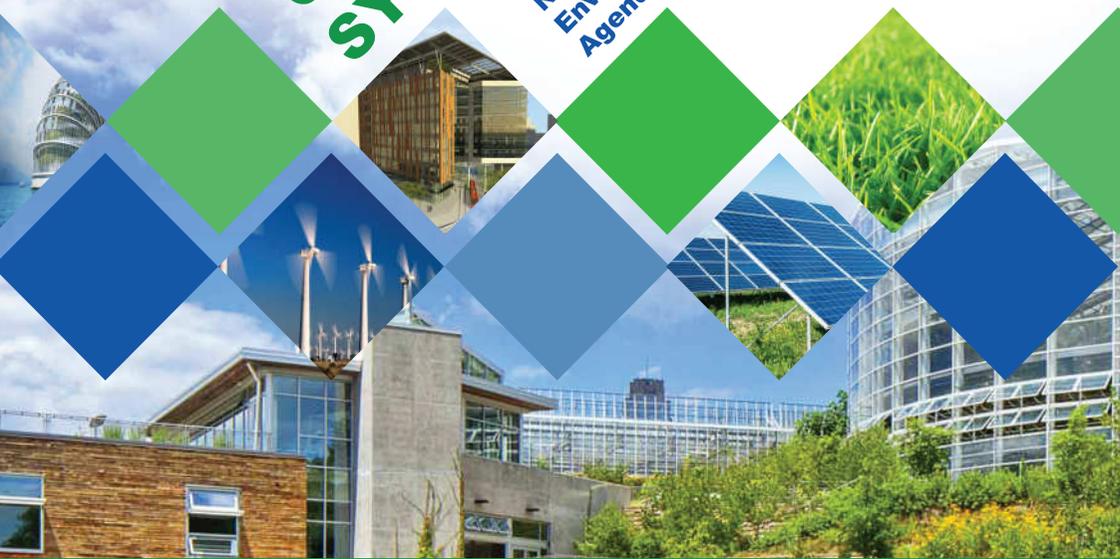




# THE 6<sup>th</sup> WORLD CONSTRUCTION SYMPOSIUM – 2017

What's New and What's  
Next in the Built  
Environment Sustainability  
Agenda?



## Programme & Abstracts

30<sup>st</sup> June - 02<sup>nd</sup> July 2017

Organized by



CEYLON INSTITUTE OF BUILDERS  
(CIOB) SRI LANKA



DEPARTMENT OF BUILDING ECONOMICS  
UNIVERSITY OF MORATUWA

# THE 6<sup>TH</sup> WORLD CONSTRUCTION SYMPOSIUM 2017

WHAT'S NEW AND WHAT'S NEXT IN THE BUILT ENVIRONMENT  
SUSTAINABILITY AGENDA?

30 June – 2 July 2017

at  
Galadari Hotel  
Colombo, Sri Lanka

**Organised by**  
Ceylon Institute of Builders (CIOB), Sri Lanka  
&  
Building Economics and Management Research Unit (BEMRU),  
Department of Building Economics, University of Moratuwa, Sri Lanka

**With Associate Partners**  
Liverpool John Moores University (LJMU), United Kingdom  
Centre for Innovation in Construction and Infrastructure Development (CICID),  
The University of Hong Kong, Hong Kong  
Indian Institute of Technology Madras (IIT Madras), India  
Northumbria University, United Kingdom  
Robert Gordon University, United Kingdom  
Western Sydney University, Australia  
CIB-W122: Public Private Partnership  
Colombo School of Construction Technology (CSCT), Sri Lanka  
Built Environment Project and Asset Management (BEPAM): Journal, published by  
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# MESSAGES



## **Prof. Chitra Weddikara**

**Chairperson**

**The 6<sup>th</sup> World Construction Symposium 2017**



It is a great pleasure today to see all the participants for the 6<sup>th</sup> World Construction Symposium 2017 in Colombo, Sri Lanka on “What’s New and What’s Next in the Built Environment Sustainability Agenda?” and I am privileged to welcome you all for this annual event on behalf of the organizing committee.

Ceylon Institute of Builders (CIOB) as the main organizer, is doing an incredible job to educate, train and motivate the Sri Lankan builders to be high ranking professionals in the industry with the collaboration of Building Economics and Management Research Unit (BEMRU), of the Department of Building Economics, University of Moratuwa and other associate partners.

As a unique field, construction industry gets affected from numerous challenges due to the climate changes, technology changes and sometimes changes of the human desires. All stakeholders in construction industry therefore, required to explore innovations to overcome the challenges, while making the environment green and promoting the sustainable aspects.

This 6<sup>th</sup> milestone of the journey is a great occasion to recall the past of our world construction symposium, which was held based on various directions which relates to sustainable built environment. Our first symposium was held in year 2012 and it emphasized the global challenges in construction industry and the importance of resolving them in a sustainable manner for the betterment of the environment and human necessities. It has been provided an innumerable opportunity for the professionals in the construction industry as well as the researchers in the same field to share and discuss their knowledge and new research findings continuously for the last five years. All the way through these five years, highest consideration was given for various aspects of the sustainable construction as it has been become a critical requirement of the construction industry nowadays.

For the 6<sup>th</sup> symposium, the selected theme is “What’s New and What’s Next in the Built Environment Sustainability Agenda?” In this context, risk management, energy management, cost management, procurement methods, various sustainability aspects, green buildings, health and safety in construction and sustainable technologies are some of the sub areas to be conversed.

I hope all the participants will be with us for these two days and capture all valuable information presented throughout the time and also enjoy your stay in Colombo, Sri Lanka.

**Dr. Rohan Karunaratne**  
**President**  
**The Ceylon Institute of Builders (CIOB)**



On behalf of the organizing committee of the symposium, it gives me great pleasure in welcoming each one of you for this 6<sup>th</sup> World Construction Symposium. This annual symposium is a much looked forward to event by the construction fraternity in Sri Lanka and other participating countries as it provides an opportunity for the participants to share their knowledge, new research findings and other developments in relation to sustainable built environment. I would like to extend a particularly warm welcome to our international delegates who have traveled so far to be with us for this event.

United Nations has included environmental goals in its 2030 Agenda for Sustainable Development, a set of 17 Sustainable Development Goals (SDGs) that are to be implemented and achieved in every country from the year 2016 to 2030.

As per a study by the Environmental Protection Agency of the US, buildings account for 35% of the total energy consumption, 15% of the total water consumed and 38% of the total carbon dioxide emissions, worldwide. Hence, there is an absolute necessity to focus on sustainability in built environment if our country has to achieve the UN sustainable development goals by 2030.

It is my firm belief that the papers presented and knowledge shared in this symposium will help us in our quest to promote sustainable built environment in Sri Lanka. Therefore, we are keen to know What's Next in the Built Environment Sustainability Agenda.

I wish that every one of you would find the symposium inspirational and rewarding, and I wish the symposium every success.

**Eng. Saliya Kaluarachchi**  
**Hony. Secretary**  
**The Ceylon Institute of Builders (CIOB)**



I am happy to write this message to the 6<sup>th</sup> World Construction Symposium 2017, scheduled to take place from 30<sup>th</sup> June to 2<sup>nd</sup> July at Hotel Galadari. The first World Construction Symposium was held in 2012. Since then, it has become an annual international industry event taking place in Sri Lanka focusing on sustainable construction. The symposium provides a special platform for researchers and practitioners in the area of sustainable construction worldwide to exchange information on creating a sustainable built environment and thus advancing sustainable development.

The theme of this year's symposium is "What's New and What's Next in the Built Environment Sustainability Agenda?" As usual, the extensive technical programme will include three concurrent presentation tracks consisting of over fifty research papers being presented by academics and industry professionals from countries such as Sri Lanka, United Kingdom, Turkey, India, Australia, Hong Kong and Malaysia. The papers presented will be based on several sub themes covering a wide spectrum of areas set out in the programme. Over 200 local and foreign delegates are expected to attend the symposium.

The World Construction Symposium is jointly organized by the Ceylon Institute of Builders (CIOB) and Building Economics Management and Research Unit (BEMRU) of the Department of Building Economics, University of Moratuwa with the partnering and endorsement of many professional and academic institutions worldwide, as given in detail in this publication. It also includes the awards from BEPAM journal (an Emerald publication) and from CIOB.

Hon. Patali Champika Ranawaka, Minister of Megapolis and Western Development will grace the inauguration of the Symposium as the Chief Guest. Professor Akintola Akintoye, a distinguished academic from the Leeds Beckett University, United Kingdom and Professor Srinath Perera, an eminent academic from the Western Sydney University, Australia will deliver their key note addresses at the inaugural session of the Symposium. After conclusion of the event, awards and certifications will be presented to organizations, products and buildings that have achieved CIOB Green Certification, recognized after a rigorous evaluation process, and to professionals who have successfully completed the CIOB Advanced certificate course for Green Managers. In conclusion, on behalf of CIOB, I thank and congratulate all who worked tirelessly to make this event a success and look forward to welcome all participants to Sri Lanka.

**Eng. Sagara Gunawardena**

**Mr. Kalana Alwis**

**Co-Chairpersons**

**The 6<sup>th</sup> World Construction Symposium**



On behalf of the Organizing Committee, we warmly welcome all the delegates to the 6<sup>th</sup> World Construction Symposium to be held from 30 June to 02 July 2017 at Hotel Galadari. This symposium will bring both the academics and the construction industry professionals under one roof as it is organized by our institute, which represents the building professionals and Department of Building Economics, University of Moratuwa which is known for its academic excellence. Our sincere thanks to the members of the organizing committee for working arduously to put together, what promises to be an exciting weekend.

The theme of the symposium “What’s New and What’s Next in the Built Environment Sustainability Agenda?” aptly describes the objective of the symposium. The purpose and vision of this symposium is the promotion of academic and research activities in the field of sustainable construction. The symposium will bring like-minded individuals on one platform to discuss new trends and challenges in the field of Sustainable construction. In the symposium, Sri Lankan academics, research scholars and practitioners will get the opportunity to interact with eminent experts in green construction from countries such as Australia, Hong Kong, India, Malaysia, Oman, Turkey and United Kingdom.

There has been tremendous impetus worldwide to use environmental friendly technologies in the design and construction of buildings. It is a matter of great pride to note that our institute has been promoting green construction technologies during the past 3 years by evaluating and rating buildings and building contractors for their overall environmental performance. As Sri Lanka is in the midst of a construction boom, there is a necessity to promote green building technologies aggressively. In this backdrop, we are confident that the deliberations of the symposium will prove a new mile stone for the development of research and practice of green construction in Sri Lanka.

We hope that the delegates will have an enjoyable and fruitful stay in Colombo and return home with fond memories.

We wish the Symposium grand success.

**Dr. Yasangika Sandanayake**  
**Head of the Department**  
**Department of Building Economics**  
**University of Moratuwa**



It is a great pleasure to send this message to extend my warmest wishes for the 6<sup>th</sup> World Construction Symposium 2017. This is an exciting venture jointly organised by Ceylon Institute of Builders (CIOB) and the Building Economics and Management Research Unit (BEMRU), Department of Building Economics, University of Moratuwa, Sri Lanka for the sixth consecutive year. 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), Northumbria University, UK, Robert Gordon University, UK, Western Sydney University, Australia, Colombo School of Construction Technology, Sri Lanka (CSCT), CIB-W122: Public Private Partnership and Built Environment Project and Asset Management (BEPAM): journal, published by Emerald Group Publishing are the associate partners of the symposium.

After the end of the 30 year civil war, Sri Lankan construction industry has faced a boom in the recent years focusing the need of the Built Environment to make a thorough understanding on sustainability and future potentials. In this context, the 6<sup>th</sup> World Construction Symposium focuses on "What's New and What's Next in the Built Environment Sustainability Agenda?" in order to identify the critical aspects to be considered in the sustainable Built Environment to establish the future agenda.

The 6<sup>th</sup> World Construction Symposium 2017 provides a platform for both local and international delegates to share their knowledge and ideas with regard to sustainability in the built environment. I hope all delegates would take this opportunity to share their knowledge, ideas and views on the theme of the symposium.

I wish all the success for the 6<sup>th</sup> World Construction Symposium 2017.



# KEYNOTE SPEAKERS

**Prof. Akintola Akintoye**  
**Dean**  
**School of Built Environment and Engineering**  
**Leeds Beckett University**  
**United Kingdom**



Prof. Akintola was previously Director of Research and Innovation of Faculty of Science and Technology and Dean of Grenfell-Baines School of Architecture, Construction and Environment at the University of Central Lancashire, United Kingdom. He holds the Chair of Construction Economics and Management. He was Visiting Professor to the Department of Civil Engineering, Asian Institute of Technology, Thailand and the Department of Building and Real Estate, Hong Kong Polytechnic University and a Distinguished Scholar of the University of Cape Town, South Africa. He is Fellow of both the Royal Institution of Chartered Surveyors and Chartered Institute of Building and Past Chair of the Association of Researchers in Construction Management. In addition, he is Editor-in-Chief of the Journal of Financial Management of Property and Construction. Professor Akintoye is Co-Coordinator of the World CIB Working Commission (W122) into Public Private Partnership.

He has gained international recognition for his scholarly work in the area of construction risk management and procurement, construction estimating and modelling, construction economics, and construction inventory management. He has over 150 academic publications and outputs and has been invited as keynote speaker to conferences in USA, Europe, Asia, Australia and Africa.

Professor Akintoye has continued to work very closely with industry in the UK and have established a robust international network of experts in many countries. He has served in various consultancy teams which have advised government institutions and private organisations on PPPs and PFIs across Europe and Asia. He has edited four published books in Construction Innovation and Process Improvement and Public Private Partnerships.

**Prof. Srinath Perera**  
**Personal Chair in Built Environment and**  
**Construction Management**  
**School of Computing Engineering and Mathematics**  
**Western Sydney University**  
**Australia**



Professor Srinath Perera is a coordinator of the CIB TG83 Task Group, e-Business in Construction. He has been admitted as a Fellow of the prestigious Royal Society of New South Wales and is a fellow of the Australian Institute of Building (AIB). He is a Chartered Quantity Surveyor and a Project Manager with membership of both the Royal Institution of Chartered Surveyors (RICS), and Australian Institute of Quantity Surveyors (AIQS). He has worked as a consultant quantity surveyor, project manager and as an academic in Sri Lanka, Ireland, UK and Australia.

He has extensive experience in doctoral student supervisions and examinations. He has over 150 peer reviewed publications and is co-author of the popular textbook *Cost Studies of Buildings* 6<sup>th</sup> edition, published by Routledge.

He has successfully supervised and examined several doctoral and higher degree candidates around the globe. He has extensive experience as external examiner for several undergraduate and postgraduate degree programmes in many universities. He has also served in several course accreditation and validation panels for various universities and professional bodies both within UK and internationally.



# PANEL DISCUSSION

*on*

## **PPPs - The GOOD, the BAD and the OPTIMAL: Greening Potential, Grey Areas and Life-cycle Best Value**



## Panel Discussion Moderator



### **Professor Mohan M. Kumaraswamy**

Joint Coordinator, CIB W122 on PPP  
Editor-in-Chief, BEPAM Journal

Mohan Kumaraswamy is an Honorary Professor of The University of Hong Kong, having been based there from 1992 to 2013. He has been a Visiting Professor at Universities in Singapore, Australia and India and also a Consultant to the World Bank.

Before joining academia, he worked on designs, construction and project management, including as Construction Manager of a 5 star hotel in Colombo and a Director of the pioneering construction project management company in Sri Lanka.

His contributions to academia-industry-link bodies include those as: Sri Lanka representative of CIOB (UK) until 1992; Vice-Chairman of CIOB Hong Kong in 1996-97; Chairman of the Civil Division of Hong Kong Institution of Engineers in 1997-98; and as a member of the Institution of Engineers Sri Lanka Accreditation Board from 2014.

He is also the Founding Director of the Centre for Innovation in Construction & Infrastructure Development, Hong Kong and the Editor-in-Chief of the 'Built Environment Project and Asset Management' journal, both of which are supporting this 6th World Construction Symposium.

Furthermore, he is a Joint Co-ordinator of the international CIB Working Commission W122 on 'Public Private Partnership' which initiated the panel discussion on PPP at this Symposium.

## Panel Member



### **Ms. Amali Rajapakse**

Senior Infrastructure Specialist, World Bank, Colombo

Amali Rajapaksa leads the dialogue on PPPs as well as managing the transport portfolio in Sri Lanka. She joined the Bank in late 2003 as an Infrastructure Specialist covering the Bank's portfolio on transport, energy and water. During this time she has also been involved in the Bank's energy projects in India and Pakistan. Having joined at the inception of the Bank's involvement in the transport sector, she has contributed greatly to the growth of the transport sector within the Bank's portfolio in Sri Lanka where she has also been instrumental in bringing the first PPP in the road sector.

Prior to joining the Bank, Amali has worked for the Government of Sri Lanka at the Bureau of Infrastructure Investments which was responsible for facilitating private investment in to infrastructure projects. During this time she worked as Director (Power and Ports) specializing in providing financial advice on Public-Private Partnership (PPP) transactions for a period of seven years. In this capacity she has been involved in the negotiation of several independent power plants, the first PPP transaction in the Port sector as well as work associated with the restructuring of the Power Sector. Prior to this, she has worked for IBM in the United Kingdom.

Amali is a Fellow of the Chartered Institute of Management Accountants (UK) with a Masters degree in Business Finance from Brunel University in UK.

## Panel Member



### **Prof. Akintola Akintoye**

Dean, School of Built Environment and Engineering,  
Leeds Beckett University, UK  
Joint Coordinator, CIB W122 on Public Private Partnership

Professor Akintoye is Dean of School of Built Environment and Engineering at Leeds Beckett University, United Kingdom. He was previously Director of Research and Innovation of Faculty of Science and Technology and Dean of Grenfell-Baines School of Architecture, Construction and Environment at the University of Central Lancashire, United Kingdom. He holds the Chair of Construction Economics and Management. He was Visiting Professor to the Department of Civil Engineering, Asian Institute of Technology, Thailand and the Department of Building and Real Estate, Hong Kong Polytechnic University and a Distinguished Scholar of the University of Cape Town, South Africa. He is Fellow of both the Royal Institution of Chartered Surveyors and Chartered Institute of Building and Past Chair of the Association of Researchers in Construction Management. In addition, he is Editor-in-Chief of the Journal of Financial Management of Property and Construction. Professor Akintoye is Co-Coordinator of the World CIB Working Commission (W122) into Public Private Partnership.

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Professor Akintoye has continued to work very closely with industry in the UK and have established a robust international network of experts in many countries. He has served in various consultancy teams which have advised government institutions and private organisations on PPPs and PFIs across Europe and Asia. He has edited four published books in Construction Innovation and Process Improvement and Public Private Partnerships.

## Panel Member



### **Dr. Ashwin Mahalingam**

Associate Professor, Indian Institute of Technology (IIT), Madras

Dr. Ashwin Mahalingam joined the faculty in the Building Technology and Construction Management division of the Civil engineering department at IIT-Madras in 2006. Ashwin received his B.Tech. in Civil Engineering from IIT-Madras and then proceeded to Stanford University for a Masters in Construction Engineering and Management. He then helped start up an internet based company in the USA called All Star Fleet, aimed at providing asset management services for construction companies. Following this he returned to Stanford University to pursue a PhD in the area of Infrastructure Project Management. Ashwin's research interests are in the areas of Public Private Partnerships (PPP) in Infrastructure planning and management, and the management and governance of large engineering projects. Ashwin's current research focuses on institutional strengthening and post-award governance of PPP projects in India. Ashwin is also a co-founder of Okapi Advisory Services Pvt. Ltd. and serves as a Director on the Board.

## Panel Member



### Mr. Bradley Emerson

CEO, PPP Unit at Ministry of Finance, Sri Lanka

Bradley has been a career Banker prior to joining CIMA in May 2007, as the Regional Director, Middle East, South Asia and Middle East. He has worked with Commercial Bank as Senior Manager Operations, Nations Trust Banks as Head of Retail Banking and Pan Asia Bank as Deputy CEO.

Bradley received the Achievers Award in 2004, from the PIM, in recognition of outstanding achievements. He publishes management articles regularly in the papers and business magazines.

Bradley served as an Examiner for the National Quality Awards 1996 – 1998, and Bank Marketing for the Institute of Bankers of Sri Lanka, 2001 and 2003. He has been appointed at judging panels of MTI Consulting for “MTI Venture Start up Challenge” and Sri Lanka Institute of Marketing for “SLIM Brand Excellence 2010”. Bradley is an eminent Jury Member of DMA Asia ECHO Awards.

Bradley is a visiting faculty member of Faculty of Management Sciences, COMSAT University, Lahore, Pakistan.

Currently, he is working as the Director/CEO of the PPP Unit of Sri Lanka – Ministry of Finance, Sri Lanka.

## Panel Member



### **Mr. Arjuna Obeyesekere**

Senior Deputy Solicitor General, Attorney Generals Department, Sri Lanka

Having joined the Attorney General's Department as a State Counsel in January 1993, Arjuna is presently functioning as a Senior Deputy Solicitor General. Arjuna obtained his Masters Degree in Law in Commercial Law with Second Class Upper division pass awarded by the University of Cambridge in 1994. He has passed the final exam of the Sri Lanka Law College with Honours in 1991. Arjuna is an Attorney-at-Law of the Supreme Court of Sri Lanka since 1992.

As far as PPP's are involved, Arjuna has been involved in the negotiation of the Concession Agreement relating to the SAGT Terminal at the Colombo Port (1998), which was done on a PPP basis as well as with the South Terminal with the Chinese at the Colombo Port (2010) and the Port City Agreement (2016).

He has appeared for the Government of Sri Lanka and Government owned Corporations at several international arbitrations held in USA, UK and Singapore involving investment disputes (Mihaly International vs GOSL - 2001) and construction law disputes (Kumagai Gumi vs Road Development Authority - 2011).

## Panel Member



### **Mr. Kamal Dorabawila**

IFC Principal Investment Officer, Colombo

Kamal Dorabawila is a Principal Investment Officer at IFC, the private sector arm of the World Bank Group, which promotes development in emerging markets. He leads IFC's investments in Energy and Infrastructure in a number of countries in South Asia and has extensive experience leading project and corporate debt transactions as well as equity investments. Prior to relocating to Colombo (Sri Lanka) in 2012 where he is currently based, Kamal was based in Washington D.C. at IFC's headquarters for 13 years, leading transactions across the globe in oil and gas, power and transport sectors. He is a graduate from the Wharton School of Business at the University of Pennsylvania and also has a M.Sc. in Electrical Engineering from the Engineering School of the same University.

## Panel Member



**Prof. Steve Rowlinson**

Chair of Construction Project Management, The University of Hong Kong

Professor Rowlinson is the Chair Professor Construction Project Management at the Department of Real Estate and Construction at Faculty Architecture in the University of Hong Kong. He has spent the past 30 years researching construction project management, occupational health, safety and well-being in the Hong Kong construction industry. Current fields of interest are VR and serious video gaming in construction management and training and education.

**SYMPOSIUM ORGANISERS  
AND  
ASSOCIATE PARTNERS**



## SYMPOSIUM ORGANISERS

### **The Ceylon Institute of Builders (CIOB), Sri Lanka**



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 leading to gaining corporate membership of the institute.

[www.ciob.lk](http://www.ciob.lk)

### **Department of Building Economics, University of Moratuwa, Sri Lanka**



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.

[www.becon.mrt.ac.lk](http://www.becon.mrt.ac.lk)

# ORGANISING COMMITTEE

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<b>Symposium Secretariat</b>	Ms. Piumi Dissanayake Ms. Mathusha Francis Ms. Anushika Ekanayake Ms. Navodana Rodrigo Ms. Nethmin Pilanavithana Ms. Udara Ranasinghe Ms. Nipuni Wimalasena Mr. Udara Abeydeera Mr. Rohana Balasuriya Ms. Malathi Piyasena Mr. V. Ramanah

## SYMPOSIUM ASSOCIATE PARTNERS

### Liverpool John Moores University, United Kingdom



Ranked in the top 400 universities world-wide in the Times Higher Education World University Rankings 2013-14, the exceptional student experience Liverpool John Moores University offers is founded on high quality teaching, ground-breaking research and dedicated staff throughout the university.

[www.ljmu.ac.uk](http://www.ljmu.ac.uk)

### Centre for Innovation in Construction and Infrastructure Development (CICID), The University of Hong Kong, Hong Kong



The Centre for Innovation in Construction and Infrastructure Development (CICID) based at 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.

[www.civil.hku.hk/cicid](http://www.civil.hku.hk/cicid)

### Indian Institute of Technology Madras (IIT Madras), India



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 centres in various disciplines of engineering and pure sciences, with nearly 100 laboratories organized in unique pattern of functioning.

[www.iitm.ac.in](http://www.iitm.ac.in)

### Northumbria University, United Kingdom



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 10<sup>th</sup> in the UK in the Guardian 2017 and Property Management 7<sup>th</sup> in the Complete University Guide 2017. Quantity Surveying is one of our longest established degrees having commenced in the 1970's.

[www.northumbria.ac.uk](http://www.northumbria.ac.uk)

## Robert Gordon University, United Kingdom



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.

[www.rgu.ac.uk](http://www.rgu.ac.uk)

## Western Sydney University, Australia



Western Sydney University is a world-class university with a growing international reach and reputation for academic excellence and impact-driven research. It is ranked amongst the top three percent of universities in the world, globally focused, researched and committed to making a positive impact – at a regional, national and international level. It was established as a modern university in 1989 from its predecessors dating back to 1891. The WSU currently have over 40,000 students in a sprawling series of campuses across the Western Sydney region.

<https://www.westernsydney.edu.au/>

## CIB-W122: Public Private Partnership



CIB W122: Public  
Private Partnership

The CIB Working Commission on PPP was established in February 2017 to replace the former CIB Task Group TG72 - Public Private Partnership. The Commission will provide an international research and development platform for academics, practitioners and policy experts in the field at international, national and regional levels through seminars, meetings, other fora and publications.

[http://site.cibworld.nl/db/commission/browserecord\\_comnr.php?&commission\\_no=W122](http://site.cibworld.nl/db/commission/browserecord_comnr.php?&commission_no=W122)

## Colombo School of Construction Technology (CSCT), Sri Lanka



The CSCT was established in 2008, with the motto 'Sapientia et Doctrina', which is Latin for Wisdom and 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.

[www.csct.edu.lk](http://www.csct.edu.lk)

## **Built Environment Project and Asset Management (BEPAM): Journal, published by Emerald Group Publishing**



BEPAM provides, a unique one-stop forum that publishes peer-reviewed research and innovative developments in both project management and asset / facilities management of building and civil engineering infrastructure. The journal also targets important interface issues between the planning, design and construction activities on the one hand, and the management of the resulting built assets / facilities on the other. Launched in 2011, BEPAM is well established internationally, e.g., being encouraged by CIB, recognised by the Australian Business Deans Council and indexed in SCOPUS, EBSCO, INSPEC and the Emerging Sources Citation Index (ESCI) of Thomas Reuters.

[www.emeraldinsight.com/bepam.htm](http://www.emeraldinsight.com/bepam.htm)

# SCIENTIFIC COMMITTEE

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Dr. Thanuja Ramachandra	<i>University of Moratuwa, Sri Lanka</i>
Dr. Sachie Gunatilake	<i>University of Moratuwa, Sri Lanka</i>

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Ch.QS. Indunil Seneviratne	<i>University of Moratuwa, Sri Lanka</i>
Associate Prof. James Rotimi	<i>Auckland University of Technology, New Zealand</i>
Dr. Kanchana Ginige	<i>University of Northumbria, United Kingdom</i>
Ch.QS. Kanchana Perera	<i>University of Moratuwa, Sri Lanka</i>
Prof. Koshy Varghese	<i>Indian Institute of Technology, Madras, India</i>
Associate Prof. Lalith de Silva	<i>University of Moratuwa, Sri Lanka</i>
Prof. Mohan Kumaraswamy	<i>University of Hong Kong, Hong Kong</i>
Dr. Mohan Siriwardena	<i>Liverpool John Moores University, United Kingdom</i>

Dr. Motiar Rahman	<i>Institut Teknologi Brunei, Brunei</i>
Dr. Nayanathara de Silva	<i>University of Moratuwa, Sri Lanka</i>
Dr. Nirodha Fernando	<i>University of Northumbria, United Kingdom</i>
Dr. Raj Prasanna	<i>Massey University, New Zealand</i>
Prof. Sam Wamuziri	<i>A' Sharqiyah University, Sultanate of Oman</i>
Dr. Sepani Senaratne	<i>University of Western Sydney, Australia</i>
Assistant Prof. Sivakumar Palaniappan	<i>Indian Institute of Technology, Madras, India</i>
Prof. Srinath Perera	<i>University of Western Sydney, Australia</i>
Ch.QS. Suranga Jayasena	<i>University of Moratuwa, Sri Lanka</i>
Dr. Thilini Jayawickrama	<i>University of Moratuwa, Sri Lanka</i>
Dr. Udayangani Kulatunga	<i>University of Salford, United Kingdom</i>
Dr. Upendra Rajapaksha	<i>University of Moratuwa, Sri Lanka</i>
Dr. Wei Pan	<i>University of Hong Kong, Hong Kong</i>

# **SYMPOSIUM INFORMATION**

## **The 6<sup>th</sup> World Construction Symposium**

The symposium is on 30 June 2017 from 09.00 am to 05.30 pm and on 01 July 2017 from 08.30 am to 04.30 pm at the Galadari Hotel, Lotus Road, Colombo 01. The inauguration is held at Grand Ballroom, Galadari Hotel.

## **Fellowship and Awards Night**

The Fellowship and Awards Night is held on 01 July 2017 at Ramada Hotel, No. 30, Sir Mohamed Macan, Colombo 03 from 07.00 pm onwards. Foreign participants those who have requested transportation from Galadari to Ramada Hotel and the return, please assemble at the hotel lobby at 06.30 pm. The foreign guest will be transported back to the hotel at 10.30 pm from Ramada Hotel.

## **Symposium Secretariat**

Ceylon Institute of Builders (CIOB), 4-1/2, Bambalapitiya Drive, Colombo 04, Sri Lanka

Tel : 0094-11-2508139 (Rohana)

Fax : 0094-11-2508139

Email : [wcs.2017@yahoo.com](mailto:wcs.2017@yahoo.com)

Website : <http://2017.ciobwcs.com>

## **Language**

The official language of the symposium is English. There will be no simultaneous translation.

## **Dress Code**

Symposium - Business, Lounge or National

Fellowship and Awards Night - Smart Casual

## **Registration**

Symposium delegates can collect their materials at the registration desk, located at the Galadari Hotel. Opening times of the registration desk will be from:

30 June 2017 - 09.00 am to 05.30 pm

01 July 2017 - 08.30 am to 04.00 pm

## **Secretariat Room**

During the symposium, the secretariat room is located at the Salon Rose of Galadari Hotel, where the main symposium is being held. The opening hours of the secretariat will be from 08.30 am to 05.30 pm on 30 June and 01 July 2017.

## **Awards**

Following awards will be presented during the symposium Fellowship and Awards Night on 01 July 2017. Award winners will be announced during the symposium sum-up.

- BEPAM Best Paper Award (with a certificate and a prize of 12 months online subscription for the author(s))
- Two (02) BEPAM Highly Commended Paper Awards (with a certificate for the author(s) of each Highly Commended Paper)
- CIOB Best Paper Award
- CIOB Best Presenter Award

## **Certificate of Attendance**

A certificate of attendance will be issued to all participants, after the symposium sum-up.

## **Liability**

The organising committee is not liable for personal accidents, loss or damage to private properties of registered participants during the symposium. Participants should make their own arrangements with respect to personal insurance.

## **Disclaimer**

Whilst every attempt be made to ensure that all aspects of the symposium mentioned in this announcement will take place as scheduled, the Organising Committee reserves the prerogative to make last minute changes should the need arise without prior notice.



# **SYMPOSIUM PROGRAMME AND SESSION PLAN**

# SYMPOSIUM PROGRAMME

**Friday, 30 June 2017 at Galadari Hotel**

09.00 am	Symposium Registration	
09.30 am	Symposium Inauguration	<b>Grand Ballroom</b>
09.40 am	Welcome address by President, CIOB <b>Dr. Rohan Karunaratne</b>	
09.50 am	Address by Vice Chancellor, University of Moratuwa <b>Prof. Ananda Jayawardane</b>	
10.05 am	Address by Guest of Honour	
10.20 am	Address by Chief Guest	
10.35 am	Launch of “Construction Today” Magazine and Presentation of Symposium Proceedings	
10.40 am	Keynote Address on “Public Private Partnership for Health and Long Term Care of Older People: Ageing-in-Place” <b>Prof. Akintola Akintoye</b>	
11.10 am	Address by Editor-in-Chief, BEPAM <b>Prof. Mohan Kumaraswamy</b>	
11.30 am	Keynote Address on “The Carbon Imperative in the Built Environment Sustainability Agenda” <b>Prof. Srinath Perera</b>	
12.00 noon	Address by Representative from Associate Partners <b>Prof. Andrew Ross</b>	
12.10 pm	Vote of Thanks by Hony. Secretary, CIOB <b>Eng. Saliya Kaluarachchi</b>	
12.20 pm	Symposium Photograph	
12.30 pm	Lunch	

01.30 pm	<b>Parallel Session 1</b> <i>(There will be THREE parallel sessions)</i>	<b>Salon Orchid Salon Jasmine VIP Lounge</b>
03.15 pm	Tea / Coffee Break	
03.45 pm	<b>Parallel Session 2</b> <i>(There will be THREE parallel sessions)</i>	
05.30 pm	End of Day 1	

### **Saturday, 01 July 2017 at Galadari Hotel**

08.30 am	Registration	
09.00 am	<b>Parallel Session 3</b> <i>(There will be THREE parallel sessions)</i>	<b>Salon Orchid Salon Jasmine VIP Lounge</b>
10.30 am	Tea / Coffee Break	
11.00 am	<b>Parallel Session 4</b> <i>(There will be THREE parallel sessions)</i>	
12.30 noon	Lunch	
01.30 pm	<b>Panel Discussion on:</b> PPPs - The GOOD, The BAD and The OPTIMAL: Greening Potential, Grey Areas and Life-cycle Best Value  <b>Panel Members:</b> Ms. Amali Rajapakse Prof. Akintola Akintoye Dr. Ashwin Mahalingam Mr. Bradley Emerson Mr. Arjuna Obeyesekere Mr. Kamal Dorabawila Prof. Steve Rowlinson  <b>Panel Moderator:</b> Prof. Mohan Kumaraswamy	<b>Bougainvillea Ballroom</b>

- 03.15 pm      Tea / Coffee Break
- 03.45 pm      Rapporteur's Report by  
**Dr. Anuradha Waidyasekara**  
**Dr. Thilini Jayawickrama**  
**Dr. Michele Victoria**
- 04.00 pm      Announcing the Award Winners
- 04.15 pm      Vote of Thanks by Scientific Committee Co-Chairperson
- 04.30 pm      End of Programme

### **Fellowship and Awards Night at Ramada Hotel**

- 07.00 pm      Fellowship and Awards Night
- Liberty  
Ballroom**

## SYMPOSIUM SESSION PLAN AT-A-GLANCE

Friday, 30 June 2017							Saturday, 01 July 2017						
08.30 - 09.00	<b>Registration</b>						<b>Registration</b>						
09.00 - 09.15							<b>Session 3A</b>	S10031	<b>Session 3B</b>	S10008	<b>Session 3C</b>	S10060	
09.15 - 09.30								S10039		S10030		S10014	
09.30 - 09.45								S10058		S10038		S10051	
09.45 - 10.00	<b>Symposium Inauguration Galadari Hotel</b>						S10021	S10052					
10.00 - 10.30							Q&A		Q&A		Q&A		
10.30 - 11.00							<b>Tea / Coffee Break</b>						
11.00 - 11.15							<b>Session 4A</b>	S10006	<b>Session 4B</b>	S10035	<b>Session 4C</b>	S10028	
11.15 - 11.30								S10015		S10055		S10047	
11.30 - 11.45								S10033		S10053		S10057	
11.45 - 12.00								S10034		S10043		S10032	
12.00 - 12.15													S10044
12.15 - 12.30													Q&A
12.30 - 13.30							<b>Lunch</b>						
13.30 - 13.45	<b>Session 1A</b>	S10010	<b>Session 1B</b>	S10007	<b>Session 1C</b>	S10050	<b>Panel Discussion on PPPs - The GOOD, The BAD and The OPTIMAL: Greening Potential, Grey Areas and Life-cycle Best Value</b>						
13.45 - 14.00		S10017		S10048		S10037							
14.00 - 14.15		S10046		S10018		S10012							
14.15 - 14.30		S10063		S10056		S10029							
14.30 - 14.45		S10016		S10059		S10013							
14.45 - 15.15	Q&A		Q&A		Q&A								
15.15 - 15.45	<b>Tea / Coffee Break</b>												
15.45 - 16.00	<b>Session 2A</b>	S10023	<b>Session 2B</b>	S10049	<b>Session 2C</b>	S10022	<b>Symposium Sum-Up</b>						
16.00 - 16.15		S10045		S10064		S10061							
16.15 - 16.30		S10040		S10005		S10019							
16.30 - 16.45		S10062		S10027		S10054							
16.45 - 17.15	Q&A		Q&A		Q&A		<b>Fellowship and Awards Night Ramada Hotel</b>						
19.00 - 22.30													



# DETAILED SESSION PLAN

Friday, 30 June 2017

## Session 1A

**Theme** Project Financing, Investment and Procurement  
**Session Chair** Dr. Sepani Senaratne  
**Venue/Time** Salon Orchid – 01.30 pm – 03.15 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
01.30 – 01.45 pm	<b>S10010 - Special Purpose Vehicle (SPV) Model for Private Finance Initiatives for Large Scale Infrastructure Projects in Sri Lanka</b> <i>B.A.S.W. Chandrarathna, Vijitha Disaratna, S.M.N. Anuruddika and N.N. Wimalasena</i>
01.45 – 02.00 pm	<b>S10017 - Opportunities and Challenges Faced by the Sri Lankan Construction Companies in the Stock Market</b> <i>S.M.W.L. Siriwardhana, Vijitha Disaratna, S.M.N. Anuruddika and N.N. Wimalasena</i>
02.00 – 02.15 pm	<b>S10046 - Construction Industry Investment Challenges: Barriers for SME Expansion</b> <i>Iniya Sriskandarajah and Chandanie Hadiwattege</i>
02.15 – 02.30 pm	<b>S10063 - A Study on the Application of Economies of Scale in the Construction Industry: The Sri Lankan Perspective</b> <i>Thanuja Ramachandra, Devindi Geekiyanage and Sajith Lakshan Perera</i>
02.30 – 02.45 pm	<b>S10016 - Procurement System Selection Model for the Sri Lankan Construction Industry</b> <i>R.A.C. Chanudha, Vijitha Disaratna, S.M.N. Anuruddika and M.R.M.F. Ariyachandra</i>
02.45 – 03.15 pm	<b>Q&amp;A</b>

Session Coordinator : Mr. Udara Abeyadeera

**Friday, 30 June 2017**

**Session 1B**

**Theme**                                **Building Information Modelling**  
**Session Chair**                      Prof. Andrew Ross  
**Venue/Time**                         Salon Jasmine – 01.30 pm – 03.15 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
01.30 – 01.45 pm	<b>S10007 - Challenges of Transcending BIM Information from Design Phase to Real Time On-site Construction Phase</b> <i>M.K.C.S. Wijewickrama, H.S. Jayasena and M.R.M.F. Ariyachandra</i>
01.45 – 02.00 pm	<b>S10048 - BIM for Facilities Information Management</b> <i>K.A.D.N.C. Wijekoon, Anupa Manewa and Andrew Ross</i>
02.00 – 02.15 pm	<b>S10018 - Software Capabilities of Sri Lankan Architectural Professionals for BIM Adoption</b> <i>E.K.A.S. Kumara, H.S. Jayasena and M.R.M.F. Ariyachandra</i>
02.15 – 02.30 pm	<b>S10056 - IPD and BIM: Making Sense of Chaos?</b> <i>Steve Rowlinson, Wei Lu, Koh Tas Yong and Dan Zhang</i>
02.30 – 02.45 pm	<b>S10059 - Adaptability of Green BIM Technology for the Green Buildings in Sri Lanka</b> <i>H.W.T.P. Rathnasiri, H.S. Jayasena and Nadun Madusanka</i>
02.45 – 03.15 pm	<b>Q&amp;A</b>

*Session Coordinator : Mr. Sadith Chinthaka*

**Friday, 30 June 2017**

**Session 1C**

**Theme** Sustainable Systems and Technologies  
**Session Chair** Prof. Lalith de Silva  
**Venue/Time** VIP Lounge – 01.30 pm – 03.15 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
01.30 – 01.45 pm	<b>S10050 - Evaluating Innovative Technologies in Construction Industry: The Case of High Rise Buildings</b> <i>M.M.C.D.B. Manathunga and K.G.A.S. Waidyasekara</i>
01.45 – 02.00 pm	<b>S10037 - Applicability of Phase Change Materials (PCMs) for Peak Load Shifting of Air Conditioning and Mechanical Ventilation (ACMV) Systems of Office Buildings in Tropical Climates</b> <i>M.A. Wijewardane, S.A. Figurado, M. Kajaharan, N.D.A.M. Weerasinghe and R.A.C.P. Ranasinghe</i>
02.00 – 02.15 pm	<b>S10012 - Introduction of a Systematic Process for Building Control in Sri Lanka</b> <i>W.N.L. Fernando, B.A.K.S. Perera and M.N.N. Rodrigo</i>
02.15 – 02.30 pm	<b>S10029 - Design Process Standardisation for Building Projects in India</b> <i>Mathew Joe, Vijayalaxmi Sahadevan and Koshy Varghese</i>
02.30 – 02.45 pm	<b>S10013 - Embracing Adaptive Re-use of Buildings: The Case of Sri Lanka</b> <i>G.D.R. De Silva, B.A.K.S. Perera and M.N.N. Rodrigo</i>
02.45 – 03.15 pm	<b>Q&amp;A</b>

*Session Coordinator : Ms. Navodana Rodrigo*

Friday, 30 June 2017

**Session 2A**

<b>Theme</b>	<b>Health and Safety in Construction Projects and Built Environment</b>
<b>Session Chair</b>	Ch.QS. Suranga Jayasena
<b>Venue/Time</b>	Salon Orchid – 03.45 pm – 05.15 pm
<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
03.45 – 04.00 pm	<b>S10023 - Significant Management Practices Influencing the Occurrence of Workplace Injuries: The Case of Apparel Industry in Sri Lanka</b> <i>K.A.R.D.G. Samarasingha and Harshini Mallawaarachchi</i>
04.00 – 04.15 pm	<b>S10045 - Fire Safety in Residential Apartment Buildings for Low Income Residents in Sri Lanka</b> <i>M.R. Fathima, A.M.N.M. Adikari and Nayanthara De Silva</i>
04.15 – 04.30 pm	<b>S10040 - Investigation into Workplace Health and Safety Issues within the Australian Commercial Construction Industry's Migrant Workforce</b> <i>Swapan Saha, Srinath Perera, Richard Murphy</i>
04.30 – 04.45 pm	<b>S10062 - Reducing Accidents in Large Construction Projects in Sri Lanka</b> <i>Muththu Mohamed Anfas, L.D. Indunil P. Seneviratne and L.H.U.W. Abeydeera</i>
04.45 – 05.15 pm	<b>Q&amp;A</b>

Session Coordinator : Ms. Udara Ranasinghe

Friday, 30 June 2017

**Session 2B**

**Theme** Sustainable Construction and Assessment  
**Session Chair** Dr. Nirodha Fernando  
**Venue/Time** Salon Jasmine – 03.45 pm – 05.15 pm

**Time**

03.45 – 04.00 pm	<b>S10049 - Challenges in Maintaining the Green Certification in Sri Lankan Hotel Sector</b>  <i>N.H.M.W.W.C.P.K. Bandara, D.M.P.P. Dissanayake, Gayani Karunasena and Nadun Madusanka</i>
04.00 – 04.15 pm	<b>S10064 - Are Green Buildings Economically Sustainable? A LCC Approach</b>  <i>Achini Shanika Weerasinghe and Thanuja Ramachandra</i>
04.15 – 04.30 pm	<b>S10005 - Assessing Sustainability of Road Projects in Sri Lanka</b>  <i>H.N.M. Hapuarachchi and T.S. Jayawickrama</i>
04.30 – 04.45 pm	<b>S10027 - Involvement and Influence of Construction Professionals for Environmentally Sustainable Design Outcomes</b>  <i>J.D.I. Darshani, S. Gunatilaka and N.N. Wimalasena</i>
04.45 – 05.15 pm	<b>Q&amp;A</b>

*Session Coordinator : Ms. Mathusha Fransis*

Friday, 30 June 2017

**Session 2C**

**Theme** Risk and Disaster Management  
**Session Chair** Dr. Anupa Manewa  
**Venue/Time** VIP Lounge – 03.45 pm – 05.15 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
03.45 – 04.00 pm	<b>S10022 - Risk Management of Green Retrofitting Projects in Sri Lanka</b> <i>Indeewari Ranawaka and Harshini Mallawaarachchi</i>
04.00 – 04.15 pm	<b>S10061 - Through-Life Risk Management in Mega Projects</b> <i>Anupa Manewa, Tafadzwa Muza, Mohan Siriwardena and Andrew Ross</i>
04.15 – 04.30 pm	<b>S10019 - The Importance of Disaster Management and Impact of Natural Disasters on Hospitals</b> <i>Seyed Payam Salamati Nia and Udayangani Kulatunga</i>
04.30 – 04.45 pm	<b>S10054 - A Situational Paradigm on Flooding and Built Environment Interventions in the UK</b> <i>T. Wigglesworth, O. Adeniyi, K. Ginige and J. Pearson</i>
04.45 – 05.15 pm	<b>Q&amp;A</b>

Session Coordinator : Ms. Nethmin Pilanawithana





**Saturday, 01 July 2017**

**Session 3C**

**Theme** Construction Law and Dispute Resolution  
**Session Chair** Ch.QS Kanchana Perera  
**Venue/Time** VIP Lounge – 09.00 am – 10.30 am

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
09.00 – 09.15 am	<b>S10060 - Revisiting Causes of Disputes: Perspectives of Project Participants, Phases of Project and Project Characteristics</b>  <i>Mathusha Francis, Thanuja Ramachandra and Srinath Perera</i>
09.15 – 09.30 am	<b>S10014 - Gaps in Existing Apartment Ownership Law of Sri Lanka</b>  <i>K.D.M.S. Udayangani, Vijitha Disaratna, N.N. Wimalasena, Udara Ranasinghe and N.M. Pilanawithana</i>
09.30 – 09.45 am	<b>S10051 - TRIZ-DR Model for Dispute Resolution in Construction Industry</b>  <i>P.T.N. Gunasekara, Y.G. Sandanayake and E.M.A.C. Ekanayake</i>
09.45 – 10.30 am	<b>Q&amp;A</b>

*Session Coordinator : Ms. Pavithra Ranasinghe*

Saturday, 01 July 2017

**Session 4A**

**Theme** Infrastructure Project Delivery  
**Session Chair** Dr. Mohan Siriwardena  
**Venue/Time** Salon Orchid – 11.00 am – 12.30 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
11.00 – 11.15 am	<b>S10006 - Application of Client's Quantity Surveying Practices in the Power Sector in Sri Lanka</b> <i>D.G. Melagoda and T.S. Jayawickrama</i>
11.15 – 11.30 am	<b>S10015 - Comparison of Sustainable Materials for Railway Track Support Systems: A Literature Review</b> <i>S. Senaratne, O. Mirza and T. Dekruif</i>
11.30 – 11.45 am	<b>S10033 - Significant Factors Affecting Effectiveness of Community Based Organisations in Rural Water Supply Sector of Sri Lanka</b> <i>M.D. Rathnayake, Mahesh Abeynayake and Sadith Chinthaka Vithanage</i>
11.45 – 12.00 noon	<b>S10034 - Investigation into the Current Project Risk Management Practices within the Libyan Oil and Gas Industry</b> <i>Raeif Elhoush and Udayangani Kulatunga</i>
12.00 – 12.30 pm	<b>Q&amp;A</b>

Session Coordinator : Ms. Anushika Ekanayake

**Saturday, 01 July 2017**

**Session 4B**

**Theme** Culture and Attitudes  
**Session Chair** Prof. Swapan Saha  
**Venue/Time** Salon Jasmine – 11.00 am – 12.30 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
11.00 – 11.15 am	<b>S10035 - Computer Based Model to Change Occupational Safety &amp; Health and Energy Management Attitudes of Occupants in the Garment Industry</b> <i>A.D. Ratnasinghe, L.D. Indunil P. Seneviratne and Udara Ranasinghe</i>
11.15 – 11.30 am	<b>S10055 - Nature of Existence of Public Sector Construction Project Culture: An Exploratory Case Study</b> <i>Aparna Samaraweera, Sepani Senaratne and Y.G. Sandanayake</i>
11.30 – 11.45 am	<b>S10053 - Alcohol Consumption Patterns of Construction Workers in Hong Kong</b> <i>Steve Rowlinson, Yuzhong Shen and Tas Yong Koh</i>
11.45 – 12.00 noon	<b>S10043 - Predicting Unsafe Behaviour of Construction Workers</b> <i>N.H.C. Manjula and Nayanthara De Silva</i>
12.00 – 12.30 pm	<b>Q&amp;A</b>

*Session Coordinator : Ms. Nipuni Wimalasena*

Saturday, 01 July 2017

**Session 4C**

**Theme** Carbon and Energy Management  
**Session Chair** Dr. Kanchana Ginige  
**Venue/Time** VIP Lounge – 11.00 am – 12.30 pm

<b>Time</b>	<b>Paper ID, Title and Author(s)</b>
11.00 – 11.15 am	<b>S10028 - Ecological Footprint to Evaluate Environmental Sustainability of Apparel Sector Built Environments: The Sri Lankan Perspective</b> <i>B.J. Ekanayake and Y.G. Sandanayake</i>
11.15 – 11.30 am	<b>S10047 - Estimating Whole Life Cycle Carbon Emissions of Buildings: A Literature Review</b> <i>R.A.G. Nawarathna, Nirodha Gayani Fernando and Srinath Perera</i>
11.30 – 11.45 am	<b>S10057 - Carbon Hotspots of Office Buildings in the UK</b> <i>Michele Victoria, Srinath Perera, Alan Davies</i>
11.45 – 12.00 noon	<b>S10032 - Hybrid Renewable Energy as a Solution for Energy Crisis in Sri Lanka</b> <i>K.S.L. Mendis, K.G.A.S. Waidyasekara and E.M.A.C. Ekanayake</i>
12.00 – 12.15 pm	<b>S10044 - Use of Energy Retrofits to Reduce the Energy Demand of Existing Office Buildings</b> <i>T.L.W. Karunaratne and Nayanthara De Silva</i>
12.15 – 12.30 pm	<b>Q&amp;A</b>

*Session Coordinator : Ms. Achini Weerasinghe*

# **ABSTRACTS OF THE PROCEEDINGS**

**The 6<sup>th</sup> World Construction Symposium 2017**

**Theme:**

**What's New and What's Next in the Built Environment  
Sustainability Agenda?**

**Edited by**

**Dr. Y. G. Sandanayake**

**Dr. T. Ramachandra**

**Dr. S. Gunatilake**

**Building Economics and Management Research Unit (BEMRU)**

**Department of Building Economics**

**University of Moratuwa**

**Sri Lanka**



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# PAPER ABSTRACTS



# A SITUATIONAL PARADIGM ON FLOODING AND BUILT ENVIRONMENT INTERVENTIONS IN THE UK

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## ***Abstract***

Flooding in the United Kingdom (UK) is increasing in both frequency and severity, leading to huge social and economic cost consequences, despite which there seems to be limited data or research on built environment related interventions such as effectiveness of flood defence schemes across the UK. As the UK remains at the pinnacle of urban development, this study seeks to underline the inherent relationship between flooding occurrences and the construction industry related interventions. The study examined the effectiveness of flood defences in the UK, regarding their economic suitability, their physical effectiveness and how they are managed and funded by the UK Government. Case study research strategy was employed and interview was used as the data collection method in the case study. This study revealed that the underlying cause of increased flooding in the UK is due to several factors including; climate change and urbanisation. In terms of the physical defences built to protect the built environment, the study has shed light on the level of protection they offer, their cost effectiveness and how such schemes are financed. This study targeted the creation of a situational paradigm that could be transposed and generalised to enhance the understanding of flooding intervention in the UK and other urban environments.

**Keywords:** Built Environment; Defences; Disaster; Flood; Leeds; Paradigm.

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# A STUDY ON THE APPLICATION OF ECONOMIES OF SCALE IN THE CONSTRUCTION INDUSTRY: THE SRI LANKAN PERSPECTIVE

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## ***Abstract***

The application of economic concepts acts as a catalyst to enhance the productivity and quality in the industries such as automotive, transportation and tourism. Economies of Scale (EOS) is such a concept, which could be applied to address the above concern. This research therefore explored the application of EOS to the construction industry. The study adopted a qualitative approach by conducting structured interviews among 14 participants representing consultants and contractors in the construction industry. Subsequently, a content analysis was performed to analyse the data collected, with the aid of NVivo 11. Considering the views of experts, the application of EOS concept is limited to pre-cast elements in both building and civil engineering projects in the construction industry. Majority of the experts opined that application of EOS concept is limited in the construction industry mainly due to unawareness on applicability of EOS (71%) and unique nature of the construction industry (43%). Further, it was identified that uncertainties in the construction industry act as the major barrier to the application of EOS. Confirmation of drawings at the initial stage, conducting training sessions and researches are strategies to promote the use of EOS in the construction industry, which in turn would enable direct economic growth via price efficiencies.

**Keywords:** Construction Industry; Economies of Scale; Pre-cast Elements; Sri Lanka.

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# ADAPTABILITY OF GREEN BIM TECHNOLOGY FOR THE GREEN BUILDINGS IN SRI LANKA

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## *Abstract*

To raise awareness of green building constructions, Building Information Modelling (BIM) has been incorporated with unique sustainable strategies. Green BIM technology is a significant innovation of BIM, emerged through the integration of BIM with sustainable strategies, which enhance the sustainable growth of buildings while making better opportunities to improve the performance of green buildings. However, the utilisation of Green BIM technology for existing buildings is less amongst green building practitioners though Green BIM is widely used for design and construction phases of buildings. In the Sri Lankan context, since BIM is not implemented yet in building construction, operation and maintenance, the inherent capabilities of Green BIM technology are hidden and invisible. Thus, an effort is needed to convince and prove the importance of Green BIM technology for green building practitioners. Towards this effort, the research is aimed at identifying the potential of implementing Green BIM technology for the existing green buildings in Sri Lanka where BIM is not applied. Accordingly, a mixed research approach was followed to accomplish the research aim. Literature review revealed that, the data availability required for Green BIM techniques and tools is the critical requirement to implement the Green BIM technology for the established buildings. A desk study was conducted to determine the required data and availability of the data was analysed through a questionnaire survey and a case study. The findings of questionnaire survey demonstrated that, there is an acceptable level of data within the current established green buildings. The results of the case study highlighted the potential of Green BIM implementation for the existing green buildings. Thus, the study concluded by identifying the ability of incorporating Green BIM technology for the existing green buildings considering the real-life context which ensure the Green BIM implementation for the green building sector in Sri Lanka.

**Key Words:** Building Information Modelling (BIM); Building Performance; Green BIM; Green Building; Sri Lanka.

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# ALCOHOL CONSUMPTION PATTERNS OF CONSTRUCTION WORKERS IN HONG KONG

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## *Abstract*

Alcohol consumption is prevalent among construction workers, and it may have negative implications for workers' overall health, productivity, and safety performance. The alcohol-related risks are associated with drinking pattern and consumption volume. To understand the drinking pattern and help devise effective interventions to prevent drinking problem in construction workers in Hong Kong, the research team conducted a one-month drinking pattern survey with a convenience sample of construction workers on railway projects in Hong Kong, using the Alcohol Use Disorders Identification Test (AUDIT) as the primary instrument. With 1203 valid responses, the research team compared alcohol-related risk exposure among different categories of workers through Chi-squared tests. The results showed that 16.6% of respondents drink excessively, and 28% drink in a harmful way. Furthermore, male workers are prone to more severe alcohol-related risks than their female counterparts, Nepalese workers are exposed to more severe alcohol-related risks than their Chinese counterparts, workers in four trades (i.e., mechanics, welders, shotfirers, and miners) are more likely to experience alcohol-related risks than others, and workers in the age group of 30-39 are subject to more severe alcohol-related risks. The findings can help regulatory bodies formulate industry-wide codes of practice and prompt management to give special attention to certain categories of workers.

**Keywords:** Audit; Chi-squared Test; Construction Worker; Hong Kong.

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# APPLICABILITY OF PHASE CHANGE MATERIALS (PCMs) FOR PEAK LOAD SHIFTING OF AIR CONDITIONING AND MECHANICAL VENTILATION (ACMV) SYSTEMS OF OFFICE BUILDINGS IN TROPICAL CLIMATES

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## *Abstract*

Air Conditioning and Mechanical Ventilation (ACMV) Systems are often used to maintain the thermal comfort and the indoor air quality in office buildings in tropical climates. These ACMVs usually account for more than 50% of the total energy consumption of the buildings. Compared to other available technologies, use of Phase Change Materials (PCMs) has been identified as an attractive innovative technology to reduce the peak cooling load and also to shift the peak cooling load to after office-hours. Temperature of building envelopes constructed using conventional materials such as bricks and concrete tend to vary with the surrounding environmental conditions, as they only absorb or release the sensible heat. On the contrary, PCMs can absorb or release much larger amount of thermal energy from/to the surrounding as latent heat, while maintaining the building envelope temperature unaffected under varying environmental conditions. Thus, conventional building envelopes accompanied with PCMs are able to significantly reduce the external heat gains into the conditioned spaces of the buildings, resulting a significant reduction in the peak cooling load. This study is mainly focused on exploring the applicability of PCMs for hot and humid tropical climates. Numerical analysis supported and validated by an experimental program and a case study revealed that by covering exterior of building envelop with 5 mm – 10 mm thick PCMs can reduce the building peak cooling load by 8% - 12%. Moreover, it was found that the peak cooling load could be easily shifted to after office hours by increasing the PCM thickness. Economic analysis showed that the PCMs with higher thermal cycles reduces the pay back periods up to 2 – 3 years and, further supported the use of low-temperature PCMs for building applications. Findings of this study recommend to incorporate the PCMs on the building envelops of the sunlit walls to reduce the peak cooling load of the building with the aim of reducing the energy consumption by the ACMV system.

**Keywords:** Air Conditioning and Mechanical Ventilation (ACMV); Building Energy Consumption; Building Envelope; Peak Cooling Load; Phase Change Materials (PCMs).

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# APPLICATION OF CLIENT'S QUANTITY SURVEYING PRACTICES IN THE POWER SECTOR IN SRI LANKA

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## ***Abstract***

The effective use of Quantity Surveying practices is vital for the construction sector and its contribution to the overall economic growth and development of the country. With today's competitive economy, the profession has been identified as paramount in a broad range of development sectors. In Sri Lanka, Quantity Surveyors' involvement is limited to the construction stage of power generation and distribution projects as Consultant's Quantity Surveying and Contractor's Quantity Surveying practices. With the amplification of the power sector, cost and time overruns have been identified in power generation and distribution projects due to the absence of cost plans and the poor documentation of bids and contracts, leading to disputes, legal costs and poor administration of projects. Therefore, the involvement of Client's Quantity Surveyors in power sector projects has been identified as important. This is an emerging path for Quantity Surveyors to contribute their expertise in Sri Lankan public sector developments projects. In this context, the study investigated the applicability of client's quantity surveying practices in the Sri Lankan power sector. A mix research approach was adopted in the study including a preliminary survey and a questionnaire survey. The findings of preliminary survey were analyzed with content analysis technique. Data collected through questionnaire survey were analyzed using Relative Importance Index. It was identified that non-involvement of client's Quantity surveyors in the Sri Lankan power sector is due to the lack of recognition of the requirement of the profession in the sector and execution of duties demanding quantity surveying expertise by other professionals in the power sector.

**Keywords:** Client's Quantity Surveyor; Power Sector; Quantity Surveying.

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# ARE GREEN BUILDINGS ECONOMICALLY SUSTAINABLE? A LCC APPROACH

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## ***Abstract***

In the context of Sri Lanka, the number of green certified buildings is still at a minimal level and the reason could be attributed to green building investors who continue to perceive that green buildings are costly and the initial cost premium ranges from 20 to 25% and fail to appreciate the subsequent benefits in terms of running costs. However, in the global context, researchers have indicated that green building construction cost varies largely between -15 to 21% while only a little information is available on the status of operation and maintenance costs reduction. As part of the larger study which investigates the impact of sustainable features on life cycle cost of green buildings, this paper presents a comparison on life cycle cost of green certified industrial manufacturing building with that of a conventional building to establish the economic sustainability of green buildings. Quantitative data on the construction and running costs of green and conventional buildings were collected and analysed using Net Present Value. The analysis shows that the construction cost of green industrial manufacturing building is 28% higher than that of a conventional building while the reduction in running costs is 39%. Overall the green buildings offer an economic benefit of 50% savings over its life time. It is expected that the outcome of this research would contribute to the organisational learning of green built environment and thereby uplift the sustainable construction.

**Keywords:** Green Buildings; Green Rating Systems; Life Cycle Cost; Sri Lanka; Sustainable Features.

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# ASSESSING SUSTAINABILITY OF ROAD PROJECTS IN SRI LANKA

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## ***Abstract***

Road construction as a continuously evolving notion and a key player in nation's economy. It has been identified as causing a range of countless environmental, social and economic impacts. Hence, there is a dire necessity of Sustainability Assessment (SA) in road construction. Many developed countries have their own rating systems for assessing road construction although this is lacking in developing countries. However, a commonly accepted assessment method for road construction over its life cycle is not available up to date. Addressing these gaps, this paper presents a framework for SA in road projects in Sri Lanka pertaining to construction activities associated in road life cycle under the three pillars of sustainability; i.e. Environmental, Social and Economic. A comprehensive literature survey was executed exploring road sustainability impacts and measures globally. An expert survey was carried out under two rounds with three professionals in road construction and sustainability to verify literature findings, and to explore more sustainability impacts and measures in road construction in Sri Lanka. A framework was developed including 10 major road sustainability impacts, 13 sub-impacts and 29 measures in a hierarchical structure. A pairwise comparison was carried out for the elements in the framework distributing 32 questionnaires among professionals. Collected data were analysed using Analytic Hierarchy Process (AHP). Analysed results weighted each element with a score resulting "Standard of living" (0.2362) and "Resource usage" (0.2228) as the most significant impacts where "Measures of improving Accessibility" (0.1205) as the most significant measures in the framework.

**Keywords:** Life Cycle; Road Construction; Sustainability Assessment; Sustainable Development.

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# BIM FOR FACILITIES INFORMATION MANAGEMENT

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## *Abstract*

Successful adoption of Building Information Management (BIM) during design and construction phases is recurrent, and the benefits achieved through such adaptation has been encouraged to extend BIM in to other phases of construction including facilities management. However, a limited application of BIM in construction facilities management is noted. This paper reveals the potential use of BIM in FM phase, by giving more priority on 'value of information'.

The paper is based on a detailed literature review. The first section reveals the application of BIM in AEC/FM environments and second section discusses the industry standards and guidelines behind BIM in FM. The findings of the literature review explain that the key technological features attached to BIM drive for its wide application, however most of these features are tailored to design and construction tasks rather helping in FM tasks. A non-realisation of value of information is identified as a key issue for limited adoption of BIM in FIM. Therefore the paper recommends to identify the value of BIM in its complete sense (information, technology and process) to understand the FM information requirement and technical developments that is necessary for specific FM needs.

**Keywords:** Building Information Modelling (BIM); BIM Standards; Facilities Management (FM); Information Value.

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# BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION FOR MEP SYSTEMS IN BUILDINGS: A CONCEPTUAL FRAMEWORK

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## ***Abstract***

The challenge in coordination of Mechanical, Electrical and Plumbing (MEP) systems is a common problem peculiar to the MEP industry. Although the traditional Two-Dimensional Computer Aided Design (2D CAD) has been used in the industry to resolve the problem of coordination, it has not been effective. Therefore, the aim of this paper is to develop a conceptual framework for Building Information Modelling (BIM) that can be implemented in the MEP Industry. This will facilitate a seamless transition to BIM and solve the MEP coordination problem of the traditional 2D CAD project delivery approach.

The conceptual framework was developed and refined through an extensive review of the literature concerning BIM. The framework developed is a model based collaboration framework that will allow MEP firms to collaborate to produce the coordinated construction model during the MEP coordination process. The framework has the potential to be used as a practical methodology for guiding the MEP firms that intend to implement BIM.

**Keywords:** Building Information Modelling (BIM); Construction Industry; Framework; Mechanical, Electrical and Plumbing (MEP).

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# CARBON HOTSPOTS OF OFFICE BUILDINGS IN THE UK

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## ***Abstract***

Embodied carbon of buildings is receiving substantial attention due to the increasing statutory requirements on operational carbon of buildings. Even though the embodied carbon of buildings is not regulated at present there is a need to control embodied impacts of buildings because embodied carbon of buildings tends to increase as the operational carbon savings increase. Focusing on intensive emissions sources or the hotspots is an effective way of managing embodied carbon during the early stages of design though there is a gap with regards to the knowledge of carbon hotspots. Therefore, embodied carbon estimates of 28 office buildings in the UK were obtained and the carbon hotspots of buildings (in accordance with NRM element classification) were identified using the 80:20 Pareto Principle. Frame, Substructure, External walls, Services and Upper Floors were identified as carbon hotspots of the sample. However, findings do not support the 80:20 ratio in this case but propose a ratio of 80:36. In addition, the building elements were categorised into three types based on the probability of each element is being identified as a hotspot in the sample which is referred to as the 'carbon hotspot probability'. The elements that were categorised as 'Lead Positions' and 'Special Positions' are the elements with higher reduction potential compared to remainder positions and require more attention during the early stages of design to achieve maximum reduction in embodied carbon.

**Keywords:** Carbon Hotspots; Embodied Carbon; Office Buildings; Pareto Principle.

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# CAUSES OF ACCIDENTS IN HIGHWAY CONSTRUCTION PROJECTS IN OMAN

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## ***Abstract***

Construction workers are three to four times more likely than workers in other sectors to die from accidents at work. Construction is one of the main industries in Oman providing jobs to 18% of the total population and contributing around 10% of the total Gross Domestic Product (GDP). Considering the costs associated with accidents in construction, a model identifying the root causes of accidents is proposed for construction organizations in Oman. The model classifies the accidents in construction mainly arising from main four causes: "Equipment / Materials", "Workers", "Environment" and "Management". The model is applied to a road construction project in Oman to trace the root causes of accidents. It can also be applied to construction projects in other sectors such as building or process plant construction. The results of this investigation reveal that a substantial proportion of accidents (more than 41%) arise from the "Worker". The Management contribution is 31%, Equipment/Materials contribute 14% to the accidents and the Environment contribution is 12%. These findings are based on accident statistics that occurred on a single road project. Further research is recommended to extend the study to other projects in the construction sector in order to generalize the findings. Knowing the root causes of accidents will help organizations to develop effective strategies to reduce accidents in future projects. Although the frequency distribution of accidents is likely to vary from project to project, understanding the underlying pattern of their causes helps to pinpoint the key areas where resources should be directed in the organizations' efforts to deliver the goal of zero accidents.

**Keywords:** Construction Hazards; Health and Safety; Management.

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# CHALLENGES IN MAINTAINING THE GREEN CERTIFICATION IN SRI LANKAN HOTEL SECTOR

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## ***Abstract***

Green Certification towards the sustainable concept has become a remarkable area in the hotel industry. Sustainable concept is no more new for the hoteliers and sightseers seek greener of the accommodation prior to arrival. Green Certification is contributing towards creating an environment friendly hotel by integrating the sustainability concept. Most of the hoteliers perceive that the Green Certification is a marketing tool which increases the customer demand as well as profit. Also, it is kind of aggressive tools which can contribute to competitiveness in a successful manner. Some people are saying that the Green Certification is one of the energy saving mechanisms because it directly focuses towards energy saving aspects. Even though Green Certification is more important for the hotel sector, there may be some challenges when maintaining the Green certification. Therefore, investigating those challenges is an essential requirement for entire hotel sector towards the continuation of the Green certification. Hence, the aim of this study has been initiated to investigate the challenges in maintaining Green Certification in the hotel sector in Sri Lanka. A qualitative research approach was followed to investigate the challenges in maintaining Green Certification in Sri Lankan hotel sector and twelve individuals were interviewed from three cases to obtain data for the research. Semi-structured interviews were carried out as data collection method and the collected data were subjected to cross case analysis to investigate challenges. Eventually, the outcomes of this study demonstrated that there are several challenges in maintaining Green Certification and it was explored under five categories, namely technical, managerial, political and legal, environmental and biological, social and cultural.

**Keywords:** Challenges; Green Certification; Hotel Industry.

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# CHALLENGES OF TRANSCENDING BIM INFORMATION FROM DESIGN PHASE TO REAL TIME ON-SITE CONSTRUCTION PHASE

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## *Abstract*

Building Information Modelling (BIM) is a revolutionary paradigm which espouses modernization and innovativeness to the conventional Architecture, Engineering, Construction and Operations (AECO) industry. Successful BIM model is enriched with information which was congregated during design phase and such information should be circulated throughout the project life cycle without disturbing its originality. Nevertheless, when the complete BIM information is transferred to the site office, the on-site personnel are not absorbing the real essence of effective BIM information for on-site construction activities. Improvements in Mobile Computing Technology (MCT) have succeeded in linking this communication gap through forms of electronic pocketbooks, personnel laptops and Personal Digital Assistants (PDA). Despite the fact that, there is a greater push from technology, site personnel are not willing to accept it and they still prefer the traditional procedure. This discloses that site personnel are not prepared to practice such technologies due to their nature of Resistance to Change (RTC). Subsequently, the aim of the research is to identify the challenges of transcending BIM information from design phase to real time on-site construction phase.

To accomplish the aim, a qualitative research approach was followed, steering semi-structured interviews. The gathered information was analyzed rigorously through computer based content analysis. This topical study manifest that, all the recognized resisting factors extensively challenge the transcending of BIM information to the on-site construction phase. Hence, the research has successfully identified the challenges which barricade the transcending of BIM information to real time on-site construction phase.

**Keywords:** Building Information Modelling (BIM); Mobile Computing Technology (MCT); On- Site Construction; Resistance to Change (RTC).

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# COMPARISON OF SUSTAINABLE MATERIALS FOR RAILWAY TRACK SUPPORT SYSTEMS: A LITERATURE REVIEW

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## ***Abstract***

Timber transoms have been extensively used in the railway industry for decades and are considered the most efficient and effective in terms of reliability and performance for railway infrastructure transom components. However, many studies have raised concerns surrounding the future of sustainable use and cyclic maintenance and replacement requirement of timber transom's in railway infrastructure. Over the past decade, there has been significant research and development in alternative railway transom replacements using a variety of new materials. It is vital to develop a detailed understanding of existing and new alternative transom materials that are emerging into the railway industry and delineate whether these materials may be suitable as a sustainable alternative to traditional methods. Hence, the aim of this paper was to evaluate suitability of alternative transom materials as a substitute to existing transom materials in railway track support systems. The alternative materials considered were Precast Concrete and Composite Fibre Technology Panels against the conventional timber transoms. The paper offers a comparison between these materials through a literature review. It was concluded that the fibre composite alternative has the most beneficial alternative transom option and the railway industry could consider this material as an innovative, sustainable material for railway track support system.

**Keywords:** Fibre Composite Technology; Precast Concrete; Railway Track Support Systems; Sustainability Timber Transforms.

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# COMPUTER BASED MODEL TO CHANGE OCCUPATIONAL SAFETY & HEALTH AND ENERGY MANAGEMENT ATTITUDES OF OCCUPANTS IN THE GARMENT INDUSTRY

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## *Abstract*

Garment industry is one of the major contributors to the Sri Lankan economy. Nonetheless, productivity of the industry is crucially influenced by Occupational safety and health (OSH) and Energy management (EM) mal-behaviours. Even within the industry, behaviour of sewing machine operators are vital. It is noted that that industry is the second most contributor to the OSH accidents. Further, energy demand for the manufacturing is a major concern. In fact, it is notable that these two areas can be enriched by altering personnel attitudes, which will ultimately affect to the behavioural patterns. There are varieties of tools to change attitudes of people in order to change their behaviours. Computer models can be considered as a modern approach. Thus, this research focuses on current common behavioural issues and brings-up a computer model as a solution

Consequently, the research concludes findings obtained through preliminary investigation and a semi structured questionnaire survey that was conducted upon, behavioural issues and applicability of computer model respectively. Preliminary investigation consists of two surveys; expert opinion survey and structured questionnaire survey.

Ten number of issues were confirmed. Not wearing PPEs, poor sitting positions, removing safety devices of the machine and not switching off probe lights and machine were noted as top three significant issues. In computer model, top two accepted aspects were scoring mechanism and monetary gifts for winners.

**Keywords:** Attitudes and Behaviours; Attitude Change; Computer Based Model; Energy Management; Occupational Health and Safety.

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# CONSTRAINS IN INTEGRATING FACILITIES MANAGER IN THE PROJECT DEVELOPMENT PROCESS IN CONSTRUCTION INDUSTRY

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## ***Abstract***

The role of a Facility Manager is to optimize the building performance and ensure smooth operations. The importance of having a facility manager in the development phase of construction projects has been recognized by a majority of the construction companies around the world. Sri Lankan construction sector is yet to recognize the full potential of the Facility Manager, especially in fine tuning a construction project and thus ensuring better operations later. The aim of this research was to identify the potential roles of a Facility Manager and constraints in integrating a Facility Manager in building project development process in Sri Lankan construction industry.

In order to achieve the objectives of this research 9 semi structured interviews were conducted among FM and non-FM professionals of the building construction sector and 4 expert interviews were conducted among experienced building construction professionals. Through the interviews, it was identified that Facility Managers have several potential roles in a construction project such as facilities consultant, facilities manager, facilities advisor, facilities supervisor, maintenance advisor and lighting planner. Moreover, several constraints such as limited authority, financial constraints, communication lapses, lack of resources, cost variations and knowledge gap etc. which have restricted the involvement of a FM were recognized through the interviews. Finally, the expert opinions were used to recognize how to integrate the FM in to construction projects by mitigating the constraints and how to utilize the FM knowledge and competencies for building project development process.

**Keywords:** Building Construction; Construction Industry; Constraints; Facility Manager; Project Development Process.

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# CONSTRUCTION INDUSTRY INVESTMENT CHALLENGES: BARRIERS FOR SME EXPANSION

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## ***Abstract***

This research concentrates upon the requirements for expanding Small and Medium (SME) contractors into the level of large scale contractors and barriers for such. Adequate assets is a key requirement for succeeding in construction business. Construction companies have many physical and impalpable assets. Given the SMEs fulfil required asset levels, with proper management, it is possible for SMEs to expand over time and achieve the goal of becoming large scale organisations. However, improving the grades should not focus only upon turnover, yet various other resource and management requirements need to be met.

In order to identify the exact requirements of SME to large scale conversion, necessary asset level changes and barriers for such conversions were required to be analysed. A quantitative approach was taken in collecting field data and the data were collected through a questionnaire survey. Contracting organisations were considered as the unit of analysis and data were collected from 205 units with a response rate of 76%.

The research reveals the necessity of improving annual turnover, P&E, and staff assets of SMEs in reaching the large scale organisation level. In doing so; management issues, lack of finance and motivation, and employees with insufficient knowledge and skills are the critical internal challenges. The external barriers were identified as: high cost of capital, inadequate financial structure, changes in the government policies and the political unrest, and lack of information. Thereby overcoming the identified barriers will enable SME expansion, which will increase construction industry investment complementing the economic development.

**Keywords:** Asset Levels; Barriers; Construction Industry; Investment; SME.

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# DESIGN PROCESS STANDARDISATION FOR BUILDING PROJECTS IN INDIA

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## ***Abstract***

The effectiveness of the design process significantly influences the performance of a building construction project. In a complex design environment, the advent of compressed fast-track schedules can cause disruptions in construction. It is, therefore, imperative to allocate appropriate efforts during design to minimize these disruptions. Thus, a framework which guides organizations to develop a well-structured design process will ensure better project delivery.

A preliminary study revealed that design processes in Indian construction industry were generally unstructured. A more detailed study of the design processes of four Indian developer organizations mapped the current design processes as swim lane diagrams. Analysis of these processes showed that design at each organization was driven by certain priorities and the design stage durations varied significantly, especially in the concept design stage where these priorities have maximum influence. Based on the analysis, it is apparent that standardization within an organization/project type is required and more feasible, than a single industry-wide standardization of the process.

This paper also presents a preliminary SIPOC (Supplier, Input, Process, Output, Customer) methodology to internally standardize design process which is derived from the maturity levels recommended in the Capability Maturity Model framework. This methodology has been used to develop generic process charts from the design processes mapped for the organizations sampled. It is anticipated that the availability of these standards will enable better planning and monitoring of building design.

**Keywords:** Design Duration; Variability; SIPOC Methodology; Standard Process.

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# ECOLOGICAL FOOTPRINT TO EVALUATE ENVIRONMENTAL SUSTAINABILITY OF APPAREL SECTOR BUILT ENVIRONMENTS: THE SRI LANKAN PERSPECTIVE

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## *Abstract*

Accelerated human pressure on earth has necessitated adopting environmental footprints to evaluate environmental sustainability. Ecological Footprint (EF), Carbon Footprint (CF) and Water Footprint (WF) are common environmental footprints used to evaluate environmental sustainability globally. Although there is a growing interest for calculating CF and WF, there is a lack of application of EF for environmental sustainability evaluation in Sri Lankan apparel sector. Therefore, this research investigates the applicability of EF to evaluate environmental sustainability in apparel sector built environments in Sri Lanka. Research scope was limited to evaluate environmental impacts of energy consumption, water utilisation and waste generation in apparel sector built environments.

A qualitative research approach was followed to pursue the research aim. A comprehensive literature review was conducted to review the concept of EF and the relationship of EF with CF and WF. Subsequently, three apparel sector factories were investigated in detail to identify the nature of EF application in Sri Lanka and collected data was subjected to content analysis. Findings revealed that, even though EF is not currently fully calculated, it is partially evaluated through quantification of CF and Grey WF. It was also revealed that EF can be practiced to evaluate environmental sustainability in apparel sector built environments in Sri Lanka. Difficulty to understand the underlying assumptions of EF of water utilisation and EF of waste generation was identified as the main barrier. Providing training and awareness on the application of EF, raising awareness on calculating EF of water utilisation and EF of waste generation are some of the strategies to overcome barriers.

**Keywords:** Apparel Sector Built Environments; Carbon Footprint; Ecological Footprint; Environmental Sustainability; Water Footprint.

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# EMBRACING ADAPTIVE RE-USE OF BUILDINGS: THE CASE OF SRI LANKA

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## *Abstract*

As a result of the land scarcity, the ever-increasing demand for new constructions has caused a grave crisis in the construction industry. This has led to the inevitable demolition of the existing building stock. In many cities, there are malfunctioning or abandoned ancient buildings situated mostly in commercially significant locations. These buildings which narrate the evolution of their cities have become important, either for historical reasons or because of their cultural heritage. For any country, its existing building stock will be of significant economic, physical and socio-cultural value. Adaptive Re-use of Buildings (ARB) is the best option available to make optimum use of the existing stock. Developing countries still have not appropriately embraced this concept as in developed countries. Thus, the objectives of this research were to identify the key parameters, benefits, barriers and challenges related to ARB in Sri Lanka. A qualitative research approach was adopted to achieve this aim by conducting expert interviews on five case studies and semi-structured interviews involving 15 local expert professionals already practicing ARB to validate the expert interview findings. Content analysis was used to analyze the findings. Physical, social and economic considerations, building codes, regulations, lack of awareness on adaptive re-use opportunities and the scarcity of material and skilled tradesmen were identified to be the most frequently encountered barriers among which were further categorized under five major groups.

**Keywords:** Adaptiveness; Adaptive Re-use of Buildings (ARB); Barriers and Challenges; Existing Building Stock; Socio-Cultural and Environmental Benefits.

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# ESTIMATING WHOLE LIFE CYCLE CARBON EMISSIONS OF BUILDINGS: A LITERATURE REVIEW

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## ***Abstract***

Building sector has been increasingly recognised as one of the significant sectors which emits considerable amount of carbon to the atmosphere. Therefore, lowering carbon emissions of buildings has become an essential response to the global carbon reduction targets. In response to that, many efforts have been put forward in estimating and reducing carbon emissions in this sector over the last few decades.

Whole life cycle carbon of a building is considered as the total amount of operational and embodied carbon occurred throughout its lifecycle. A building life cycle consists of four main phases as product, construction, operation and end of life. Even though, many studies have examined the whole life cycle carbon emissions during the assessment zones of operational and detailed design, it was found no studies have been conducted to examine the whole life cycle carbon emissions during early stage of a design. However, it is believed that the carbon emission reduction potential is high in the early stages of a project. Accordingly, the aim of this paper was to review the existing literature on building life cycle carbon estimation in order to identify the reasons for the less focus on early stage life cycle carbon estimation and to learn further research aspects on life cycle carbon estimation. A comprehensive literature review was carried out referring secondary data sources to achieve this aim. It was found out that insufficient primary data and limited approaches in estimating life cycle carbon as a major reason for the less focus on life cycle carbon estimations in early stage of design. Accordingly, it creates the need of a rigorous approach for early stage life cycle carbon estimating.

**Keywords:** Buildings; Building Life Cycle; Carbon Emission; Life Cycle Carbon Estimation.

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# EVALUATING INNOVATIVE TECHNOLOGIES IN CONSTRUCTION INDUSTRY: THE CASE OF HIGH RISE BUILDINGS

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## *Abstract*

Construction industry is associated with risks and uncertainties, due to its nature. On the other hand, those risks and uncertainties have instigated the discovery of innovative technologies to eliminate risks and uncertainties. Although technologies in construction industry is being innovated to provide solutions for potential issues on time, cost, quality, and sustainability, past researches still emphasize that the construction industry is not yet developed as other parallel industries. In the post war period, Sri Lankan construction industry became vast and advanced with high rise building constructions. Land scarcity and high population growth are reasons for such tremendous development of high-rise buildings. However, the deficiency in the development of technologies in the construction industry does not fulfil modern necessities.

Therefore, the purpose of this research paper is to investigate the innovative technologies adopted in high rise building construction projects in Sri Lanka, for a successful completion within the budget, on time, and with adequate quality. A comprehensive literature review survey was performed to identify innovative technologies integrated in building construction industry during the design and construction development phases. Data were collected through eight (08) ongoing high rise building projects located in urban Colombo area, and these data were categorized according to the cases and presented as percentages among the projects. The results from the study revealed that the use of innovative technologies vary, and currently, common technologies are used during the design and construction phases. Further, the study identified identical benefits the client and the contractor can gain by using innovative technologies, and the challenges faced by industry stakeholders.

**Keywords:** Benefits; Challenges; High-rise buildings; Innovative technologies.

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# FACTORS AFFECTING SUSTAINABLE DESIGN IN ARCHITECTURE: PERCEPTIONS FROM TURKEY

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## *Abstract*

A significant portion of the scholarly contributions to the sustainable architecture debate falls into the 'eco-technic' stream of thought with its considerable emphasis on efficiency and high-technology as the solutions of environmental problems. This perspective, however, can be criticised for ignoring the interaction of a large set of contextual factors that surround the ongoing debate. As part of a research study which aims to develop a prediction model for the pro-environmental behaviours of architects as practicing professionals, a questionnaire survey was designed and delivered to the members of Istanbul Chamber of Architects. The measurement instrument had an open question: What are the factors that influence (hinder or facilitate) the development of sustainable solutions in architecture? Around 120 architects responded and these responses were qualitatively analyzed to identify the factors that influence their sustainability-related decisions. The findings suggest that while the client-related, economic and legal factors are especially critical to achieve targets, the adoption and implementation of sustainable solutions in the building industry require a thorough understanding of the interactions of individual, organization, inter-organization, and country-level factors. Decision makers who are responsible for designing sustainability policies and steering mechanisms in the building industry can be the main beneficiaries from a better understanding of such interactions.

**Keywords:** Architects; Building Industry; Sustainable Architecture; Sustainable Design; Turkey.

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# FIRE SAFETY IN RESIDENTIAL APARTMENT BUILDINGS FOR LOW INCOME RESIDENTS IN SRI LANKA

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## ***Abstract***

Fire risk is a critical matter to be considered in apartment buildings constructed for low income residents. Accordingly, management of fire safety carries a big role. However, it become a challenging task in these type of buildings due to residents' low income, educational level and social backgrounds. Hence, it is vital to evaluate the fire safety in such apartment buildings and to identify their issues. The research is focused to analyze gaps in the fire safety management. Thirty apartment buildings located in Colombo metropolis were selected for the study. Members of the management corporations were interviewed to gather data.

Finding showed that lack of knowledge and awareness, not having a proper fire safety system, lack of resources, less commitment of residents, lack of support from relevant authorities and poor maintenance practices are the most critical issues in fire safety management. Enhancing the fire regulation, increasing the awareness, implementation of proper fire safety management systems and construction technologies were identified as required improvements to fill the gap in fire safety.

Findings of the research can be considered to enhance the fire safety of apartments constructed for low income families.

**Keywords:** Apartment Buildings; Fire Safety; Fire Safety Management; High-rise Buildings; Low Income Families.

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# GAPS IN EXISTING APARTMENT OWNERSHIP LAW OF SRI LANKA

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## ***Abstract***

The concept of condominium has gradually increased as a solution for the housing demand in Sri Lanka through the past few decades. With the development of the condominium sector Condominium Management Authority of Sri Lanka was established as the governing body of both the private and public condominiums in country. The Apartment Ownership Law (AOL) was enacted as the regulation for the condominiums by Act No 11 of 1973. The Apartment Ownership Law has amended several times up to its last amendment in 2003.

According to many writers there are many issues raised in the condominium sector and the provisions provided in the AOL are not enough to solve those issues in several situations. Furthermore, lack of research could be found about the gaps in Apartment Ownership Law of Sri Lanka. Therefore, this research study was conducted in order to find the gaps which exist in the Apartment Ownership Law of Sri Lanka.

A comprehensive literature survey was carried out to find the theoretical background and Interview survey was carried out through experienced professionals in condominium sector as well as legal sector. According to the findings of the research there are gaps in provisions relating to many areas such as compulsory registration of condominium, common properties use and enjoyment, scattered housing properties, mixed development condominiums, developers obligations and sub management corporations. Finally, suggestions were made to rectify the identified gaps in AOL.

**Key words:** Apartment Ownership Law; Condominiums; Gaps; Sri Lanka.

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# HYBRID RENEWABLE ENERGY AS A SOLUTION FOR ENERGY CRISIS IN SRI LANKA

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## ***Abstract***

The global energy industry is at the edge of fundamental revolution where renewable energy plays a major role in responding to the challenges ranging from sustainability to environmental protection. However, the use of a single renewable energy source in producing energy has been reducing due to the inconsistency of resource streams. Consequently, the enhanced energy management strategies were developed by integrating renewable resources with a standby entity and hence hybrid renewable energy systems explored to the practice. Producing energy to unlimited increasing demand is a challenging issue currently faced by Sri Lanka. Although some studies have been performed for hybrid renewable energy systems, i.e. wind and solar across the world, this is an understudied area and thus, very little information is available in Sri Lanka. Therefore, the purpose of this paper is to examine the applicability of solar and wind hybrid renewable concept as a solution for energy crisis in Sri Lanka. A comprehensive literature review was conducted to identify the significance and the emergence of hybrid energy sources. Eight (08) semi structured expert interviews were conducted with information related to solar, wind, renewable energy sources, and hybrid systems, by adopting a qualitative research approach. Collected data were then subjected to content analysis in deriving the research outcome. The findings revealed positive perceptions on implementation of solar-wind hybrid renewable energy systems in Sri Lanka and the importance of intervention at policy level for the success. Lack of knowledge on hybrid concept and updated technologies, limited financial investments, and policy incentive dilemmas, were identified as few limitations.

**Keywords:** Hybrid Energy System; Renewable Energy; Solar Energy; Wind Energy.

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# INCORPORATING FACILITY MANAGERS INTO THE DESIGN AND CONSTRUCTION PHASES TO ENHANCE BUILDING PERFORMANCE

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## ***Abstract***

Facilities Management (FM) is a relatively new discipline that envelops many essential areas of the built environment. Facility Manager concerns both optimising building performance and ensuring success of the project. Direct incorporation of the Facility Manager into design and construction phases have potential to reduce many problems during the operational phase of buildings. However, many professionals are still unclear on the roles of Facility Manager in the design and construction phases and hence, their potential contribution during these stages. Therefore, aim of this paper was to investigate the potential for incorporating of Facility Managers into design and construction phases of building to enhance building performance. A critical review of literature was carried out for the purposes of understanding roles and essential functions of Facility Manager into design and construction phases.

The case study approach was used to identify the current involvement of Facility Manager into design and construction phases. Moreover, barriers that restrict the involvement of the Facility Managers in the design and construction phases in the current context are also identified. The findings of this research is useful to promote the incorporation of a Facility Manager into design and construction phases in order to enhance quality and performance of buildings.

**Keywords:** Construction Phase; Design Phase; Facilities Management; Facility Manager.

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# INTRODUCTION OF A SYSTEMATIC PROCESS FOR BUILDING CONTROL IN SRI LANKA

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## ***Abstract***

Building Control (BC) contributes significantly to the national economy as well as to the social wellbeing of the public of a country by ensuring the quality of its buildings and their health and safety, structural stability and energy efficiency and by imposing building rules and regulations related to the construction industry of the country. Building work must be properly regulated and monitored by the local authorities during the Plan Approval Process (PAP) by strictly adhering to the relevant building rules and regulations. However, BC in Sri Lanka is fragmented and not well managed due to the low involvement of professionals in the building work and poor supervision of building plan submissions and other related tasks. This condition has led to corruption and malpractices. Therefore, there is a vital need for professionals to get involved in the field, if the existing practises in Sri Lanka are to be changed. The aim of the research was to propose a suitable mechanism for building control in Sri Lanka which will have the involvement of professionals of the country. The effectiveness of the existing system was ascertained through the research objectives. A qualitative research approach was adopted to achieve the research aim through semi structured interviews conducted with 15 professionals coming under five categories. Content analysis was used to analyse the findings and to finally propose a suitable mechanism for building PAP by considering the existing process, identifying the weaknesses in the local practices so that the unfavourable impacts on the current PAP in Sri Lanka could be reduced and corruption and malpractices mitigated.

**Keywords:** Building Control (BC); Building Rules and Regulations; Corruption and Malpractices; Plan Approval Process (PAP); Professionalism.

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# INVESTIGATION INTO THE CURRENT PROJECT RISK MANAGEMENT PRACTICES WITHIN THE LIBYAN OIL AND GAS INDUSTRY

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## ***Abstract***

The continued increase in the world's population means increasing global energy demands. According to the best estimates available, hydrocarbons will be the main contributor to meet these energy needs. However, oil and gas projects pose significant risks. The literature shows that many projects in the industry fail as a result of improper risk management practices. This research paper focuses on Libya, an important player in fulfilling the world's energy demands, where the oil and gas industry is crucial to the national economy. Given the conditions existing in Libya, appropriate project risk management for the oil and gas industry needs is important. The aim of this paper is to investigate the current project risk management practices in the oil and gas industry in Libya. Thirteen semi-structured interviews with top managers, project engineers and advisors were undertaken to achieve this aim. The results show that awareness of the concept of project risk management is still very low in Libya and there is a lack of project management culture and risk management in particular. The paper also demonstrates that although these practices are already being applied to some extent, this relies on the prior knowledge and experience of specific individuals, rather than on a systematic, documented procedure. The lack of financial resources and the shortage of experienced and qualified personnel due to the country's current situation and as well as a lack of clear organisational vision within the oil and gas industry in Libya, all limit the implementation of effective project risk management.

**Keywords:** Libya; NOC; Oil and Gas; Project Management; Project Risk Management.

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# INVESTIGATION INTO WORKPLACE HEALTH AND SAFETY ISSUES WITHIN THE AUSTRALIAN COMMERCIAL CONSTRUCTION INDUSTRY'S MIGRANT WORKFORCE

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## ***Abstract***

Each year, there are approximately 12,600 workers compensation claims arising from the Australian construction industry, each representing an injury or health condition resulting in loss of productivity. In 2013–14, the construction industry accounted for around 9% of the Australian workforce, but accounted for overall 12% of workplace related fatalities. Previous studies have shown a high association between accident rates in the construction industry and the migrant workforce adversely impacting on social sustainability. The main issues faced by non-English speaking workers were language, cultural barriers, training barriers and communication. The migrant workforce is equivalent to roughly 24% of the construction industry's total workforce. Over 11% of workers originate from countries where English is the first language and 12.2% originate from non-English speaking countries. The aim of this study is to investigate the challenges faced by non-English speaking migrant workers including communication and cultural barriers, and to explore any potential impacts this may have on construction site safety as a key contributor in achieving social sustainability. It presents a detailed single case study that is representative of a typical case, a typical "project" among many different projects. Data is captured on everyday working conditions using a series of tripartite interviews (project managers, site managers and Workplace Health and Safety officers). Using the triangulation theory, multiple perspectives were sought instead of looking only from a single perspective to facilitate a deeper understanding of these issues. The research found many unsafe working practices endemic to migrant workers and that communication and language barriers faced by migrant workers have an adverse impact on site safety within the Australian commercial construction industry.

**Keywords:** Australia; Construction Safety; Migrant Workers; Workplace Health and Safety (WH&S).

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# INVOLVEMENT AND INFLUENCE OF CONSTRUCTION PROFESSIONALS FOR ENVIRONMENTALLY SUSTAINABLE DESIGN OUTCOMES

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## *Abstract*

Environmental sustainability is concerned with protecting and conserving both biodiversity and the environment, by reducing waste, preventing pollution and using water and other natural resources as efficiently as possible. Environmental sustainable objectives can be achieved by making appropriate decisions at the design stage with the involvement of different design professionals. Therefore, it is vital to attain the environmentally sustainable design target with the concept of integration. Integration is the combination of involvement and influence for decision making by design professionals. This integration should have to be executed at each stage of the decision-making process to achieve environmentally sustainable design outcomes.

Hence, the aim of this research study is to investigate the level of involvement and influence of construction professionals at the design stage in achieving environmentally sustainable design outcomes. Firstly, a literature synthesis was carried out to study the concept of integrated decision making. Subsequently, the process of decision making is identified from the literature synthesis. Then, a case study strategy was conducted to investigate the general involvement of key professionals for decision making in the design stage and to investigate the level of influence of professionals for decision making in the design stage

The findings revealed that Architect is the key decision maker and the professional who has the highest influence on decision making. Quantity Surveyors and Engineers have the second and third highest levels of influence for decision making at the design stage respectively.

**Keywords:** Construction Industry; Design Stage; Environmental Sustainability; Integrated Decision Making.

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# IPD AND BIM: MAKING SENSE OF CHAOS?

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## **Abstract**

Why is BIM not working? Where in the world do we really have IPD (integrated project delivery)? The U.K. has failed to achieve its Level 2 BIM goals. Hong Kong is striving to implement true collaborative contracting with pain share/gain share. Where really do the problems lie?

In a recent online article Boutle (2017) stated “Not all of the UK government central departments are BIM Level 2 ready despite being almost a year into the mandate.” and followed up with “Supply chain drivers for adopting BIM are mainly to satisfy the end client, not to look at internal benefits of improved information management, smarter working and gaining efficiencies.” So, one of the BIM-leading nations that was heading the drive to implement BIM on all government projects by 2016 has missed its target by some considerable distance. It is obvious from the evidence and rhetoric that BIM is not well understood, well accepted nor of value to many in the supply chain. Therefore, it is not the panacea for increased industry efficiency and effectiveness that it was held up to be. Why not?

What is really happening? We present a case study that explores current BIM implementation for MEP (mechanical, electrical, plumbing and fire safety systems) coordination in Hong Kong. Data were collected by ethnographic participant observation over 4 months and one-on-one interviews from a social network perspective. We found that BIM implementation in Hong Kong is currently at a low “maturity” level with little transformation of existing procurement routines and with professionals still following their traditional roles within project teams. Collaborative contracting and IPD exist on very few projects. Plans to add high-value professional expertise into project delivery through BIM-enabled IPD adoption are not working in Hong Kong’s construction industry. This is partly due to team members’ reluctance to change and the power conflicts (bolstered by arcane contract terms) between organisations in the teams thwarting collaboration. Professionals’ perceptions and attitudes towards BIM are embedded in the view they have of their social context. Power conflicts generated from hierarchical organizational structures and silo mentalities are a major challenge in implementing BIM-enabled IPD.

**Keywords:** BIM; Integrated Project Delivery (IPD); Process Innovation; Professional Silos; Socio-technical Systems; Social Network Analysis (SNA).

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# KEY REENGINEERING ROLES FOR THE SUCCESSFUL IMPLEMENTATION OF BUSINESS PROCESS REENGINEERING PROJECTS IN SRI LANKA

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## *Abstract*

To be highly competitive in present globalised economy, there is a decisive need for organisations to rethink and transform the prevailing business processes for improved quality and efficiency, reduced costs, and increased profitability. This leads to the introduction and evolvement of Business Process Reengineering (BPR) projects in various organisations over the past decades. Since BPR facilitates the organisations to enhance the performance of their business processes, despite the complexity and riskiness of BPR projects, it has spanned numerous industries. Regardless of the extensive adoption, in many instances efforts of BPR implementation has proved unsuccessful. BPR projects often tend to be large with long durations and tend to involve numerous stakeholders. It has been asserted that the selection and organisation of the people, who really do the reengineering, is key to the success of the endeavour. Accordingly, there is a necessity to identify the key stakeholders who should get involved in BPR projects to assure their success. Since the key stakeholders involved in each reengineering project may differ based upon the process being selected for reengineering, this study is aimed investigating the key reengineering roles for the successful implementation of BPR projects.

Altogether, four (4) BPR projects implemented within the last two years in four different organisations in the Western Province of Sri Lanka were selected as case studies to investigate the BPR roles. Findings revealed eight (8) reengineering roles that is needed to facilitate successful implementation of BPR projects in the Sri Lankan context. The functions to be performed by each role during the pre-implementation, implementation and post-implementation phases of BPR projects were also identified. The study revealed two reengineering roles: i.e. 'initiator' and 'reengineering facilitators'; not identified in literature, but were recognised as important in BPR implementation in the Sri Lankan context. In doing so, the paper brings forwards the findings with respect to the key reengineering roles to be involved throughout the BPR projects in the Sri Lankan context.

**Keywords:** Business Process Reengineering (BPR); Key Reengineering Roles; Key Stakeholders; Sri Lanka.

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# NATURE OF EXISTENCE OF PUBLIC SECTOR CONSTRUCTION PROJECT CULTURE: AN EXPLORATORY CASE STUDY

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## ***Abstract***

Cultural differences cause conflicts among construction project participants, deterring success of the project. Thus, understanding the nature of existence of construction project culture can assist in achieving better project management. An exploratory case study was adopted to develop propositions with this regard for further research purposes. The research was limited to study the culture of a public sector building construction project. Semi-structured interviews with nine key project participants and observation of two progress review meetings were used as the data collection techniques. As per the research findings, construction projects being temporary organisations, culture was basically emerged focusing on clearly defined project objectives. In addition, construction project culture could be emerged and transferred through continuous interactions and socialisations with the time. Thus, time became a concern for proper internalisation of the cultural aspects. Project members at high authority levels contributed more for emergence and transfer of cultural aspects. Shared behavioural norms were not much popular in the studied project culture. Highly differentiated professional sub-cultures such as; client, contractor and consultant were available. Fragmented behavioural norms were identified creating conflicting and paradoxical situations within the project. These findings can be further confirmed by replication in multiple case studies.

**Keywords:** Behavioural Norms; Construction Project Culture; Culture Emergence; Fragmentation; Sub-Cultures.

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# OPPORTUNITIES AND CHALLENGES FACED BY THE SRI LANKAN CONSTRUCTION COMPANIES IN THE STOCK MARKET

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## *Abstract*

In recent years, the social and technological changes originating from globalization, information revolution and knowledge-based economy fundamentally modified the construction industry environment. Local contractors need to originate a strategy to upgrade not only its technological capacity, but also the financial capacity to compete successfully in this landscape. Access to capital is one of the key strategic asset which contributes to the success of construction firms. This research focuses on to determine suitability of financing through the Stock Market for Construction Companies.

Survey approach was used to collect data. Mainly questionnaire was designed to identify the opportunities and challenges in the Stock Market for a Construction Company. Semi structured interviews were conducted to identify the strategies to enhance opportunities and face challenges in Stock Market. Preliminary survey was carried to structure the questionnaire.

The data gathered related to the Challenges were analysed using SPSS one sample t-test and IPA matrix. Simple graphical analysis methods and manual content analysis technique also were used to analyse data. A total number of 22 opportunities related to the Stock Market for a Construction Company were identified during the questionnaire survey and semi-structured interviews. Then identified the 17 challenges related to the Stock Market for a Construction Company. However, just only 4 number of challenges were identified as critical challenges. Mechanisms available to enhance opportunities and to face challenges in the Stock Market were investigated. Finally, identified that financing through Stock Market is a better opportunity for the Construction Companies in Sri Lanka.

**Keywords:** Construction Companies; Opportunities and Challenges; Sri Lanka; Stock Market.

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# PREDICTING UNSAFE BEHAVIOUR OF CONSTRUCTION WORKERS

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## ***Abstract***

The construction industry is known to be one of the most accident-prone of work sectors around the globe. Although the construction output is less in Sri Lanka, compared to developed countries in general, the magnitude of the accident rate in the construction industry is still significantly high. Most of the occupational accidents are due to the unsafe behaviour of the workers. Thus, studying the people-related factor in safety is an effective way to manage safety at work sites. This is a concept gaining more interest across industry sectors globally, and has the great advantage of needing the involvement of the individual employees. The paper therefore focused to investigate the factors influencing construction workers' unsafe behaviours and develop a model to predict unsafe behaviours based on those factors. The factors affecting construction workers' unsafe behaviour were identified through literature survey. Expert interviews were carried out to validate and generalize the factors found in literature, to the Sri Lankan context. Survey approach was used to collect data and the processed data were used to develop and train an Artificial Neural Network (ANN) model to predict unsafe behaviour of a construction worker. Then training and validation of the developed model under 7 design parameters was carried out using the data on influential factors of unsafe behaviour of 284 construction workers of C1 Building Construction sector. The data were applied to the backpropagation algorithm to attain the optimal ANN Architectures. The findings depict that the success of an ANN is very sensitive to parameters selected in the training process gaining good generalization capabilities in validation session. The model can be used to determine the unsafe behaviour level of construction workers and their safety training needs.

**Keywords:** Artificial Neural Networks; Construction Industry; Unsafe Behaviour.

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# PROCUREMENT SYSTEM SELECTION MODEL FOR THE SRI LANKAN CONSTRUCTION INDUSTRY

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## ***Abstract***

Construction procurement system involves processes of acquiring services and products for the project activities starting from investigation up to the completion. With the development of new concepts and technologies, construction procurement arrangements have also advanced. Erroneous selection of a procurement system usually leads project to failure. Although, several procurement selection tools have been developed to minimize the adverse effect of overwhelmed wrong selections, those tools are not widely used in Sri Lanka (SL). Hence, it is vital to propose a new Procurement System Selection Model (PSSM) which can overcome barriers of existing PSSM.

A qualitative approach was used to identify prevailing practices and barriers to practice existing selection methods. Decision charts were developed by assigning average utility values for functional grouping, payment method and pricing mechanism.

Accordingly, the preliminary procurement system selection framework was arranged which includes seven steps namely; appoint an independent advisor, identification of project brief, identification and prioritizing factors affecting selection of procurement selection, choose functional grouping and payment modality, presentation of options found in step four in ascending order, selection of procurement strategy by the client and selection of parties involved in the project. Ultimately, proposed PSSM in this study merge the existing selection procedure in SL in a manner that leads selection into its best position. The study further recommends timely modernization of decision charts with Average Utility Value (AUV) and procurement systems, since suitability of each procurement system to selection criteria may change with development of construction industry.

**Keywords:** Procurement System; Selection Criteria; Sri Lanka (SL).

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# PROMOTING FLEXIBLE WORKPLACE TO ENHANCE PRODUCTIVITY OF OFFICE WORKER

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## *Abstract*

To improve workforce productivity and to make major cost savings, various innovative workplace concepts are being utilised. A carefully planned workplace can have a significant impact on the performance of an organization. Even though the importance of flexible workplace towards increased productivity has been identified as a vital point in workplace planning and designing in Sri Lankan office context, there is a lack of research done on the enhanced productivity of office workers of public sector offices in Sri Lanka through the flexible workplace approach. Thus, this research was undertaken to study the relationship between productivity level of the employees and the flexible workspace design arrangements of workplace environment. Accordingly, the study was structured with a mix approach to accomplish the aim of this research. Literature revealed that flexible workplace approach relates to the concept of the physical layout and functional opportunities of the workspace which affect the office worker productivity and thereby conceptual framework was developed based on the literature findings. Through the case study approach, study identified the existing workplace practices. Expert survey was carried out to discover barriers, strategies which can be used in Sri Lankan office context when implementing flexible workplace approach. The gathered data were thereafter analysed using N-Vivo (2011) software. Finally, a framework was developed to promote flexible workplace concept in order to enhance productivity of the workers of Sri Lankan public offices. The framework could be useful for designers, planners and real estate developers to incorporate flexible workplace planning in Sri Lankan public office sector.

**Keywords:** Employee Productivity; Flexible Workplace; Office Buildings; Workplace Planning and Design.

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# REDUCING ACCIDENTS IN LARGE CONSTRUCTION PROJECTS IN SRI LANKA

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## *Abstract*

Construction industry is considered as one of the leading industries in Sri Lanka, which contributes a significant percentage to the economy. At the meantime, it causes wide range of impact on health and safety of worker. On the other hand, construction industry is well known as an accident-prone industry. Nowadays, large scale construction projects are commonly distributed throughout the world. Hence, it is highly important to ensure proper safety management in the building process with the rising complexity of the projects.

Different types of accidents, contributing factors to the accidents, causes for the accidents and control measure to reduce the accidents were identified through a literature review and it was substantiated through a pilot survey among five safety experts. Subsequently, a questionnaire survey was carried out among the safety practitioner who are involving with construction safety, to assess the pre-identified causes, strategies and mostly occurred construction accidents. A quantitative research analysis was carried out to assess the factors which are assess through pilot survey. Specially, RII was used for data analysis to prioritize the factors and one sample t-test was carried out to identify the significant factors by using SPSS. Finally, the analysis results were used to develop the framework. Sixteen different types of accidents, thirty-four causes for the accidents and thirty-five control measure/ safety practices were identified in this study. Among them seventeen causes and nineteen control measures were finalized as critical factors and those factors were used to develop final framework in order to mitigate the accidents in large construction projects in Sri Lanka.

**Keywords:** Construction Safety; Construction Site Accidents; Framework; Large Construction Projects; RII; Sri Lanka.

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# REVISITING CAUSES OF DISPUTES: PERSPECTIVES OF PROJECT PARTICIPANTS, PHASES OF PROJECT AND PROJECT CHARACTERISTICS

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## ***Abstract***

Dispute management is a proactive way to avoid disputes beforehand and resolve them effectively once disputes have materialised. Thus, dispute management should begin at early stage of project where different project characteristics are originated. On this note, the current research revisits the causes of disputes from different perspectives; project phases, project participants, and project characteristics. A comprehensive literature review was carried out by referring key research papers and books in the areas of disputes and related issues. Firstly, a total of 50 causes were identified and analysed using frequency count in order to identify the significant causes of disputes. Secondly, those causes were sub-themed into project participants, phases of project and project characteristics. The research revealed that the causes of variations, inadequate/incomplete drawings and specifications and payment delays are the most significant causes of dispute. Further, the research found that contractor is responsible for the variations and poor quality of work during construction stage of a project. The consultant is responsible for inadequate/incomplete drawings and specifications which occur during design and tendering stages. Client mainly responsible for payment delays during construction stage of a project and scope changes throughout the project. Thus, the identified causes have further clustered under project phases and responsible parties. The consultant, contractor, and client are contributing to disputes in terms of 11, 7 and 6 numbers of causes respectively. The study found that there is link between the key project characteristics and causes of dispute. Thus, the research identified around eight key project characteristics have influenced in certain causes of disputes. Thus, the review concludes that the disputes need to be addressed in every stage of construction project and by each party to contract. In addition, the review recommends that there is possibility to manage disputes through the view point of project characteristics at the early stage of construction projects.

**Keywords:** Causes; Dispute; Project Parties; Project Phases; Project Characteristics.

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# RISK MANAGEMENT OF GREEN RETROFITTING PROJECTS IN SRI LANKA

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## *Abstract*

The comparison made upon other developed and developing countries proves that green retrofitting projects are entirely new to the Sri Lankan construction industry. Green retrofit can be defined as an upgrade, extension and alternation, change the use of building, renovation of existing buildings. In such, partially or wholly occupied existing buildings are upgraded by integrating sustainable or green features to achieve its foremost benefits. However, green retrofitting of existing buildings are riskier than constructing a new building as where it requires a proper strategy to manage the risk. Hence, evaluating the risk in green retrofit projects is very helpful to construction industry as it may assist to get right decision about the project and also to effectively handle and manage it. Thus, this research aims to propose probable risk responsive strategies through a comprehensive risk assessment of green retrofitting projects in Sri Lanka.

As the first step in research process, thirty risk factors were identified by reviewing key literature relating to five major categories, such as, financial, market, industry, performance and legislative risks. The identified factors are evaluated through questionnaire survey which was conducted among forty experienced green professionals in three selected green retrofitting projects in Sri Lanka. The survey data are analysed based on its criticality by using descriptive statistical analysis techniques to identify high, moderate and low risk factors. According to overall results, ten risk factors are determined as 'critical' factors, such as, construction cost, inflation, energy saving uncertainty, warranty risk, delay in project completion, requirement of permits and their approval, design changes, procurement delay, damage to structure or property etc. Finally, risk responsive strategies are proposed to avoid, reduce, retain and/or transfer the identified risks of green retrofit projects as the final outcome of this research. Further, this research implies a way of ensuring an effective risk management of green retrofit projects in Sri Lanka and other developing countries.

**Keywords:** Green Retrofitting; Risk Assessment; Risk Responsive Strategies; Sri Lanka.

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# SIGNIFICANT FACTORS AFFECTING EFFECTIVENESS OF COMMUNITY BASED ORGANISATIONS IN RURAL WATER SUPPLY SECTOR OF SRI LANKA

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## *Abstract*

Water as a basic need of all humans, their ultimate expectation is to have health and well-being life fulfilled with social and economic development through getting access to use of safe drinking water. Subsequently, providing adequate drinking water to all poor living areas has become a major challenge in developing countries like Sri Lanka. Community engagement in rural water supply (RWS) projects should become essential as the client and end-users are not involved in the project management process during a typical project. Therefore, the aim of the research is to investigate the factors which are significantly affect for effectiveness of community based organisation (CBO) management in both client's perspective and community perspective.

A mixed approach was utilized for the study. A comprehensive literature review was intended to explore factors which are affecting for effectiveness of CBO management. Significant factors were observed through semi structured interviews based on Delphi technique to collect data on client's perspective. Questionnaire survey was carried out based on close ended questionnaires to collect CBO perspective data. Data was analysed via content analysis to generate qualitative outcome while RII technique was utilised to analyse statistical data.

Effective revenue, effective billing to collection ratio, effective CBOs' managerial level, effective stakeholder relationship and monitoring quality of water were identified as both perspectives agreed factors. The most significant factor on CBO perspective was considered as effective CBOs' managerial level while client perspective factors such as effective CBO involvement in operation and maintenance phase, development of CBO performance and relationship between National Water Supply and Drainage Board (NWS & DB) and CBOs was considered as most significant. Outcome of the study can be recommended to use as a tool before commencing the water supply project for aware about which factors are mostly assist to increase the effectiveness of CBO management.

**Keywords:** Community Based Organisation; Rural Water Supply; Significant Factors.

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# SIGNIFICANT MANAGEMENT PRACTICES INFLUENCING THE OCCURRENCE OF WORKPLACE INJURIES: THE CASE OF APPAREL INDUSTRY IN SRI LANKA

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## *Abstract*

Safety culture provides a basis to understand the state of safety in an organization. Further, it gives considerable contribution to the performance of the industry. The management practices; one of components in safety culture also creates a considerable influence on achieving safety. The reviewed literature proved that there is a relationship between management practices and workplace injuries. Workplace injuries can be identified as the bad consequences of the improper safety handling. However, most of the researches have not focused on in-depth investigation of management practices in safety culture and have not looked at the influence which is created on workplace injuries. Therefore, this study aims to identify the critical management practices influencing occurrence of workplace injuries in apparel industry in Sri Lanka.

The quantitative research approach was applied in this research. Questionnaire survey was conducted to collect the data. Nineteen management practices identified through literature are evaluated under six major categories, such as, management commitment, employee participation, training programmes, communication and feedback, hiring practices and rewards system. The questionnaire survey data were analysed using statistical software and Mean Weighted Rating was used to determine significant management practices. As per the statistical test results, nineteen significant management practices influencing occurrence of workplace injuries in apparel industry in Sri Lanka are determined. As the main implication, this research provides a basis for modelling the relationship between different management practices and the occurrence of workplace injuries and, for implementing best management practices in apparel industry in Sri Lanka.

**Keywords:** Apparel Industry; Critical Management Practices; Workplace Injuries; Safety Culture; Sri Lanka.

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# SOFTWARE CAPABILITIES OF SRI LANKAN ARCHITECTURAL PROFESSIONALS FOR BIM ADOPTION

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## ***Abstract***

Building Information Modelling (BIM) is a technological and attainable concept, which has upgraded the construction industry into a more diligent industry. It has globalized in a way, which make innovative, cost effective, energy efficient, sustainable and practicable products as well as faster and more effective processes. By the aid of various BIM software packages connected with different disciplines for various stages, this realisation could achieve more accomplishments. However, majority of practitioners of the construction industry only have competencies over the traditional software and this is also one of the major constraints for not applying BIM to the construction organizations. Therefore, construction practitioners must have proficiency over the competencies required for effective BIM products. Interestingly, there seems that many BIM tools have similarities to conventional tools. Software developers over the world have developed several BIM software tools for each of the disciplines which are currently involved in the projects. Majority of the recently completed BIM assignments have typically used software suites belonging to Autodesk software developers, as such there is high potential of using such suits in early BIM projects in Sri Lanka. Hence, this study aims to identify extent to which BIM like activities in conventional tools are practiced in the Sri Lankan industry. It synthesizes the findings of a literature review on software disciplines which are used in the BIM implementation by various professionals in each of the stages of project sequence. Through the desk study and the expert interviews a qualitative study conducted to identify the gap between 3D BIM modelling competencies with the current competency level of the Sri Lankan Architect. It was found that, working in Revit is more like building a building than drawing one. Further, the great thing about Revit is that all the objects work not the same as in AutoCAD. So if designer know how to place a wall in CAD, but designer can't place a wall in Revit. Because it use object oriented method. Fundamentals are just about the same, there are of course a few differences but can work through those fairly easily. According to the summary, can be concluded that Sri Lankan Architects much familiar about few of the task. But, the handling/performing such activities much differ than what they follow.

**Keywords:** Architects' Activities; AutoCAD; Building Information Modelling; Revit; Sri Lankan Architects' Competency.

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# SPECIAL PURPOSE VEHICLE (SPV) MODEL FOR PRIVATE FINANCE INITIATIVES FOR LARGE SCALE INFRASTRUCTURE PROJECTS IN SRI LANKA

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## *Abstract*

Sri Lankan infrastructure development funding take up a good portion from the country annual budget. To cover up the cost of infrastructure projects, Sri Lanka use foreign funds and loans along with domestic earnings. Due to this process continuation for a long time, Sri Lanka has now ended up with dependencies to other countries. This research focus on studying Private Financing Initiatives (PFI) as an alternate solution for loans and insufficient Gross Domestic Product (GDP). Identifying available alternative methods, assessing suitability on private financing and developing a suitable Special Purpose Vehicle (SPV) model to suit Sri Lankan industry is the main objectives of this research. Moreover what is PFI and how PFI was applied in other countries in their large-scale development projects, characteristics of PFI, how PFI can be attached with SPVs, what is an SPV have also studied using the available literature. In order to identify a suitable SPV in a PFI agreement, different types of SPV models has being compared. Further reasons for failure and rare existence of PFI in Sri Lanka, how PFI can be adopted to Sri Lanka, success factors, suitability of PFI and SPV, if a SPV is adopting to Sri Lanka how its relationships to be formed was identified by carrying out in-depth interviews. As conclusion, factors related to making a trend in PFI for project funding in Sri Lanka, government contribution in such projects and the need of change in government policies to bring up PFI contracts with a SPV, providing solutions for resisting PFI and leads to a successful adoption of PFI has being discussed.

**Keywords:** Large Scale Infrastructure; PFI; Project Financing; Special Purpose Vehicle.

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# STRATEGIES TO IMPROVE THE PRODUCTIVITY OF SITE LEVEL BUILDING CONTRACTORS IN SRI LANKA

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## ***Abstract***

The construction industry is widely recognised as a laggard in terms of productivity improvement. Site level construction productivity is a major influential factor to reduce the overall productivity in the construction industry. The main reason behind this is the critical site level construction productivity problems faced by Sri Lankan contractors. Therefore, aim of the study is to identify the possible solutions to enhance the site level construction productivity of building contractors in Sri Lanka. Accordingly, a mixed approach was used for the research. Initially, an extensive literature review was carried out to identify the site level construction productivity influential factors which was followed by a preliminary survey to investigate the critical problems influencing the site level construction productivity of contractors in Sri Lanka. A questionnaire survey was carried out to identify the most critical site level problems faced by the building contractors in Sri Lanka. Finally, expert interviews were conducted to identify the possible solutions to enhance the site level construction productivity of building contractors. Findings revealed that the most critical site level problems include worker skills problems, worker motivation problems, unavailability of skilled labours, and material management problems on sites. Accordingly, introducing proper training programs, implementing incentive, rewards and appreciation schemes as per the workers' performance, training unskilled workers, educating site workers on proper usage of materials are the possible solutions for the identified four most critical problems.

**Keywords:** Building Contractors; Construction Process; Construction Productivity.

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# SUSTAINABLE FACILITIES MANAGEMENT (SFM): A REVIEW OF PRACTICES AND BARRIERS

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## *Abstract*

Practicing sustainability helps Facilities Management (FM) professionals to reposition themselves from traditional FM to strategic support function. But embracing sustainability is challenging because FM scopes are firm specific and integrating sustainable practices are puzzling. Yet, incorporating sustainability into FM practice is seen as a great potential and FM professionals are identified at the forefront in delivering sustainability. However, only few FM professionals are able to embrace the sustainability concept into their operations due to various reasons such as; lack of capability, knowledge and skills, financial support and support from government being the major barriers as per theory. Hence, this paper focusses on identifying current FM scope with desired sustainable practices and explores the existing barriers to practice sustainable facilities management (SFM).

For that purpose, critical literature review was carried out exploring past indexed journals, conference papers and books etc. The findings revealed that, FM scope could be expanded among 15 support services among which building services and management, and real estate management were most commonly cited. In addition, SFM practices were identified in terms of achieving economic, environment and social sustainability. Herein economic sustainability contains 2 strategies and 8 practices, environment sustainability consist of 3 strategies and 11 practices while social sustainability includes 4 strategies and 15 practices. Moreover, existing barriers were examined to practice SFM and 32 sustainable barriers were identified. This showcase that FM professionals needs to focus on identifying firm specific FM scope and its sustainable practices by improving the capability.

**Keywords:** Facilities Management (FM); Sustainable Facilities Management (SFM); Support Services.

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# THE IMPORTANCE OF DISASTER MANAGEMENT AND IMPACT OF NATURAL DISASTERS ON HOSPITALS

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## ***Abstract***

The purpose of this research is to study and explore the importance of hospitals in natural disaster events and to identify the impacts on the hospitals in natural disaster events. A disaster is an unforeseen event, which can overwhelm the capacity of the affected people to manage its impact. Many people are periodically exposed to natural disasters in their life, and most disasters, or more correctly hazards that lead to disasters, cannot be prevented. However, their effects can be mitigated. Disaster management efforts aim to reduce or avoid the potential losses from hazards, assure prompt and appropriate assistance to the victims of a disaster, and achieve a rapid and effective recovery. It is crucial that hospitals remain safe and functional during and after disasters. Health facilities at all levels deserve special attention in the case of natural disasters as they must continue the work of current patient treatment within their facilities and provide additional care for persons injured by the disaster event. Disaster management becomes even more important for hospitals as the health sector has been particularly vulnerable to the damage caused. For this study, secondary information was retrieved from the Internet on sudden-onset natural disasters in different parts of the world was collected. This study found some barriers and deliverables for disaster managers that could mitigate the risk of a natural disaster's impact on a hospital. Accordingly, this paper evaluates the importance of disaster management for hospitals and the challenges that need to be considered during the disaster response.

**Keywords:** Hospitals; Impact; Natural Disasters; Mitigation; Strategy.

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# THROUGH-LIFE RISK MANAGEMENT IN MEGA PROJECTS

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## ***Abstract***

Mega Projects play a significant role in the UK construction industry. They provide infrastructure, business and employment opportunities for the nation. They are complex, and involve considerably high cost, and risk. Therefore, through-life risk management practices are considered as a mandatory consideration in mega projects. These risks arise in externally (political, economic, social, technological, environmental, legal, etc.) and/or internally (project, stakeholders, etc.), and the influence of such risks leads to a substantial cost overruns. Therefore, such risks need to be managed efficiently to endorse the project success. This study investigates the through-life risk management strategies that are adopted in the UK Mega Projects.

A literature review, four semi-structured interviews and a structured online questionnaire survey were the methods used to collect data. Interview data was analysed through NVivo and appropriate themes were developed. This was compared with the survey findings and conclusions were drawn accordingly. The findings explain that through-life risk management is a mandatory requirement in mega projects, and design and economic risk are the two most significant project risks that need to be addressed in advance. However environmental risks also play an important prerequisite role in mega projects. Findings further explain risk register as a mandatory requirement for mega projects, which provides the opportunity for the project to keep track of all risk whether they have happened, will happened or currently happen.

**Keywords:** Through-life Risk Management; Types of Risks, Strategy, Mega Projects; United Kingdom.

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# TRIZ-DR MODEL FOR DISPUTE RESOLUTION IN CONSTRUCTION INDUSTRY

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## *Abstract*

Conflicts and disputes are inevitable in the construction industry. This is due to the complex nature and the involvement of so many parties along the contractual chain, adversarial relationships, uneven risk allocation and uneven bargaining power. Different formal and informal Dispute Resolution (DR) strategies are currently being practiced in construction industry aimed at resolving disputes as effective as possible. But the major drawback of these strategies is the lack of innovativeness generated within their processes. In this background, significance of an inventive dispute resolution approach is emphasised.

As an inventive problem solving tool, TRIZ methodology has become famous in various fields such as Engineering, Manufacturing and Information Technology. TRIZ is primarily about solving technical and physical problems, but is now being used in solving many problems or situations. Hence, this study aims to develop TRIZ-DR model to resolve disputes in construction industry.

Accordingly, a mixed methods research approach was followed to achieve the research aim. A comprehensive literature review followed by semi structured interviews with seven subject matter experts were used to investigate the common construction disputes, existing dispute resolution strategies and their drawbacks, applicability of TRIZ based approach for construction dispute resolution and implantation procedure. The collected data were then analysed using code based content analysis and statistical mode in developing the TRIZ-DR model. The four phase model is a systematic procedure of abstracting problem, relating to TRIZ-DR matrix, interpretation, suggesting a solution, checking the feasibility of the solution and implementation to be followed at each phase. Therefore, this research offers a TRIZ-DR model to enhance inventiveness in construction dispute resolution, hence providing an effective dispute resolving mechanism.

**Keywords:** Dispute Resolution; Inventive Problem Solving; TRIZ Methodology; TRIZ-DR (TRIZ-Dispute Resolution) Model.

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# USE OF ENERGY RETROFITS TO REDUCE THE ENERGY DEMAND OF EXISTING OFFICE BUILDINGS

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## ***Abstract***

Continuous increase of energy demand is a common issue faced by people around the globe. Meanwhile, buildings have been identified as one of the major contributors for the ever-rising energy demand of the world. Consequently, buildings nowadays are built while giving more attention to the ways of reducing building energy demand. However, the existing buildings which are expected to occupy the majority of the total building stock for many years to come, are still being operated with a higher energy demand. Accordingly, building energy retrofits are identified as an efficient approach to reduce the energy demand of the existing buildings, and the aim of this research is to study the use of energy retrofits in office buildings of Sri Lanka.

The research approach was predominantly quantitative, which was followed by three case studies. A thorough literature survey was carried out to identify the prevalent retrofit techniques and the practicable enablers to enhance the use of energy retrofits. Findings of the literature survey was validated by a pilot survey before carrying out the questionnaire survey. Subsequently, three case studies were conducted to determine the costs and benefits of implemented retrofit techniques.

The results of the study showed that the use of energy retrofits in Sri Lankan office buildings sector is at a lower level. Further, the case study results depicted that the selected retrofit projects have generated significant energy savings which had led to better project feasibility. It was also established that the use of energy retrofits could be enhanced by implementing the identified enablers based on the perception of the building managers.

**Key Words:** Energy Demand; Energy Retrofits; Office Buildings.

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# WHAT DOES DEVELOPING LEAN CAPACITY MEAN?

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## ***Abstract***

There has been an increase in lean implementation in the construction industry during last few decades, but the progress has been hampered by several barriers. This is due to evidence that suggest the misconceptions regarding lean and its applicability to the construction industry. It appears that either the industry does not recognize lean as a capacity enhancing measure to contribute to bottom line success, and /or there is an inability to overcome the barriers that prevent the uptake of lean. Although, construction literature related to lean implementation barriers and solutions are available in the worldwide, there is a lack of research in capacities that excel lean. Hence, there are two major issues that need to be addressed. Firstly, an insightful discourse on what is meant by lean (as a means of capacity enhancing) is required. Secondly, type of capacities needed to overcome some of the barriers already identified in literature, is necessary. In developing this paper, the strong interconnectedness of both issues is recognized. In this regard, this paper will discuss the contextual aspects in relation to developing lean capacities necessary to overcome the barriers and to successful lean implementation in the construction industry. A literature review was carried out to discuss the unique characteristics of lean construction and reasons for lean implementation failure to identify the context of lean capacity. The findings revealed that, lack of capacities as the prevalent issue for construction companies to enable lean and these capacities need to be evidently defined for the successful lean implementation. Having considered the construction literature, lean capacity can be defined as the hard/soft resources of an organization which enable maximizing value and minimizing waste of a competitive organization. Lean capacities can divide into 2 categories as soft resources (attitude, capability, knowledge, experience, skill to direct or lead the change and improvements, strategic leadership, program and processes management and networking creation) and hard resources (dedicated employees' time, allocation of fund, means of communication, information, material, financial resources, machineries, technologies/methodologies, facilities and infrastructure) of an organization. These capacities will allow lean implemented construction organisations to be retained and excelled in lean. Hence, construction organizations need to establish lean capacities to maximize the lean performance and thereby increase competitiveness.

**Keywords:** Capacity; Lean Capacity; Lean Construction; Resources.

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# WORK STRESS OF FACILITIES MANAGERS IN THE SRI LANKAN CONTEXT

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## ***Abstract***

Work stress has become a global phenomenon in modern day workplaces. Sri Lankan organisations is no exception and Facilities Managers are increasingly encountering stress issues relating to work day by day. Facilities Managers work environment include both hard Facilities Management (FM) and soft FM functions which is complex and constrained by time, as they run to manage and support the operational functions of their core business. Hence the pressure on Facilities Managers to produce high quality results in limited time is severe. Thus the impact of this would be reflected on organisation's core business through unwanted loss in terms of cost and low quality services due to workload. Therefore, it is vital to address this growing issue in order to survive in today's competitive world and cultivate a healthy profession with good ethical standards. This study focuses on work stress of Facilities Managers working in Sri Lankan organisations. A comprehensive literature review was carried out and identified the factors influencing work stress of Facilities Manager. Questionnaire survey and semi-structured interviews were used as two separate techniques to explore how work stress of Facilities Manager impacts performance in an organization and to identify the manageability level of stressors by Facilities Manager. Research findings revealed the common problems associated with work stress of Facilities Managers such as contradictory requirements placed at work, multi-disciplinary task, keeping the workplace on top shape, hardly hear good comments from end user and high quantitative demand of work, reasons behind them, and strategies to mitigate work stress, while addressing potential barriers in implementing those strategies.

Keywords: Facilities Managers; Sri Lanka; Stressors; Work Stress.

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