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THE IMPACT OF DESIGN CHANGES ON APARTMENT PROJECTS' FEASIBILITY AND PROJECT PERFORMANCES IN SRI LANKA

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ABSTRACT

Design changes are inevitable in the construction industry. Among all, the consequences of design changes in apartment buildings are more crucial and evident with the existing salient nature of commercial aspects unlike in other building constructions. While the impacts of design changes on project performance have been investigated in usual building construction, there is a lack of focus on apartment construction projects and their reflections towards commercial behaviour. Therefore, this study aims to investigate the impact of design changes on project performance in terms of time, cost and feasibility in the case of apartment building construction in Sri Lanka. The research aim was achieved through the mixed-method approach. A questionnaire survey and expert interviews were conducted as data collection techniques. The impacts of design changes on project performance in apartment projects were identified by the questionnaire survey. Six experts were selected, who had experience in apartment construction projects for the semi-structured interview to investigate the reflections on financial feasibility. The quantitative data were analysed statistically and qualitative data from expert interviews were analysed using the code-based content analysis method. The findings of the research revealed that there is a significant impact of design changes on financial feasibility in apartment projects. Furthermore, ten strategies were proposed to minimise the impact of design changes on project performance and project feasibility, optimising both project performances and the feasibility of the apartment building projects for its whole life cycle.

Keywords: Apartment Building Construction; Design Changes; Financial Feasibility; Project Performance; Sri Lanka.

1. INTRODUCTION

The Sri Lankan construction sector is crucial for the country's development due to its forward and backward linkage with other industries. However, design changes pose significant challenges during project implementation (Perera et al., 2020). Such alterations, inherent in construction projects, impact overall project performance. These alterations, inherent in construction, adversely affect overall project performance

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(Olawale & Sun, 2010; Jaffar et al., 2011), contributing to time and cost overruns and necessitating costly rework (Enrica et al., 2021). Research by Aslam et al. (2019) indicates that design changes can account for potential cost escalations ranging from 5% to 40% of total construction costs. Hence it becomes clear that achieving financial feasibility in such conditions becomes challenging (Hau et al., 2018).

Over the past decade, Sri Lanka has witnessed numerous luxury high-rise apartment projects, with many more underway (Mayes, 2018). The dominance of apartment buildings in South Korea's construction industry, as highlighted by Sack and Goldin (2007), underscores the importance of the real estate sector in shaping the economy. However, construction and design errors often lead to substantial losses, necessitating expensive re-work and redesigns (Sack & Goldin, 2007). The frequency and extent of design changes in apartment buildings depend on various internal and external factors, such as project size, client preferences, participant expertise, construction costs, and project complexity. Apartment construction, characterised by uniform floor plans and interconnected buildings, magnifies the risk of design changes, as alterations in one area can trigger a chain reaction affecting multiple components such as public facilities, underground structures, parking lots, balconies, and rooftops (Lee, 2018). While design changes significantly impact project performance globally (Olawale & Sun, 2010; James et al., 2014), the Sri Lankan construction industry faces challenges in effective project management readiness (Perera et al., 2020). Timely completion, adherence to budget, and maintaining quality are crucial for apartment project success. Unlike other types of construction, the profitability and sustainability of apartment building projects depend heavily on how well project performance and project feasibility coincide with each other (Ndihokubwayo, 2008).

Previous literature has mainly focused on exploring the broader implications of design changes in apartment projects within the construction sector worldwide. However, there is a noticeable gap in the literature specifically addressing apartment projects in Sri Lanka. These projects, often high-rise and large-scale constructions, pose potential risks in terms of time, cost, and overall feasibility. Nevertheless, this raises the question of whether the impacts of design changes on project performance in apartment constructions worldwide are similar to those in Sri Lanka. Additionally, the relationship between the effect of design changes and the financial aspects of apartment projects has not yet been thoroughly explored. Thus, this study is aimed to investigate the impact of design changes on project performance and feasibility in Sri Lankan apartment construction. It is achieved via identifying the effects of design changes on project performance in construction and secondly by investigating the level of impact of design changes on time and cost performances and its' reflection on the project feasibility in apartment projects. Later, strategies are proposed to enhance apartment project performances. Initially, this study was conducted on time and cost project performance parameters whereas quality was not considered due to resource limitations.

2. LITERATURE REVIEW

The construction industry, with its myriad stakeholders and numerous variables including design changes, variations, and regulations, poses challenges in project management (Gharaibeh, et al., 2020). The following sections present the existing scientific knowledge within the domain of design changes in construction projects.

2.1 CONTRIBUTORY FACTORS FOR DESIGN CHANGES

Design changes in a construction project can occur at various stages and due to various factors. According to Alnuaimi et al. (2009), there are 31 factors affecting design changes in construction projects. Client adjustments and design changes were ranked as the utmost primary sources of variation orders in Omani public construction projects. Design changes are resulted from internal and external factors. Internal factors involve project stakeholders such as owners, design consultants, construction management consultants, and contractors. External factors included political, economic, and environmental issues, technological advancements, and the involvement of third parties outside the project's internal system (Yana, et al., 2015). Apart from the main factors mentioned above, problems on-site, design errors, and omissions are common causes of design changes in construction projects. These alterations stem from various sources, including owners altering plans, consultants' lack of collaboration, and contractors facing financial constraints or labour shortages. Additionally, shifts in regulations and economic conditions prompt design changes. Bassa et al. (2019) identified the main causes: lack of review, design errors, client plan changes, incomplete contracts, differing site conditions, design evaluator inexperience, and decision-making delays. Yap and Skitmore (2017) added drivers such as team shortcomings, poor workmanship, site constraints, safety issues, regulatory challenges, reworks, communication gaps, evolving end-user needs, and risk management flaws. Altogether, it is evident that the causes of design changes in apartment projects are rarely explored yet discussed in overall building construction.

2.2 EFFECTS OF DESIGN CHANGES ON PROJECT PERFORMANCE

Olawale and Sun (2015), and Ibbs et al. (2005) highlight that design changes significantly affect construction project performance across all stages, leading to potential adjustments in contract durations, cost, and scope of work. Design changes often necessitate rework (Sun & Meng, 2009), resulting in time delays and cost overruns which adversely affect the project performance (Ekambaram et al., 2014; Hui Yap et al., 2015). Despite their acceptance in the construction industry, design changes are seen as detrimental to project performance, primarily assessed through time and cost considerations. This study focuses specifically on identifying the impact of design changes on time and cost in apartment projects.

2.2.1 Impact on Project Duration Due to Design Changes

Design changes have emerged as a significant factor contributing to construction project delays, as highlighted in various studies. Memon et al. (2014) categorised delays into excusable and non-excusable, with excusable delays often attributed to design changes. In California, for example, design changes increased construction project durations by 69% across four tested projects (Chang, 2002). Similarly, delays in design approvals were found to impede project progress (Williams et al., 1995). According to Dosumu and Aigbavboa (2018), construction delays were identified as a major issue stemming from design changes. These findings underscore the substantial negative impact of design changes on project schedules, a consistent trend observed across studies worldwide.

2.2.2 Impact on Project Cost Due to Design Changes

The financial implications of design changes vary across projects and countries. Aslam et al. (2019), revealed that virtually every project undergoes a transition from design to construction. Studies have consistently shown that design changes inevitably lead to cost

overruns and specifically found that design changes are a primary cause of cost overruns, accounting for up to 40% of total project costs (Aslam et al., 2019). Chang (2002) reported direct cost impacts ranging from 2.1% to 21.5% of overall construction costs due to design changes. These findings underscore the universal challenge of cost overruns resulting from design changes, affecting projects worldwide (Aslam et al., 2019).

Likewise, past research extensively studies factors affecting design changes and project performance in overall construction whereas less attention is paid specific to apartment projects. This gap risks misleading generalisations when applying findings from broader construction studies.

3. METHODOLOGY

After considering the characteristics of this research and identified knowledge in the literature review, the data were collected using a mixed-method approach. The mixed methodology approach provides a comprehensive understanding of the research topic which allows the author to logically resolve the research problem. As there are wide range of attributes such as causes and impact of the design changes in Sri Lankan Apartment projects, a mixed methodology is required to fully capture the intricacy, interrelationships, and in-depth analysis of these variables both quantitatively and qualitatively. It is necessary to understand the financial aspects of apartment projects, the effect of design changes on project performance in terms of cost and time, and the feasibility aspects. Quantitative data provide measurable insights, while qualitative data offer in-depth understanding, making both essential for a comprehensive analysis. The general causes and impacts were identified through a comprehensive literature review and tested the applicability of those causes and impacts of the Sri Lankan apartment projects. Based on the findings of the literature review, a questionnaire survey was conducted to assess the impact of design changes on the project performance of apartment building construction in Sri Lanka in terms of time and cost. From the questionnaire survey, the literature review findings were validated. The survey included insights into procurement types, frequency of changes, and their effects on project performance, targeting professionals with apartment project experience. Data analysis highlighted the influential factors for project performance and viability. Identified causes and effects were further explored in expert interviews, leading to proposed strategies to mitigate design change impacts. Apart from that, different implications over financial feasibility owing to design changes were revealed. Quantitative data was analysed using the Chi-square method with adjustments made using Yates' theory for the 2x2 contingency table and Relative Important Index (RII). Subsequently, qualitative data were gathered from semi-structured interviews and analysed to assess the impact on project feasibility and performance in Sri Lankan apartment construction. Suggestions for overcoming the negative impact of design changes on project performance and feasibility were proposed. Qualitative data from semi-structured interviews were examined by the manual content analysis method, a qualitative research method that involves systematic coding and identifying patterns (White & Marsh, 2006). Finally, the conclusion of the study derived from inductive theory. Since the study was not committed merely from a single paradigm the believed philosophy is pragmatism.

4. DATA ANALYSIS

In this section, both the findings from the quantitative and qualitative analysis are presented. A total of 51 responses were received from a questionnaire survey with non-probability sampling method. Ten survey responses were rejected due to no experience in apartment projects. Interviews were conducted with six industry experts. Among the questionnaire respondents, 56% had over six years of experience in apartment construction, while all experts in the semi-structured interviews had at least seven years of industry experience.

4.1 QUESTIONNAIRE SURVEY ANALYSIS

The questionnaire survey involved Quantity Surveyors, Engineers, Building Information Modelling (BIM) Managers, Architects, and other relevant professionals with extensive experience in Sri Lankan apartment building projects. Their insights contribute significantly to analysing the data and addressing the research questions, particularly in identifying the impacts of design changes on project performance in this section.

4.1.1 Frequency of Design Changes

The survey delved into the frequency of design changes in projects by gathering insights from participants. Results revealed that 44% of respondents experienced four to six revisions per drawing, followed by one to three revisions as the second-highest frequency. Notably, a minority reported over six revisions per drawing. Remarkably, none of the participants reported encountering an apartment project without any drawing revisions. On average, drawings were altered between four to six times.

4.1.2 Causes of Design Changes

According to the diagram, the most common cause of design changes, cited by 32 out of 41 participants, was site conditions which is about 78% of the total, making it the most significant factor. Studies have shown that inadequate site conditions are major factors causing delays and cost overruns in construction projects. Errors and omissions in design, and scope changes by owners were the second and third most frequent causes indicating 25 and 26 out of 41 respectively. Surprisingly, only five respondents (about 12%) identified legislation and regulations as a factor. While these factors may be beyond the parties' control, they warrant attention for future predictions. Figure 1 illustrates the root causes of design changes in Sri Lankan apartment projects. Having said that, other causes that were listed in the literature were not selected.

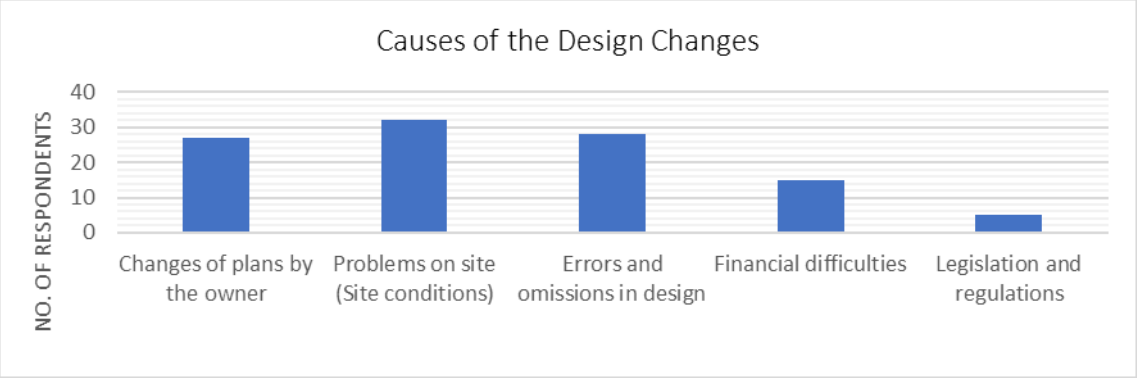

Figure 1: Causes of design changes

4.1.3 Impact Caused to the Time and Cost of the Project

Our research focuses on the effects of design changes in apartment projects, specifically on project performance in terms of time and cost. Figure 2 and Figure 3 illustrate the impact of design changes on time and cost in apartment projects in Sri Lanka. Analysis of questionnaire responses revealed that 24 respondents reported potential delays of 1-100 days in project completion due to design changes, accounting for 59% of total respondents. The second most common response indicated delays of 101-200 days, with 16 out of 41 respondents reporting this. According to the literature, design changes can significantly affect project costs (Aslam et al., 2019). To verify this in the context of Sri Lankan apartment construction projects, participants were specifically asked about the cost impacts caused by design changes. Regarding project cost, 21 respondents (51% of total participants) noted a 1% to 10% increase due to design changes. Additionally, 17 respondents reported cost impacts ranging from 11% to 20% in their apartment projects. Only three participants (7% of total participants) stated that costs were impacted by 21% to 30%, and none have experienced impacts exceeding 30% of the total project cost. This analysis highlights significant concerns regarding design changes in Sri Lankan apartment projects, which often lead to delays and cost escalations for developers. Figures 2 and 3 visually depict these impacts on project time and cost, respectively.

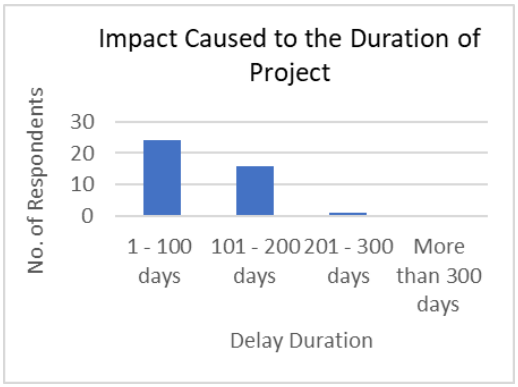

Figure 2: Impact caused to the cost of projects

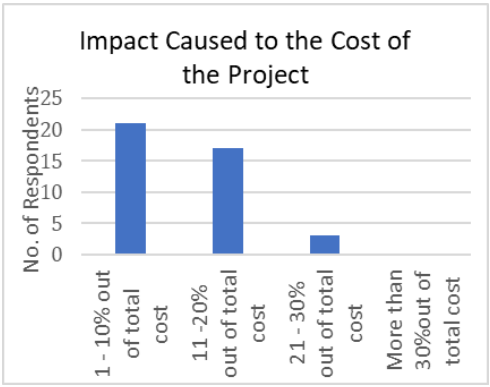

Figure 3: Impact caused to the duration of projects

4.1.4 RII Findings

The RII analysis shows that design changes significantly impact project performance in apartment buildings, with project duration having the highest RII value of 0.84, followed closely by project cost at 0.81. The slight difference indicates a correlation between factors causing time and cost overruns (Olawale & Sun, 2010), as summarised in Table 1.

Table 1: RII data analysis

	Ranking						
Factors	Most Significant	Significant	Moderate	In-Significant	Negligible	Weighted Total	
Time	16	19	4	2	0	172	0.839
Cost	13	18	9	1	0	166	0.810

4.1.5 The Commonly used Procurement Type for Apartment Projects

The questionnaire initially focused on gathering data about the contract type and procurement method used in participants' apartment projects. Results revealed that 70% of respondents preferred the design and build procurement method, with others opting for the traditional method. According to Davis et al. (2004) and Hewamulla et al. (2022), the traditional procurement method, despite its flexibility, often results in more client-initiated design changes, leading to time wastage due to design reworks. Understanding these prevalent practices is crucial for contextualising the study's findings and assessing factors that influence project outcomes, particularly the impact of design changes on project feasibility and performance.

4.1.6 Test of Association

Given that time and cost have been identified as the primary factors affected by design changes in apartment buildings, the test of the association focused solely on these two factors to examine their correlation with the following instances.

- Type of the procurement method of the project and the influence of project duration due to design changes
- Type of the procurement method of the project and the influence of cost due to design changes

After conducting the hypothesis testing from a test of association using Chi-Square distribution, below the results were achieved for each instance.

Procurement Method of the Project and the Influence of Project Duration due to Design Changes

Initially, the test of association for the influence of project duration due to design changes was tested. Table 2 presents the summary table of recorded data and Table 3 shows the Chi-Square calculation.

Table 2: Summary of observations

Delay in Project Duration			
Procurement Method	**1-100**	**101-200**	**Sum of rows**
Design and Build	17	11	28
Traditional	5	5	10
Sum of Columns	22	16	38

Table 3: Test of association for the influence of project duration due to design changes

Observations (O)				
O	17	11	5	5
Expected values (E)	16.211	11.789	16.211	4.211
O-E	0.789	-0.789	-11.211	0.789
O-E ı	0.789	0.789	11.211	0.789
O-E I - 0.5	0.289	0.289	10.711	0.289
(O-E)2	0.084	0.084	114.726	0.084
(O-E)2 /E	0.005	0.007	7.077	0.02

Defined hypothesis:

Ho – No association between the type of procurement method of the project and the impacted project duration due to design changes

H1 – There is an association between the type of procurement method of the project and the impacted project duration due to design changes

Since it has been a 2x2 contingency table and has at least one expected value of five, the Chi-Square analysis was conducted with Yate's correction for an unbiased continuity (Camilli & Hopkins, 1978). With a calculated Chi-Square value of 7.109, exceeding the critical Chi-Square value of 3.841 at a 5% significance level, the null hypothesis (Ho) can be rejected. This indicates significant evidence of an association between the type of procurement system and the incidence of project delays in apartment buildings at a 5% significance level.

Procurement Method of the Project and the Influence of Project Cost Due to Design Changes

Table 4 illustrates the summary of the observations and Table 5 shows the table for test association for the influence of cost due to design changes.

Table 4: Summary of observations

Impact on Project Cost			
Procurement Method	**1% - 10%**	**11% - 20%**	**Sum of rows**
Design and Build	16	10	26
Traditional	3	7	10
Sum of Columns	19	17	36

Apart from the set observations, there were another two observations recorded in the impact of project cost of over 20% in the design and build procurement method. Since its outliers with the central tendency of the data distribution, it was excluded from the further data analysis.

Table 5: Test of association for the influence of cost due to design changes

Observations (O)				
O	16	10	3	7
Expected values (E)	13.722	4.722	5.278	4.722
O-E	2.272	5.278	-2.278	2.278
|O-E|	2.272	5.278	2.278	2.278
ı O-E I - 0.5	1.778	4.778	1.778	1.778
(O-E)2	3.160	22.827	3.160	3.160
(O-E)2/E	0.230	4.834	0.599	0.670

Defined hypothesis:

Ho – No association between the type of Procurement method of the project and the impacted cost due to design changes

H1 – There is an association between the type of Procurement method of the project and the impacted cost due to design changes

As it follows the Chi-Square distribution, the critical value at 5% on one degree of freedom is 3.84. Since 6.332 is higher than this value Ho can be rejected at a 5% of significance level. Based on this analysis, it became evident that there exists an association between the procurement type employed in the project and the impact on project cost by design changes. Hence, it is apparent that both delays in project completion duration and construction project cost overruns are associated with various procurement systems, primarily attributed to design changes.

4.2 QUALITATIVE DATA ANALYSIS FROM EXPERT INTERVIEWS

The questionnaire survey findings provide concrete evidence of the impact of design changes on project performance in apartment construction. Through expert interviews, the discussion extended to the implications of these performance impacts on project financial feasibility. The data from the expert interviews was analysed across several theme codes: the impact of design changes on selling price, profitability, and the selling volume of apartment projects. Based on that, critiques on financial feasibility arising from project performance were identified and explored in apartment projects.

Table 6: General information of the participants

Code	Profession	Industry experience
R1	Architect	Over 20 years
R2	BIM Manager	Over 9 years
R3	Charted Quantity Surveyor	Over 8 years
R4	Engineer	10-15 years
R5	Senior Quantity Surveyor	Over 7 years
R6	Charted Quantity Surveyor	Over 10 years

4.2.1 Impact of Selling Price of an Apartment Unit

Design changes significantly affect the selling price of apartments, which have been repeated with high frequency in discussing the financial feasibility of apartment construction projects. Unlike other projects, apartment construction involves unique commercial considerations, with the unit price playing a central role in financial viability. This feasibility encompasses both project costs and return on investment. All the interview participants except R2 believe that unit prices are often adjusted to maintain financial feasibility amidst design changes. However, R2 contends that unit prices should remain fixed regardless of project cost fluctuations, only de-escalating if a project is delayed due to design changes and the demand for apartments decreases. All the other believed, that when design changes compromise a project's financial viability, adjusting unit prices becomes essential to restore feasibility. Additionally, R3 stated, "unit costs will only increase if buyers purchase the apartment units after the design changes occur; if purchased beforehand, the unit price remains unchanged". Based on that insight, it is safe to say design changes can impact the unit price of apartments in various ways. Consequently, the apartment construction sector often experiences increased apartment unit prices when financial feasibility is challenged by design changes.

4.2.2 Impact on Profitability of the Apartment

Profitability stands as a crucial determinant of successful completion in apartment projects, as their ultimate goal is to generate profits through unit sales. Interviewees, R2 and R4 concurred that profitability could fluctuate, potentially increasing or decreasing based on project size and circumstances. While one interviewee (R4) suggested profitability could generally be managed despite design changes, R3 highlighted a scenario where their company faced losses due to an inability to adjust selling prices, resulting in reduced profit margins. These perspectives underline the impact of design changes on profitability, which directly influences financial feasibility. Maintaining profitability within acceptable bounds is essential for achieving financial feasibility, as project profitability serves as a key benchmark. Thus, cost overruns resulting from design changes can jeopardise project profitability and, consequently, financial feasibility.

4.2.3 Impact of Selling Volume of the Apartment Project and Reflection on Financial Feasibility

The term "selling volume of the apartment" refers to the quantity of units intended for sale within a given apartment complex or development. Based on the majority of experts' interpretations, it was made clear that the selling volume can be impacted due to design changes in apartment projects. R1, R2 and R3 stated that project delays caused by design changes can threaten the market potentially reducing selling volume. R1 and R4 added that increased unit prices due to design changes can also affect the marketability and reduce the selling volume. However, R5 and R6 argued that design changes have less impact on units sold during construction, yet it can affect the units unsold or units about to be sold. The selling volume and rate of sales will also have an implication on profitability thereby on the financial feasibility, due to the fact that sooner the units are sold the better the chance of achieving payback. Furthermore, the investors generally forecast the Return on Investment (ROI) and demand levels based on the prevailing market condition with reasonable allowances to accommodate for risks. If the apartment units are unsold within the expected time, it may expose the project to greater risks and uncertainties that may jeopardise the financial feasibility. Being delayed for project completion places the property developers at risk of not achieving the intended ROI. Thus, may result in a lack of financial feasibility.

4.2.4 Strategies to Minimise the Impact on Project Performance and Project Feasibility in Apartments

To minimise the impact of design changes on project performance and project feasibility in apartment building ten strategies were scrutinised based on the data gathered by questionnaire survey and expert interviews. The underlying principle was to minimise design changes to lessen the impact on project performances. The given strategies are:

i. Site conditions should be investigated prior to the start of the project,
ii. Proper coordination between parties and the employees,
iii. Identify all client requirements within the design stage (clear project brief),
iv. The design should be in line with the feasibility study,
v. Testing procedures and feasibility should be done properly initially,
vi. Selection of highly recommended employees,
vii. BIM implementation,
viii. Maintain a proper risk management process,
ix. Solid base financial involvement, and

x. Provide provisions for customisation in early stages.

They emphasised the importance of site investigation before project commencement mainly. This is acknowledged in a study done by Wuala and Rarasati (2020) for developing countries. Additionally, improved coordination among stakeholders and employees was crucial to avoid misconceptions. This coordination facilitates timely discussions and implementation of solutions to address design changes thereby minimising their adverse effects. Miscommunication was identified as a significant risk factor. Moayeri et al. (2017) stated that, developing an automated BIM model to visualise and compare original and altered designs, aids in coordinating changes and analysing their ripple effects. Proper risk management practices, financial involvement, and provisions for customisation in the project's early stages were also endorsed in overcoming design changes.

5. CONCLUSIONS

Design changes in construction projects cause delays, cost overruns, and scope alterations (Olawale & Sun, 2015), negatively impacting timelines, expenses, and outcomes (Ekambaram et al., 2014; Hui Yap et al., 2015). Studies show these changes consistently increase project duration and costs, posing global challenges (Hui Yap et al., 2015). The literature review reveals that more focused studies on Sri Lankan apartment construction are needed to address the unique challenges and develop targeted solutions, as these projects frequently face design changes and higher risks. In Sri Lankan apartment construction, the Design and Build procurement method emerged as the prevailing choice as it is widely used offering flexibility to meet clients' preferences yet often leading to many design changes. Design changes are identified as a common occurrence, predominantly influenced by causes such as site conditions, design errors, and scope modifications. These alterations significantly impact project time and cost, with delays ranging from one to 300 days and cost overruns ranging from 1% to 20% of the project's total cost. Notably, the RII underscores the substantial influence of design changes on project time and cost. Expert interviews shed further light on the consequences of design changes on project financial feasibility. A linkage between the selling price, profitability, and selling volume of the apartment units was revealed, indicating that these factors collectively determine the financial feasibility of apartment projects. This emphasises the interconnectedness of pricing strategies, profitability margins, and market demand, all of which play pivotal roles in ensuring the economic viability of such developments. Potential strategies were uncovered through this research that would be helpful in curbing the negative impact of design changes on project performance and its' reflection on project feasibility in apartment projects in the Sri Lankan context. To overcome the design changes impact, the fundamental need is to minimise the design changes during the apartment construction. Through the study, the discussed insights can be utilised to look forward to the betterment of foreign apartment industries as well. More in-depth future research should delve deeper into the impact of design changes towards financial feasibility in apartment construction and reveal the correlated linkages such as causes of design changes and different procurement routes.

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