delegation of power, and as such it demonstrates that managers trust workers' ability and judgment, and that managers value workers' contributions. Empowerment would thus be expected to contribute to POS. In turn, empowerment would further strengthen social exchanges, and in conditions where safety is highly valued by the organization, empowerment would encourage reciprocation and reinforce safety behavior. Shannon *et al.* (1997), in a review of ten studies examining the relationship between workplace and organizational factors and injury rates, found that empowerment of the workers and delegation of safety activities, were consistently related to lower injury rates, i.e. the relation was significant in at least two thirds of the studies. In an interview study with first-line supervisors and workers' safety representatives in construction work, one of the main constituents of workplace safety, in their opinion, was cooperation across hierarchical levels and functions, and support for cooperation through empowerment, mutual trust and having a keen ear (Torner and Pousette 2009). Results of Clarke and Ward (2006) showed a positive relation between management tactics characterized by being consultative, by inspirational appeals and rational persuasion, and a good safety climate and safety behavior. They also found a positive correlation between coalition tactics and safety participation. Clarke and Ward suggested that these types of management tactics have a beneficial influence on perceptions of communication and perceptions of managers' competence in decision making, which supports development of trust and increases safety participation. As a design criterion for the questionnaire that assessment of management safety empowerment and encouragement of employee safety participation should be included.

Table 3: Demonstration of a Leading Safety Climate Factor "Management Commitment to Safety" at Different Levels of Achievement (CPWR 2014)

Uniformed →	**Reactive** →	**Complaint** →	**Proactive** →	**Exemplary** →
Representation from management rarely comes to the actual jobsite. When they are present, they often act as poor safety role models by breaking organizational safety policies and procedures. Management does not participate in safety audits. If employees bring concerns to any level of management they are not acted upon.	Management gets involved only after an injury occurs. They often blame workers for injuries, leading to suspension or even termination. Safety rules are enforced only after an incident or when audit results are negative.	Management conforms strictly to OSHA regulations, never more or less. Safety compliance is based on owner or regulatory directives. Managers participate in safety audits.	Management initiates and actively participates in safety audits. Managers meet with workers to ask for advice and feedback regarding hazard reduction. Management conducts spontaneous site visits and recognizes workers for identifying hazards, working safely, and keeping co-workers safe. Leaders participate in safety program development and provide adequate resources to ensure a positive safety climate. The safety management system is reviewed annually to ensure effectiveness and relevance.	Management integrates safety into every meeting and engages in continuous improvement regarding safety conditions and hazard reduction. External audits are conducted to evaluate top management's involvement in safety. Managers are held accountable for safety expectations through annual performance evaluations. Safety trends are analyzed. There is a formalized process for corrective actions.

4. PROCESS OF USING SAFETY CLIMATE FACTORS FOR SAFETY IMPROVEMENT

Safety climate factors can be measured among different categories of staff working in a construction organization or in a project undertaken by the construction organization which will reflect the safety climate of organization or safety climate of the specific project. After assessment of safety climate construction organizations will be able to identify and prioritize the weak areas for improvement. Safety climate leading factors can be reviewed on a five level scoring scale to assess what level of safety culture for that factor is achieved by a construction organization.

Maturity level for all the factors can be classified as uniformed, reactive, complaint, proactive and exemplary. Table 3 presents different levels for demonstration of a leading safety climate factor “management commitment to safety’’. Construction organizations can make short term (1-2 months), mid-term (6-12 months) and long term (1-2 years) if the required level for the factors is not adopted.

5. CONCLUSION

The risk associated with construction workers is higher than other industries which results in more accidents and both organizations and individuals involved in accident suffer in different ways including financially. This paper presented the concept for construction organizations for improvement of safety performance through safety climate dimensions. Construction companies in partnership with workers are responsible for ensuring that jobsite hazards are eliminated, or at least minimized. These partnerships are most effective when they exist within a positive safety climate. The leading factors which contribute to safety climate are discussed and how these factors are measured within construction organizations are highlighted. Using these factors on a scoring scale can help the organizations to understand the level of their safety climate to predict the safety culture and safety performance. Construction is a leading and rapid growing industry of Oman, which is highly contributing to the country economy, needing to improve their safety performance. 92% of the total workforce in the construction industry are foreigners and in case of accidents construction organizations bear more financial cost such as for medical treatment, workers compensation, repatriation cost in case of death, replacement and delay in completion of projects. Assessment of safety climate will help construction organizations in Oman to develop short, mid and long term plans to improve their safety outcomes. As this is the initial report of the research in progress, the actual assessment of safety climate in selected organizations needs to be carried out so that it could be recommended to the other construction organizations confidently.

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WIN-WIN SETTLEMENT: APPLICABILITY OF NEGOTIATION PRINCIPLES FOR DISPUTE NEGOTIATIONS IN CONSTRUCTION PROJECTS

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ABSTRACT

Effective resolution of dispute is always helpful for sustainable construction practices. However, it is experienced that parties continuously failing to reach settlements in an effective and efficient manner. Although many researches write on how to carryout negotiations successfully those concepts hardly adopted in construction dispute negotiations. Construction dispute negotiations are different to other business negotiations due to some unique features inherited such as complexity, regulated by contract, and tendency of discouraging claims. Therefore, it is identified new theories need to be developed and applied in construction dispute negotiations. Thus, the study was focused on improvement of fundamental principles of negotiation to address characteristics of construction projects.

The study was approached through a multiple case study and in-depth study was carried out on two selected cases which claims based dispute negotiation successfully concluded. Success factors of claims based dispute negotiation identified through literature review compared with actual setting of selected cases. Further, it was identified how parties have addressed special characteristics of claims based disputes in construction projects when conducting negotiations.

Analysis reveals that, how far theory can be explained through research findings and which theory should be extended based on knowledge explored. Accordingly conceptual framework had been developed and it is concluded that the negotiation process shall be merged with characteristics of construction disputes in order to achieve win-win settlement through negotiation. Major deviation from existing theory when applying to claims based dispute negotiation in a road project is negotiation shall be based on both position and interest of the parties.

Keywords: *Claims; Dispute Resolution; Negotiation; Win-win Settlement; Road Projects.*

1. INTRODUCTION

Unsettled claims lead to disputes between parties to the contract (Malak *et al.*, 2002), which is a common phenomenon in construction industry. Often parties fail to reach settlements for these disputes “in an effective, economical and timely manner” (Barrie and Paulson, 1992 cited Ren, 2002, p.17). Resolving disputes effectively is always helpful for sustainable construction practices.

To resolve construction disputes, parties use several methods. Due to numerous advantages inherited such as cost effectiveness, informality, speediness, simplicity, confidentiality, party autonomy and preservation of business relationship, negotiation is identified as the most suitable (De Zylva, 2007) and the preferred (Jayasena and Kavinda, 2012) method of resolving construction disputes. “Negotiation is a strategy of conferring with parties of shared or opposed interests with a view to compromise or to reach an agreement” (Project Management Institute, 2008, p.421).

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Negotiation plays a significant role in prevention and resolution of disputes arisen through unsettled claims (Ren, 2002). Unresolved claims tend to be settled amicably by the parties at first instance of the dispute before starting any adversarial process (Cheung *et al.*, 2006). Standard forms of contracts and arbitration acts also encourage amicable settlements (Arbitration Act, 1995; FIDIC, 1999; FIDIC, 2006).

However construction dispute negotiation is not simple. As one construction lawyer had written, negotiation is a game, but if it is not practiced properly the game can be deadly because construction disputes worth millions of money (Shapiro, 2015). As a result of this it can be seen that claim negotiations are often difficult, adversarial, inefficient and ineffective (Ren, 2002; Hu, 2006 cited Ren *et al*., 2011). Further Cheung and Chow (2011) stated that parties to construction contracts continuously fail in reaching settlement through negotiation. Ren *et al.* (2011, p.131) identified that to improve sustainable construction practices "new theories and principles need to be developed and applied in claims based dispute negotiations". Thus the study is focused on improvement of fundamental principles of negotiation to adopt in claim based disputes settlement in construction industry.

2. STUDY METHOD

There is a need to identify steps to be followed to achieve a win-win settlement for claims based dispute negotiation while addressing identified barriers specialised for construction projects. Accordingly, this study focuses on how to achieve a win-win settlement for claims based disputes negotiation in construction industry. Aim of the research was to develop a conceptual framework to achieve win-win outcome from claims based dispute negotiations which would be specialized with characteristics of construction industry. In order to achieve the aim, two succeeded negotiations were examined. This explained the theoretical framework identified in current literature and explored new paradigm which was particular to construction industry through understanding of the situation. Thus research is combination of explanatory study and exploratory study. Accordingly, this paper aims to extend a theory.

Case study is a strategy has ability to conduct an in-depth investigation of a particular case within its real life context to answer a 'how' or 'why' question (Yin, 2004). Further Zainal (2007, p.4) explained that the detailed qualitative descriptions which are generally formed in case studies are not limited "to explore or describe a real life environment, but also help to explain the complexities of real life situations which may not be captured through experimental or survey research". Accordingly, in this research, case study research strategy was used. Two case studies were examined where claim based disputes were successfully resolved through negotiation. Document review and semi-structured interviews were used as data collection techniques. The data produced from interviews and document review were qualitative data in respect of how negotiating parties achieved a win-win outcome in selected cases. Thus content analysis was selected as the basic data analysis technique of this study. Content analysis includes both "within case analysis" and "cross case analysis". Pattern matching was used to compare the literature findings against case study findings to identify applicability of negotiation principles for dispute negotiations to claims based dispute negotiations in construction projects.

3. STEPS TO MAKE A SUCCESSFUL NEGOTIATION

Review of current literature, showed that there would be eight steps to make a negotiation success identified under three stages of negotiation process. Pre-negotiation stage consists of three steps which should be followed in sequence before sit in the negotiation table. Those steps are (i) getting people in to negotiation, (ii) forming negotiation team and (iii) setting up bottom lines. Further, when both teams sit in the negotiation table they have to adhere to four more steps which are parallel steps can be used to carry out meeting successfully. Those parallel steps are (iv) separate the people from the problem, (v) focus on interests, (vi) invent options for mutual gain and (vii) insist on using objective criteria. At the end of the negotiation session, to conduct negotiation efficiently it is identified the parties should (viii) summarise the discussion and keep minutes of meetings as the last step.

3.1. Step 1: Getting People in to Negotiation

Ghauri and Usunier (2003) identifies that, through informal meetings and information gatherings, parties try to understand each other's needs and demands in pre-negotiation stage. Accordingly the parties decide whether to commence, continue or abandon the negotiation. Ren *et al*. (2011) state that unlike a business negotiation, getting people in to negotiation table is the hardest in respect of a dispute negotiation. Since negotiation is a voluntary process, parties' real interest to resolve their dispute through negotiation is important to achieve a successful outcome.

3.2. Step 2: Forming Negotiation Team

Smith (1992) identifies that the negotiator should be capable in adopting more than one negotiation style. Further he recognizes that emotional people should not be selected as negotiators since their emotions easily can get them in to trouble. In case if other party's negotiators are known, it is important to select people who will interact easily with them. Further to these, Ren (2002) states that the parties should define their representative's authority level which will be helpful in making successful conclusions to a negotiation.

3.3. Step 3: Setting Up Bottom Lines

Proper preparation is essential to negotiate successfully (Ghauri and Usunier, 2003; Ren, 2002; Ren *et al*., 2011). Preparation is time consuming hard work which has to be followed by each party before sitting at the negotiation table in order to gain better outcomes (Ren e*t al*., 2002). Proper planning strengthens self-confidence of the negotiators (Mahmoodi, 2012) and avoids agreeing in to settlements by over compromising which is not possible to be lived with (Thomas, 2001). Sometimes parties try to cut down their loss through negotiations (Yuan and Ma, 2012). Knowing their own weaknesses will minimise creation of unreasonable deadlocks. Thus preparation is very important in carrying out an effective negotiation.

In negotiation, each party has a 'bottom line' which is "the maximum or minimum amount which a party can offer to or accept from its opponent" (Ren, 2002, p.166). Overlap range between bottom lines of the parties constitutes the possible scope of an agreement which is called 'Zone of Possible Agreement' (ZOPA). This is a theoretical "zone" which is not known to the parties and only possible to partially identify through negotiating (Alfredson and Cungu, 2008). The SWOT analysis can be used to set up bottom lines as preparation in pre-negotiation stage.

3.4. Step 4: Separate the People from the Problem

A basic fact about negotiation is that negotiators are not simply business representatives of each side, but human beings with "emotions, deeply held values, and different backgrounds and viewpoints" (Fisher *et al.*, 1991, p.14). This human aspect of the negotiators makes negotiations difficult. People easily get angry and unhappy. This may result in confusing their perceptions with reality and difficulty in clear communication (Fisher *et al.*, 1991). Shapiro (2015) states that, at the negotiation table parties should avoid the debate getting personal but keep everything on business level.

3.5. Step 5: Focus on Interests, not Positions

Positions are what parties say that they want, but interests are things that they really need. Often position and interest are not the same (Ren *et al*., 2011). Fisher *et al*. (1991, p.24) state that "the basic problem in a negotiation lies not in conflicting positions, but in the conflict between each side's needs, desires, concerns, and fears". Thus to understand the true problem behind the dispute, it is required to identify the real interests of the parties. Ren *et al*. (2011) further explain that the people have a tendency in their minds to challenge to the opponent's position by taking extreme positions. However, Ren *et al*. (2011, p.124) has found that the "underlying true interests are actually compatible, not mutually exclusive". Hence to achieve win-win outcome parties should focus on interests, not on positions.

3.6. STEP 6: INVENT OPTIONS FOR MUTUAL GAIN

Fisher *et al*. (1991) point out that generally people negotiate with a belief in mind that their offer is reasonable and it should be accepted by the other party. When it comes to dispute negotiation, people usually believe that they are right and they know the right answer. Therefore, usually parties fight over original positions trying to achieve win-lose outcome without focus on win-win solution. Fisher *et al*. (1991) identify that the parties should invent options to the real problem behind the dispute.

3.7. STEP 7: INSIST ON USING OBJECTIVE CRITERIA

Fisher *et al*. (1991) suggest that when parties could not come to a solution, looking for an objective criterion will help to resolve the issue. Having identified some objective criteria and procedures make it possible to bring fairness, efficiency or scientific merit to the negotiation (Fisher *et al*., 1991). Further it helps to taking out emotions and allows both parties to take decisions on rational and logical basis (Ren *et al*., 2011).Parties tend to accept outcome based on the objective criteria since the result is “not under the control of any single party” (Ren *et al*., 2011, p.124).

3.8. STEP 8: SUMMARISING DISCUSSION AND KEEPING MINUTES OF MEETINGS

Negotiation may not be over in a single session, but it will drag much more. At the end of each negotiation session summarising discussion and keeping minutes of meetings is important (Ghauri and Usunier, 2003). It will help to continue negotiation without unnecessary delays by avoiding discussion over and over about same issue. Further this will help to draft the agreement at the post negotiation stage incorporating all terms that have been agreed in negotiation (Ghauri and Usunier, 2003).

4. CHARACTERISTICS OF CLAIM NEGOTIATION

Construction dispute negotiations are different to other business negotiations due to some unique features inherited by construction industry (Ren *et al*., 2011). Therefore there are some barriers in adopting steps of successful negotiation in respect of claims negotiation.

4.1. NEGOTIATORS

Ren (2002) states that the employer’s direct involvement to negotiation is important and which is not practiced in most of the cases. Participation of the consultant as an agent of the employer makes negotiation weak especially when claims are arising out of his own mistakes the consultant tends to discourage such claims (Ren *et al*., 2011; Ren, 2002).

Selecting same group of people who leads to disputes is a common mistake done when forming claim negotiation teams (Ren *et al*., 2011). When negotiation starts with same group of people they see it with prejudged mind set. Further, if negative relationships had been build up between each other makes it difficult to achieve any progress (Ren *et al*., 2011).

4.2. COMPLEXITY

Since construction claims are complex, most of the time both parties “truly believe that they hold the truth and the opponent’s requests are unreasonable” (Ren et al., 2011, p.125). Otherwise, it can be either one party or both exaggerates the opening demand by misrepresenting their contractual and/or legal positions (Pickavance, 2005).

4.3. CONTRACT GOVERNANCE

Construction projects are generally regulated by very sophisticatedly prepared conditions of contract that defines rights and obligations of the parties (Cheung *et al*., 2008). Ren *et al*. (2011) state that generally in respect of construction claims it is not a negotiation about “how much”, but about “whether parties are entitled for it based on the contractual provisions." Therefore, claims negotiation requires high level of understanding of each claim item.

5. RESEARCH FINDINGS AND ANALYSIS

Two foreign funded road projects identified as Case A and Case B as described in following sections were selected as case studies in where claim based disputes were successfully resolved through negotiation. Study method adopted was described in section 2.

5.1. CASE A

The project was a rehabilitation class A road in which the Parties to Contract were state sector authority and a local (ICTAD grading C1) contractor. The Engineer to the Contract was international and local joint venture. General Conditions of Contract were FIDIC MDB Harmonised edition 2006 (FIDIC, 2006). Accepted Contract Amount was above 1 billion LKR (7.5million USD) and Time for Completion was 450 days.

Claims no 01 and 02 were submitted by the Contractor to claim costs incurred due to acceleration instructed by the Engineer. Further, claim no 03 was submitted by the Contractor to claim damages due to changes in legislation which caused an increase in fuel price within the contract period. All three claims had been rejected by the Engineer. The Contractor gave-up his three cost claims without refereeing to dispute resolution mechanism specified in the Contract. Claim no 04 was a request of 130 days extension of Time for Completion. Determination of rejecting the claim was sent by the Engineer without proper evaluation. Claim no 05, 459 million valued cost claim, which consisted of associated cost of additional scope and the cost of prolongation for 130 days was submitted by the Contractor. Same as before the Engineer's determination of rejecting the claim was received to the Contractor. Pursuant to Conditions of Contract, notice to commence arbitration was sent by the Contractor to the Employer in order to resolve the dispute through arbitration.

Thus, the dispute was regarding 130 days of extension to Time for Completion and 459 million of cost claimed by the Contractor. Between the Employer and the Contractor negotiations were commenced as invited by the Employer as the response to notice to commence arbitration.

Negotiation sessions between the parties were conducted as follows.

Session 1: Entitlement to EOT was established by the Contractor and it was accepted by the Employer

Session 2: Agreed to grant 130 days of EOT for delayed part of Work and issued Taking-Over Certificate for the rest of Works. Agreed to pay prolongation cost based on delayed part of Work

Session 3: Established requirement of the cost claim and legitimacy of the claim. The Employer agreed

Session 4: Agreed on boundaries of claim events and decided to let the Engineer to carryout calculations and quantify cost to be paid

Session 5: Finalised quantification of the cost claim

It was agreed to settle for 130 days of extension of Time for Completion and 212 million rupees for cost claim by the Parties.

5.2. CASE B

Project was improvements for provincial roads in which the Parties to Contract were state council and local (ICTAD grading C1) contractor. The Engineer to the Contract was international and local joint venture. General Conditions of Contract were FIDIC MDB Harmonised edition 2006. Accepted Contract Amount was near 400 million LKR (2.5 million USD) and Time for Completion was 547 days.

Five claims were submitted by the Contractor and Table 1 illustrates details of claims.

Table 1: Claim Summary of Case B

Claim No	Submission	Claim Events	EOT (days)	Cost (Million)
01	October 2011	01: Non-availability of materials	12	5.7
02	December 2011	01: Delayed drawings 02: Delayed Site possession 03, 04 and 05: Variations	178	57.0
03	February 2012	Rate revision due to quantity reduction		72.8
04	February 2012	Exceptional adverse weather	34	
05	January 2013	01, 02, 03 and 04: Variations	104	37.7
		Unsettled Variations		26.4

Until the Contractor submitted claim no 04, the Engineer was at claim evaluation process and the Contractor was awaiting the Engineer's determination in regarding claims 01, 02 and 03. The Engineer granted 32 days extension of Time for Completion for the claim no 04 submitted by the Contractor and it was agreed by all the Parties.

Based on claim no 01, 02 and 03, negotiations were commenced as invited by the Employer.

Dispute was in regarding with 190 days of extension to Time for Completion and 135.5 million of cost claimed by the Contractor. Between the Employer and the Contractor negotiation sessions were conducted as follows.

Session 1: It was decided by the Contractor to withdraw the claim no 01 in good faith of the project even though they have an entitlement according to the Conditions of Contract.

Session 2: Agreed to grant 32 days EOT for claim event 4 of claim no 2

Session 3: Agreed to grant 79 days EOT for claim event 2 of claim no 2

It is agreed to pay 14.8million rupees as non-recovered overhead and profit for above 111 days by the Employer.

Session 4: In respect of claim no 2, the Contractor's entitlement to following items were agreed by the Employer in principle; idling machinery cost, extended preliminaries, extended price escalation, cost of non-release of retention. Further it was agreed to calculate idling machinery cost based on depreciation rate and the maintenance cost only. Further it was agreed to pay based on actual cost for extended preliminaries.

Session 5: Regarding claim no 3 the Contractor's entitlement to rate revision for quantities which exceeded the agreed bills of quantities was agreed in principle by the Employer. Further clarifications requested on entitlement to rate revision for items which quantities reduced than the agreed bills of quantities.

Session 6: Incurred cost due to reduction of quantities were explained and convinced to the Employer by the Contractor.

Negotiations were carried out successfully and 111 days EOT was granted but no any additional payment was made even though the Employer agreed to the Contractor's entitlement for some claim events.

Then the claim no 05 was submitted by the Contractor and the Engineer's determination was received to the Contractor rejecting all cost claims made up to date. Pursuant to Conditions of Contract a notice was sent by the Contractor declaring their intention to commence arbitration in respect of 104 days of EOT in claim no 05 and 193.9 million of cost claimed in claim no 02, 03, 05 and failure in finalising cost of Variations. The contractor was invited by the Employer to a meeting and it was agreed to continue negotiations to settle the dispute amicably between the parties.

Therefore negotiation sessions continued.

Session 7: Agreed to grant 104 days EOT

Session 8: Agreed for the Contractor's entitlement in principle to following claim events by the Employer. Non-recovered overhead and profit, cost of non-release of retention, idling machinery cost, rate revision for quantities reduction

Session 9: Agreed to the Contractor's entitlement for the Variation 02 and 04 of claim no 05

Session 10: The Contractor requested that the settlement would be within 56 to 58 million. The Parties agreed.

294 days of extension of Time for Completion was granted. Total cost certified was 96.5 million rupees. 40.5 million rupees were certified for extended preliminaries and extended price escalation for period of time extension was granted. Further 51.9 million rupees was certified considering the Contractor's entitlement for the followings; (a) non-recovered overhead and profit and cost of non-release of retention, (b) idling machinery cost, (c) rate revision for quantities reduction and (d) Variation 02 and 04 of claim no 05. Further 4.1 million rupees was granted declaring as concession for amicable settlement.

5.3. PATTERN MATCHING

Pattern matching was carried out for comparison between theory and research findings. The comparison was done for eight steps identified in theoretical framework as key steps to make a successful negotiation. Hence this pattern matching analysis reveals that, how far theory can be explained through research findings and which theory should be extended based on knowledge explored in respect of claims based dispute negotiation in construction industry.

Result of pattern matching between theorized concepts and observed data of each steps of a successful negotiation is summarized and represented in Table 2.

Table 2: Theory Verses Research Findings

Theory	Research Findings	Comments
Step 01: Getting people in to negotiation		
• This is the hardest in case of a dispute negotiation. However, in construction disputes parties cannot easily walk away from negotiation unless they are ready to step in to next dispute resolution step which is lengthy and costly.	• When the contractor decided to seek a fair determination through arbitration, it was decided by the employer to come in to negotiation table. Taking parties to negotiation table is not difficult in respect of construction disputes.	• Explain the theory
• In order to achieve successful outcome through negotiation, parties' real interest to resolve their dispute through negotiation is important.	• Parties' awareness about cost and time involved with arbitration procedure creates real interest to resolve their dispute through negotiation. Parties' real interest to resolve their dispute through negotiation is a key factor behind the success.	
Step 02: Forming negotiation team		
When forming negotiation team followings are key facts to achieve success;	When forming negotiation team followings are key facts to achieve success;	

• Negotiator should be capable in adopting more than one negotiation style, less emotional, easily interact with other party	• Negotiators should be well aware on the project, claim history, claim events and contractual entitlement according to contract between the parties	• Extend the theory
• Avoid selecting same group of people who leads to dispute as negotiators • Involvement of employer is important • Avoid participation of the consultant as an agent of the employer	• Negotiators selected from same group of professionals involved in the project • Involvement of employer is important • Participation of the consultant as an agent of the employer has limited to claim quantification	• Explain and extend the theory
• Parties should define their representative's authority level	• Parties should define their representative's authority level	• Explain the theory
Step 03: Setting up bottom lines		
In order to achieve successful outcome through negotiation, • Parties should be prepared and set their bottom line in pre-negotiation stage. SWOT analysis can be used as a tool to determine bottom line. • Since construction claims are complex, it is very difficult to find ZOPA in claims negotiation.	In order to achieve successful outcome through negotiation, • In both cases the contractor stated that they had initially decided the minimum amount which they can agree had decided by the management based on actual loss caused. • The employer did not clearly decide their bottom line before starting negotiation. They kept an open-mind and let it change as negotiation proceeded. Basis was explanations made and substantiations done to prove the contractor's demands.	• Theory does not explain how to address complexity inherited by the claims based disputes Findings elaborate that setting bottom line in pre-negotiation stage is not a key to address complexity but letting it develop with the negotiation Thus, it extend the theory
Step 04: Separate the people from the problem		
• People easily get emotional and getting things personal. • This makes negotiation hard therefore the negotiators should working together attacking the problem but not each other.	• Separate people from the problem is very important to achieve successful outcome through negotiation • Since claims negotiations are based on contractual provisions and contemporary records separating people from the problem is easy.	• Explain the theory

Step 05: Focus on interests, not positions		
• Parties should focus on interests, not on positions	• Parties should have intention to consider both position and interests. • When position based negotiation carried out, agreed in principle on entitlement and then quantify based on agreed terms made negotiation successful.	• Extend the theory
Step 06: Invent options for mutual gain		
• Inventing options for mutual gain is very important	• Inventing options beyond the contract is not possible. In order to achieve settlement inventing options is not important	• Extend the theory
Step 07: Insist on using objective criteria		
• Suggest using objective criteria when parties could not come to a solution by themselves	• Objective criteria shall be used from the beginning of negotiation as a basis for the entitlements • Examples: contract document, professional standards and decided cases	• Extend the theory
Step 08: Summarising discussion and keeping minutes of meetings		
• Recommended keeping minutes of meetings at the end of each negotiation session	• Keeping minutes of meetings at the end of each negotiation session is identified as a key factor behind the success	• Explain the theory

Requisites of successful negotiation identified in theory are developed in general business negotiation context. However the theory was not validated in respect of claim based dispute negotiation in construction industry. Little evidence from research findings shows that theory is not applicable fully in construction. The analysis shows that that the existing theory needs to be extended to comply with special characteristics in claim based dispute negotiation in construction industry.

5.4. SUMMARY

As the main outcome of the study a conceptual framework was developed to achieve successful outcome through negotiation for claims based disputes in road development projects in Sri Lanka. The conceptual framework developed is shown in Figure 1

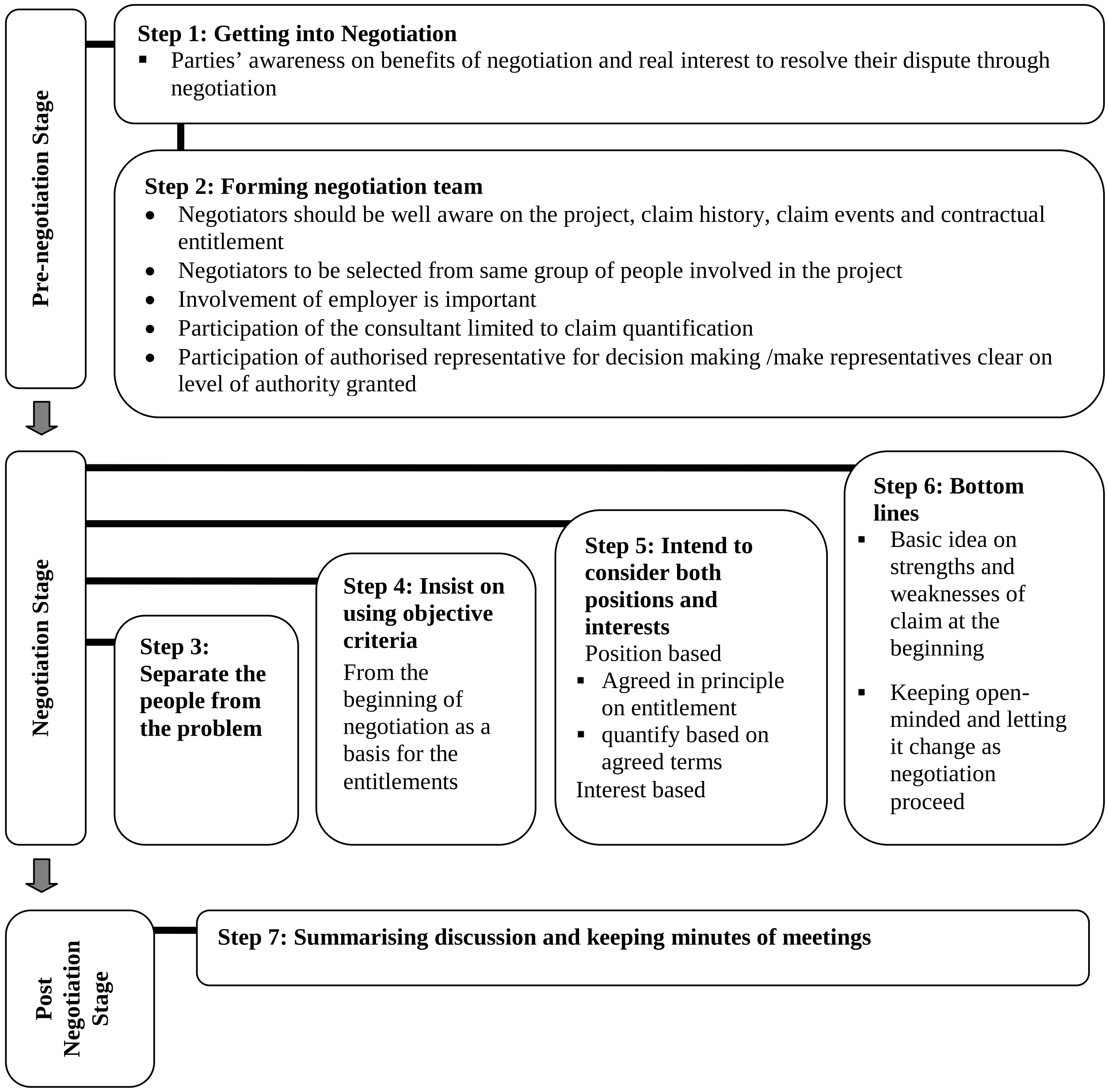

Figure 1: Conceptual Framework to Achieve Win-Win Settlement

6. Conclusion

According to findings of the study, it can be concluded that applicability of negotiation principles in to claims based dispute negotiation is limited and it should be merged with characteristics of construction industry. Major deviation from existing theory, when applying to claims based dispute negotiation in road project is that the parties shall have intention to negotiate based on both position and interests in order to reach a settlement.

7. Recommendations

The developed conceptual framework based on research findings contributes the body of knowledge through extending the theory. The existing theory recommends only interest based approach, and recommends not taking position based approach; but, it is now clear that an interest and position based approach would bring success to construction dispute negotiation. Related theoretical concepts can therefore be interpreted accommodating this deviation when applied in construction contexts.

Based on above key findings and other research findings following recommendations shall be made to private sector contracting organisations and public sector employers who are involved in road development projects for them to achieve win-win settlement through negotiation for dispute created on unsettled claims.

- Improve skills of negotiators representing through training programmes
- Public sector organisations shall make aware professionals who are representing the organisation on possibility of decisions making on negotiation within the authority level granted
- Developed conceptual framework can be used by industry practitioners in order to reach settlement for claims based disputes via negotiations

8. LIMITATIONS OF THE RESEARCH

According to the study there are some limitations in generalizing the findings. The study was limited to;

- Foreign funded road improvement projects
- Disputed claim amount in selected cases was more than 40% of initial accepted contract amount
- Based on literature findings it was assumed that settlement can be only reached through two different approaches, that are; position base negotiation and interest base negotiation
- Since win-win settlements in claims based dispute negotiation are not common in Sri Lankan context, opinions of negotiators were validated only via document study and content analysis that was within case analysis and cross case analysis

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The Ceylon Institute of Builders (CIOB)

www.ciob.lk

Established in 1961, the Ceylon Institute of Builders (CIOB) is the premier institute for Building Professionals in Sri Lanka with a strong network of Engineers, Architects, Surveyors and similar allied professions who work to inspire, encourage, educate and train students, builders, and professionals in the country. The institute welcomes young entrants and mature professionals with or without a background in construction to achieve professional level careers in the country. They are provided with a well-structured development programme that eventually lead to gaining corporate membership of the institute.

University of Moratuwa - Department of Building Economics

www.becon.mrt.ac.lk

The department of Building Economics, University of Moratuwa, Sri Lanka was founded in 1983. It is currently the pioneer Sri Lankan institution to offer programmes in Quantity Surveying, Facilities Management, Project Management, Construction law and Dispute Resolution and Occupational Safety and Health Management. Building Economics and Management Research Unit (BEMRU) is the research arm of the Department of Building Economics which specialises in research in Building Economics and management in the country as well as internationally.

International Council for Research and Innovation in Building and Construction (CIB)

www.cibworld.nl

The CIB acts as a global network for international cooperation and information exchange in building and construction research and innovation. CIB collaborates with the organisations around the world supporting the development of the industry, while facilitating international knowledge transfer on topics of interest. It covers the technical, economic, environmental, organizational and other aspects of the built environment during all stages of its life cycle.

Liverpool John Moores University (LJMU)

www.ljmu.ac.uk

Ranked in the top 400 universities world-wide in the Times Higher Education World University Rankings 2013-14, the exceptional student experience LJMU offers is founded on high quality teaching, ground-breaking research and dedicated staff throughout the university.

Centre for Infrastructure & Construction Industry Development (CICID) of the Department of Civil Engineering of the University of Hong Kong

www.civil.hku.hk/cicid

The Centre for Infrastructure & Construction Industry Development (CICID) of the Department of Civil Engineering of the University of Hong Kong, was established in November 2002. The aims include fostering continuous improvements, while targeting excellence in the construction industry in general and infrastructure development in particular, through the development of innovative strategies and techniques.

Indian Institute of Technology Madras (IIT Madras)

www.iitm.ac.in

Indian Institute of Technology Madras is one among the foremost institutes of national importance in higher technological education, basic and applied research. The institute has sixteen academic departments and a few advanced research centers in various disciplines of engineering and pure sciences, with nearly 100 laboratories organized in unique pattern of functioning.

Auckland University of Technology, New Zealand

www.aut.ac.nz

Auckland University of Technology, New Zealand (AUT) was formed on 2000 (1895 originally Auckland Technical School) when the Auckland Institute of Technology was granted university status. AUT has three secondary campuses: North Shore, South, and the Millennium Institute of Sport and Health (AUT Millennium Campus). Further, AUT holds an overall four-star rating from QS and the maximum five stars in the sub-categories of Teaching, Employability, Internationalisation, Facilities and Access.

Northumbria University, United Kingdom

www.northumbria.ac.uk

Northumbria University was first established in 1969 and is based in the heart of Newcastle upon Tyne, regularly voted the best place in the UK for students. The Department of Architecture and Built Environment has recently had Architecture placed 10th in the UK in the Guardian 2017 and Property Management 7th in the Complete University Guide 2017. Quantity Surveying is one of our longest established degrees having commenced in the 1970's.

Robert Gordon University, United Kingdom

www.rgu.ac.uk

The Robert Gordon University, commonly referred to as RGU, is a public university in the city of Aberdeen, Scotland. As one of the top modern universities in the UK, RGU offers a diverse suite of courses through three faculties; the Faculty of Design and Technology, the Faculty of Health and Social Care, and Aberdeen Business School. Consistently ranked among the UK's top universities for graduate employment for many years, RGU is rated as the Top University for graduate prospects and Top University in Scotland for Architecture, Health Professions, Journalism, and Pharmacy in the Guardian University Guide 2017.

Colombo School of Construction Technology (CSCT)

csct.edu.lk

The CSCT was established in 2008, with the motto 'Sapientia et Doctrina', which is Latin for Wisdom & Learning. It strives to create a learning environment to nurture the development of critical thinking skills; support innovation; and develop knowledge and expertise of our students. CSCT faculty have expertise in a broad range of specialties and have developed curriculums in each of the programs that meet the needs of the construction industry.

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