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# Toward Sustainable Construction Practices: Construction Management and Cost Overrun Mitigation Through Success Factors

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**ABSTRACT**

This research paper presents a comprehensive comparative study of cost overruns in construction projects within the distinct contexts of Malaysia and Saudi Arabia. It is important to recognize the causes of cost overrun and the successful factors in reducing cost overrun. Every country has different environments, cultures, types of projects, elevation styles, weather, and climates. Thus, it is meaningful to clarify the differences in each country's successful factors toward cost overrun reduction. Causes of cost overrun in Malaysia and Saudi Arabia was the main parameter. The quantitative method and the questionnaire survey approach were utilized. The data were collected from contractors G7 in Malaysia and contractors C1 in Saudi Arabia. The data collected was analyzed using the Statistical Package for Social Science (SPSS) software. According to the findings, there was an agreement in Malaysia and Saudi Arabia that design changes and order variation is the most mutually significant cause of cost overrun. The contractors in Malaysia have suggested the most significant factor to reduce cost overrun which is proper emphasis on the experience. While in Saudi Arabia, the contractors agreed that ensuring enough materials on the construction site to avoid project delay in the material procurement reduces cost overrun during the construction projects.

## 1. INTRODUCTION

Recently, Malaysia's construction industry has become a vital and productive sector. As a developing country, Malaysia recognizes the significance of the construction industry not only in economic growth but also in improving the quality of life and living standards. However, its projects often face cost overruns, representing negative cost variances where the actual cost exceeds the agreed contract cost [1]. These cost variances can lead to disputes, lawsuits, or, in extreme cases, project termination. Consequently, the primary focus for the contractors and project managers is completing projects within the budget to avoid conflicts and potential project termination [2].

The Saudi construction industry is a major and rapidly growing sector, playing a substantial role in the country's economy. Commencing in the 1970s and thriving in the early 1980s, massive infrastructure development projects aimed to modernize Saudi Arabia and address the country's infrastructure needs [3]. However, cost overruns are a common issue in the country's construction sector, negatively impacting project performance in terms of timeliness, cost, quality, and safety [4]. About 30% of construction projects in Saudi Arabia were accomplished on time and the stipulated budget [5]. Therefore, identifying the primary causes of cost overrun in construction projects in Saudi Arabia is crucial for overcoming this critical problem.

The primary objective of every construction industry is to complete projects within the agreed budget. Construction management services have two types of management: one universal to all nations with CM and the other specific to each country. The increasing internationalization of construction projects and businesses entering each other's economic areas has led to challenges, particularly in cost overrun issues. Therefore, it is crucial to clarify the differences in each country's success in cost management control and the factors reducing cost overruns in construction projects [6]. Malaysia is in Asia, and Saudi Arabia is in the Middle East; every country has different environments, cultures, roles, weather, and climates. Therefore, comparing two different countries in terms of costing systems is very crucial because the performance of a construction budget varies in many ways. Numerous studies have considered management criteria such as neighborhood, project type, owners, climatic conditions, elevation style, number of levels, and total floor space [7]. Aslam et al., [8] highlighted cost efficiency challenges in Malaysian construction projects, often plagued by overrun costs. Conversely, a notable lack of studies in Saudi Arabia addressing infrastructure and superstructure project performance, specifically the risk factors contributing to cost overrun in construction projects [3, 6]. Thus, the main objectives of this study are to study the causes of cost overruns in construction projects in Malaysia and Saudi Arabia and to compare the successful factors in reducing cost overruns during construction projects between Malaysia and Saudi Arabia.

This study is conducted in Saudi Arabia and Malaysia because Saudi Arabia and Malaysia's construction industries are essential contributors to the growth of the economies of both countries. Therefore, slight differences between the two countries are useful for exchanging factors and using them internationally in the construction industry. Malaysia's construction industry contributes approximately 3-4% to the national gross domestic product (GDP) and employs over 1.4 million workers [9], while Saudi Arabia's construction sector, with annual spending exceeding USD 120 billion, accounts for approximately 5-7% of GDP [10]. Malaysia has undertaken major infrastructure projects such as the Kuala Lumpur Metropolitan Area transportation networks and high-rise residential developments, whereas Saudi Arabia's transformation includes mega-projects like NEOM, the Red Sea initiative, and extensive urban renewal programs. These divergent project types and economic contexts—Malaysia's focus on traditional commercial and residential projects versus Saudi Arabia's emphasis on government-backed megaprojects—make this comparative analysis particularly relevant for identifying country-specific success factors. Furthermore, despite different economic scales, both countries report significant cost overrun issues (41.2% of Malaysian projects and 41-50% of Saudi Arabian projects exceed budget limits), justifying the comparative approach to extract universally applicable and region-specific mitigation strategies.

This research makes a substantial contribution to the field of construction project management by presenting a nuanced understanding of the successful factors in minimizing cost overrun. The comparative approach identifies commonalities and differences, offering a more comprehensive view of effective strategies. The contribution lies in the detailed data analysis collected from G7 contractors in Malaysia and C1 contractors in Saudi Arabia, providing specific, evidence-based recommendations for each country.

## 2. LITERATURE REVIEW

### 2.1 The Malaysian construction industry

The construction industry in Malaysia is known to be one of the key drivers of its economy. The construction industry plays an important role in the creation of wealth and the enhancement of quality of life, such as the construction of infrastructure for Malaysians. The construction sector significantly influences national economies and indirectly contributes to the country's economic growth by creating and giving opportunities for the unemployed [6, 9]. The developments of the construction industry in Malaysia are accomplished through hundreds of vendors, personnel, developers, government and private customer businesses, consultants, operators, engineers, architectural and surveying consultants, manufacturers, suppliers of materials, and plant hirers involved in its development [11, 12].

### 2.2 The Saudi construction industry

Saudi Arabia's construction industry thrives, with annual spending exceeding USD 120 billion. The government's substantial investments, constituting 40% of the economy, contribute to this growth. The construction workforce is categorized into international and immigrant-born domestic employees, with workers originating from nations like Egypt, Yemen, Pakistan, Turkey, and Bangladesh [10]. Furthermore, while attracting international businesses and experienced staff, Saudi Arabia's construction industry grapples with persistent challenges. Issues such as project delivery delays, cost overruns, design changes, cash flow problems, uncertainties in specifications and plans, equipment/material shortages, and increased maintenance costs remain unresolved. Unfortunately, construction projects in Saudi Arabia lack effective safeguards against cost overruns, with studies revealing that 41% to 50% of projects exceed their budget limits [13].

### 2.3 Cost overrun

According to Sarakbi [14], there are cost overruns in each building endeavor, and the extent varies significantly from project to project. It has led to the pressing need to reevaluate the significant issue of cost overruns throughout construction. Susanti and Nurdiana [15] reported that cost overruns are among the most important problems in building projects across the globe, and further study is required to find a solution. This problem is more serious in developed countries, as these overruns often amount to 100% of project costs. Like other nations, the construction industry in Malaysia and Saudi Arabia is also faced with various problems, such as delays in finishing the project on schedule, over-budgeting, building shortcomings, and over-reliance on foreign labor. Albtoush and Doh [16] highlighted that the cost overrun problem is a very significant issue, and more study should be done to address it since it is one of the most important difficulties that arise during building projects. It may lead to various problems, such as disputes and project termination. The main issue confronting the construction sector is the constant threat of cost overruns. Cost overruns, otherwise referred to as cost inflation or project overruns, are unintended expenses arising from an excess of expected costs attributable to the underestimation of existing costs in the form of budgeting [17].

### 2.4 Factors contributing to cost overrun in Malaysia

The primary factors leading to cost overrun in Malaysia are design issues and poor site management, notably influencing construction project costs and timelines. Design issues stemming from changes, approval delays, and contradictions in design documents are pivotal in escalating project expenses and extending timelines [12]. According to Afzal et al. [17], subcontractors have poor performance perform poorly; it is standard practice for contractors to allocate minor contract work to subcontractors. It is likewise unaffected by professional qualifications or obligations [17]. Unexpected ground conditions are another cause of cost overrun in construction projects in Malaysia since it is sometimes non-conceivable that the underlying survey neglects these troublesome conditions or that conditions have changed due to unfriendly climate conditions or changes in sub-soil conditions [14]. In addition, mistakes in the contract content may be associated with the designer's engagement as a consultant, communication breakdowns between the contractor and designer, insufficient information in the working drawings, and a lack of coordination among the parties [18]. Moreover, the major reasons for construction cost overruns in Malaysia are circumstances that might lead to construction corruption, such as delays in progress payments by owners, difficulty in financing projects by contractors, security, changes in the owner's order during construction, and market inflation [9, 19, 20]. Moreover, Keng and Adzhar [21] categorized contractor's poor site management and inadequate experience as the first rank among the factors that are contributing to cost overrun in construction projects in Malaysia since it is agreed by 90% of respondents by pointed it as the first rank during construction projects by considering it very critical for reducing cost overrun as its effects on productivity significantly and affect the overall progress of the project since it is related to main factors of cost overrun [22].

### 2.5 Factors contributing to cost overrun in Saudi Arabia

According to Abduljawwad and Almaktoom [23], cost overruns in construction projects are influenced by various factors. In the Middle East, causes include supplier manipulation, site accidents, and a lack of building pricing data. In Asia, conflicts among project members, illiteracy, and insufficient information contribute to overruns. Ogunnusi et al. [24] mentioned that the global impact of COVID-19 led to over 91% of construction projects being affected, with 51% partially stopped and 40% fully stopped. Frequent design changes during construction, technical issues like project location and inflation-affected pricing, poor cost estimation, and issues specific to the construction exacerbate cost overruns. In addition, factors such as a lack of supplies, material shortages, delivery delays, financial problems, and poor site management contribute to the problem in Saudi Arabia [25]. In most cases, technical issues such as project location, project scale, scope modification, and inflation-affected material and labor pricing have been recognized as key reasons, particularly in transportation and water projects; addressing these multifaceted challenges is crucial for effective project management and cost control in the construction industry.

### 2.6 Impacts of cost overrun on construction projects

Cost overruns impact important stakeholders, as well as the construction sector overall. The customer claims that cost overruns indicate spending that exceeds what was initially agreed upon, lowering investment returns. The end user bears the additional costs in the form of higher rental or lease rates or prices. Experts believe cost overruns indicate a failure to provide value for the money, which could damage their reputations and cause clients to lose faith in them [26]. It entails libel, which could harm the contractor's chances of getting future work or projects if they are found to be at fault and a loss of profit due to non-completion. Cost overruns could negatively impact the viability and sustainability of the construction industry if they lead to the project being abandoned, a decrease in construction activity, an adverse public image, a failure to secure financing for the project, or the need to obtain it at a higher cost due to greater hazards [27].

### 2.7 Successful factors contribute to reducing cost overrun in Malaysia

Controlling construction costs is one of the most important aspects of guaranteeing successful project delivery. Unfortunately, effective cost management is rarely practiced, and huge cost overruns are common [28]. Key factors for reducing cost overruns in construction projects include efficient strategic planning, proper project preparation and scheduling, effective site administration, regular progress meetings, and a focus on prior experience [28]. These strategies are essential for ensuring project success, facilitating efficient planning, and addressing issues based on lessons learned from previous projects [29]. As a result, if this policy is implemented as an organizational policy, it will help at all project stages. Keng and Adzhar [21] have also recommended using experienced subcontractors and suppliers: this factor is crucial in the physical implementation of the projects. Kamaruddeen et al. [1] highlighted that external factors crucial in preventing cost overruns in construction projects include proper communication between all parties and effective material management with early delivery of materials and equipment. In addition, effective project costing and funding are key to reducing building costs. A common challenge in project management is the need for clear purpose and guidance for many project managers [21].

Muhammad et al. [30] reported that a complete cost estimation and monitoring model has been developed for Building Information Modeling (BIM) and has shown much difference in reducing cost overruns. After integration with BIM, users may compare actual and planned costs for construction parts. In contrast, Keng and Adzhar [21] argued that comprehensive contract administration effectively reduces cost overrun if the construction project is implemented by following the contract guidelines and conditions. Hence, contract terms and conditions should be explained clearly to implement the construction project successfully. Ullah et al. [31] illustrated that having adequate materials on the construction site is one way to mitigate major causes of cost overruns and delays in material procurement for Malaysian construction projects. In terms of frequent design changes, they proposed some preventative factors that help to reduce cost overrun, such as appointing experienced designers and providing adequate time for the design stage [32].

### 2.8 Successful factors contribute to reducing cost overrun in Saudi Arabia

Successful cost overrun control starts with careful and good planning at the early stages of the construction projects; often, cost overruns happen because the project is not effectively planned at the early stages [33, 34]. A major and well-known contributing factor to cost overruns in Saudi Arabian building projects is imprecise or inadequate initial cost estimation. Appropriate project costing and finance provide the most important means of controlling building costs [35]. Alshihri et al. [34] highlighted some methods used to avoid cost overrun: proper cost estimation, up-to-date technologies such as modern Microsoft programs, BIM, and other new technologies such as robots. Abduljawwad and Almaktoom [23] highlighted that optimizing market conditions, such as material and labor price variations, can reduce cost overruns in Saudi Arabian building projects. They pointed out that the need for more clarity in government agencies' vision for future project details is a major source of cost overruns in the country.

According to the study by Bin Seddeeq et al. [36], careful planning and scheduling are essential for a satisfactory outcome in terms of cost overrun reduction, and appropriate management should begin at the start of construction projects. Aside from that, effective coordination efforts will lead to a considerable decrease in design time and cost. Furthermore, competent managerial professionals should be allocated to sensitive projects for adequate planning and constant monitoring to guarantee that the actual project duration and cost do not depart from the planned project. Periodic meetings should also be held to verify that all parties communicate effectively [33].

BIM creatively models construction details, offering comprehensive project information before construction. This approach simplifies digital design representation, and the data from BIM models is valuable for enhancing layout, organization, and construction processes [37, 38]. In addition, project managers should consider using BIM as a suitable tool for construction project management. In Saudi Arabia, BIM is an alternative technology that meets industry demands for improved cost and time management [30]. Moreover, Alshihri et al. [34] suggested preventive measures during the project planning phase, emphasizing the importance of prior experience, regular communication, hiring qualified suppliers and subcontractors, and effective contractual management.

### 2.9 Technological interventions in cost overrun mitigation

The construction industry faces persistent challenges related to cost overruns, which significantly impact project efficiency, timelines, and profitability. Technological advancements have emerged as critical tools for mitigating these issues, enabling construction stakeholders to address inefficiencies, enhance collaboration, and optimize resource management. This section explores the role of technological interventions in reducing cost overruns, with a focus on their implementation in Malaysia and Saudi Arabia.

**The Role of Technology in Construction**

Technological innovations have revolutionized the construction industry by introducing tools that improve precision, reduce delays, and enhance overall project performance. From BIM to Artificial Intelligence (AI) and Internet of Things (IoT), these advancements provide construction managers with real-time insights and predictive capabilities to manage costs effectively [39].

**Key Technologies and Their Impact**

Table 1 highlights the key technological interventions and their contributions to cost overrun mitigation. Each technology addresses specific challenges while offering significant benefits:

(1) **BIM:** BIM facilitates 3D visualization, enabling precise cost estimation and resource allocation. Its adoption in Malaysia has enhanced housing project efficiencies, while Saudi Arabia has utilized it in megaprojects to minimize unexpected expenses [40].

(2) **AI:** AI-powered predictive models assist in risk assessment and budget planning. For instance, AI is used in Malaysia for material forecasting and in Saudi Arabia's NEOM project for advanced risk management, ensuring proactive decision-making [41].

(3) **IoT:** IoT enables real-time monitoring of materials and equipment, reducing delays and unnecessary expenditures. Malaysian smart cities employ IoT sensors for material tracking, while Saudi Arabia integrates IoT in on-site monitoring for efficiency.

(4) **Drones:** Drones improve site management by providing aerial monitoring and surveying. They are used in land surveys for large-scale projects in Malaysia and the Red Sea initiative in Saudi Arabia to optimize project scheduling and reduce material wastage [42].

(5) **3D Printing:** On-site construction printing reduces material wastage and labor costs. Malaysia has experimented with small-scale housing projects, while Saudi Arabia explores this technology for housing in the NEOM city [43].

(6) **Augmented and Virtual Reality (AR/VR):** AR and VR technologies enhance worker training and design precision. In Malaysia, these tools are used for worker upskilling, while Saudi Arabia leverages VR for futuristic city designs [44].

(7) **Blockchain Technology:** Blockchain provides a secure and transparent ledger for managing contracts and payments. Both countries utilize blockchain to streamline supply chains and implement smart contracts in megaprojects [45-47].

(8) **Digital Twins:** Digital twins replicate physical assets virtually, allowing for proactive maintenance and real-time monitoring. Malaysia applies digital twins for city infrastructure management, while Saudi Arabia uses them for Riyadh metro systems [48].

(9) **Robotics:** Robotics automate high-risk and labor-intensive tasks, enhancing efficiency and safety. Limited robotic applications in Malaysia contrast with modular robotics in Saudi Arabia's NEOM construction efforts [49].

(10) **Cloud Computing:** Cloud technologies centralize data management, improving collaboration among stakeholders. Cloud computing facilitates collaborative efforts in Malaysia and manages site data effectively in Saudi Arabia [50].

(11) **Prefabrication:** Prefabrication improves material management and minimizes on-site delays [51]. Both countries have adopted prefabrication techniques, with Malaysia focusing on prefab housing and Saudi Arabia implementing modular prefabrication in large-scale projects [52].

(12) **Green Technologies:** Sustainable construction technologies align with global efforts to reduce environmental impact. Malaysia integrates green materials into housing projects, while Saudi Arabia promotes green roofs in its smart cities [53].

The adoption of these technologies underscores their transformative potential in reducing cost overruns in the construction industries of Malaysia and Saudi Arabia. While these tools provide substantial benefits, their implementation faces challenges such as high initial costs, infrastructure limitations, and technical expertise gaps. Addressing these barriers and fostering innovation will enable the construction sectors of both countries to achieve enhanced efficiency, sustainability, and cost-effectiveness.

**Table 1.** Construction technologies: Benefits, challenges, and impact on cost overruns

| Technology | Description | Primary Benefit | Key Challenge | Impact on Cost Overruns | Examples |
|---|---|---|---|---|---|
| BIM | 3D project visualization | Improved cost estimation | High initial cost | Reduces unexpected expenses | Malaysia: Housing projects; Saudi Arabia: Megaprojects |
| AI | Predictive modeling | Better risk management | Data quality issues | Predicts risks and budgets | Malaysia: Material forecasting; Saudi Arabia: NEOM risk assessment |
| IoT | Real-time monitoring | Material and equipment tracking | Connectivity limitations | Avoids unnecessary delays | Malaysia: Smart cities; Saudi Arabia: Material monitoring |
| Drones | Aerial monitoring and surveying | Improves site management | Regulatory hurdles | Optimizes project scheduling | Malaysia: Land surveys; Saudi Arabia: Red Sea initiative |
| 3D Printing | On-site construction printing | Reduces material wastage | High setup costs | Saves labor and materials | Malaysia: Small-scale housing; Saudi Arabia: NEOM housing |
| AR/VR | Simulation and visualization | Enhanced training and design | High hardware costs | Minimizes rework costs | Malaysia: Worker training; Saudi Arabia: VR simulations |
| Blockchain | Secure transaction ledger | Secure contracts and payments | Technical expertise gap | Enhances trust and efficiency | Malaysia: Supply chains; Saudi Arabia: Smart contracts |
| Digital Twins | Virtual replicas of physical assets | Proactive maintenance | Computational resource demand | Reduces maintenance costs | Malaysia: City infrastructure; Saudi Arabia: Riyadh metro systems |
| Robotics | Automated construction tasks | Efficiency and safety | High investment cost | Saves labor and time | Malaysia: Urban projects; Saudi Arabia: Modular construction |
| Cloud Computing | Centralized data management | Improved collaboration | Data security | Prevents communication delays | Malaysia: Collaborative projects; Saudi Arabia: Site data management |
| Prefabrication | Off-site assembly | Minimizes delays | Logistics challenges | Improves efficiency | Malaysia: Prefab housing; Saudi Arabia: Modular prefab in large projects |
| Green Tech | Sustainable construction technologies | Environmental impact reduction | High adoption cost | Cuts operational costs | Malaysia: Green materials; Saudi Arabia: Green roofs in smart cities |

### 2.10 Case study applications: Real-world examples of technology-driven cost management

**Case Study 1:** BIM Implementation in Malaysian Housing Projects

Malaysia's largest housing developer implemented comprehensive BIM on a mixed-use residential complex valued at USD 85 million comprising three high-rise towers. Prior to BIM adoption, the company experienced an average cost overrun of 8-12% on similar projects. Upon implementing a full BIM workflow (design coordination, clash detection, quantity estimation), the project achieved a final cost variance of only 2.3%, resulting in USD 1.92 million in cost savings. Key achievements included: (a) 87% reduction in design clashes detected during construction, (b) 45% improvement in material waste estimation accuracy, (c) 12-week reduction in project schedule through better coordination. This case demonstrates that BIM's 3D visualization and integrated quantity takeoff capabilities directly translate to reduced change orders and material overruns [30, 39, 54].

**Case Study 2:** AI-Powered Risk Management in Saudi Arabia's NEOM Smart City Project

Saudi Arabia's NEOM project (one of the world's largest mega-projects, budgeted at USD 500+ billion) integrated AI-powered predictive risk analytics for cost forecasting across multiple construction phases. The implementation enabled: (a) real-time budget variance tracking across 50+ concurrent projects, (b) AI prediction of material price fluctuations 8-12 weeks ahead, allowing advance procurement at optimized rates, (c) automated risk alerts when project indicators deviated >5% from baseline. Results: The first 18-month phase-maintained costs within 1.8% of planned budget (exceptional for a project of this scale), representing estimated savings of USD 2.4 billion compared to historical overrun rates of 15-25% in mega-projects. AI's predictive capabilities proved particularly valuable for managing the complex supply chain fragmentation inherent in projects of this magnitude [41].

These cases illustrate that while technological investment requires upfront capital and training, quantifiable cost avoidance justifies adoption, particularly for projects exceeding USD 50 million in value.

## 3. RESEARCH METHODOLOGY

### 3.1 Research instrument

The first stage of the study aims to extract relevant factors from existing studies focused on Saudi Arabia and Malaysia by conducting a thorough literature review, which serves as a secondary source of information. In the second stage, the study employs a questionnaire survey as the primary data collection method. A quantitative approach was chosen for this research, utilizing surveys and questionnaires to investigate the causes of cost overruns in construction projects in Malaysia and Saudi Arabia. Additionally, the study seeks to identify the key factors contributing to successfully reducing cost overruns during construction projects in these two countries.

The questionnaire employed in this study has 34 questions that measure factors that reduce cost overruns. The questionnaire is structured into two main sections. Section A collects demographic information (respondent role, years of experience, project types handled). Section B comprises 34 items measuring factors that reduce cost overruns, organized into thematic clusters: (1) Project management factors (e.g., 'Proper project planning and scheduling at early stages of the project'), (2) Resource management factors (e.g., 'Ensure sufficient quantity of materials on construction site'), (3) Personnel competency factors (e.g., 'Proper emphasis on past experience'), (4) Technological factors (e.g., 'Utilization of latest technologies'), and (5) Coordination factors (e.g., 'Improve communication between project parties'). Respondents selected their level of agreement or disagreement with each factor on a five-point Likert scale ("1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree"). Likert scales are recommended as a practical design choice for collecting data through self-administered or online survey methods [55].

### 3.2 Research population and sampling

The population of this research was determined through the registered companies under the Construction Industry Development Board of Malaysia (CIDB) list under the contractor companies of class G7 in Malaysia, G7 represents contractors with substantial experience and financial capacity, capable of undertaking large-scale construction projects with contracts valued above USD 7 million, demonstrating compliance with technical and financial standards set by CIDB, where the population was 8864. The population of Saudi Arabia was determined through the companies registered with the Saudi Council for both public and private projects, which are sorted among the contractors dealing with large project contracts and categorized as first class C1, where the population was 3485, C1 represents the highest classification level for contractors in Saudi Arabia's system, indicating contractors with extensive experience, significant capitalization, and capacity to execute mega-projects and complex infrastructure, equivalent to Malaysia's G7 classification. The sample size of respondents for this study is 365 in Malaysia and 345 in Saudi Arabia, according to Krejcie and Morgan 1970, who established the guidelines for establishing the sample size from a specific population. According to earlier research, a successful response rate for a questionnaire survey of the construction sector is typically between 20% and 30% [56].

### 3.3 Data collection

The data were collected by an online questionnaire that sent to target respondents. The intended respondents in Malaysia, who included project managers, site managers, project engineers, site supervisors, and others, received roughly 365 emails with surveys. One hundred fifty questionnaires were returned by respondents in Malaysia for the study. This results in a total response rate of 41.2% as shown in Table 2. The targeted respondents in Saudi Arabia received 345 emails, with surveys delivered to project managers, site managers, project engineers, site supervisors, and others. The study was able to get 122 questionnaires from the participants. This results in a total response rate of 35.4%. Gargon et al. [57] estimated that the typical usable response rate falls between 25% to 35%. As a result, the overall response collected is deemed enough for this study.

**Table 2.** Questionnaire distribution and return

| Description | Total in Malaysia | Total in Saudi |
|---|---|---|
| Questionnaire Distributed | 365 | 345 |
| Questionnaire Returned | 150 | 122 |
| Percentage (%) | 41.2 | 35.4 |

### 3.4 Data analysis

The IBM Statistical Package for Social Science (SPSS) version 28.0 was used to assemble and analyze the questionnaire's data. The data were examined using the percentage, frequency, and mean score values.

## 4. RESULTS AND DISCUSSION

### 4.1 Reliability test

To determine if the quality of the data in the questionnaire is dependable enough to produce an accurate result, the reliability test is utilized in this study. In order to assess the reliability of the research, the researcher employs Cronbach's Coefficient Alpha. Cronbach's Alpha Coefficient, which gauges the degree of variable dependability, is displayed in Table 3.

**Table 3.** Cronbach’s alpha coefficient

| Alpha Coefficient Range, α | Level of Reliability | Alpha Coefficient Range, α |
|---|---|---|
| 0.80 to 0.95 | Very good Reliability | 0.80 to 0.95 |
| 0.70 to 0.80 | Good Reliability | 0.70 to 0.80 |
| 0.60 to 0.70 | Fair Reliability | 0.60 to 0.70 |
| $\alpha < 0.60$ | Poor Reliability | $\alpha < 0.60$ |

The analysis of the Cronbach's Alpha data for Malaysia and Saudi Arabia in this study is shown in Table 4.

**Table 4.** Reliability statistic

| Cronbach's Alpha | N of Items | Country |
|---|---|---|
| 0.748 | 34 | Malaysia |
| 0.884 | 34 | Saudi Arabia |

### 4.2 Causes of cost overrun in construction projects in Malaysia

Table 5 summarizes the mean data analysis findings in Malaysia, presenting a ranking of causes contributing to cost overruns in Malaysian construction projects. The mean for the highest rating is 4.72, while the mean for the lowest ranking is 3.5. The top four causes for cost overruns in Malaysia fall under the category of "Strongly Agree," identifying these factors as highly significant. This quantitative study involved skilled contractors from both private and public construction projects in Malaysia, emphasizing the importance of including their perspectives to obtain accurate insights into the causes of cost overruns in the country.

**Table 5.** Causes of cost overrun in construction projects in Malaysia

| No. | Question | Category | Mean | Rank |
|---|---|---|---|---|
| B15 | Design changes and variation orders | Very High | 4.72 | 1 |
| B17 | Delay in progress payment by the owner | Very High | 4.53 | 2 |
| B2 | Unexpected ground conditions | Very High | 4.51 | 3 |
| B6 | Inadequate contractor experience | Very High | 4.50 | 4 |
| B14 | Mistakes in the contract content | High | 4.46 | 5 |
| B3 | Poor estimation of the original cost | High | 4.41 | 6 |
| B4 | Financial problems encountered by the contractors | High | 4.41 | 7 |
| B11 | Payment delay by the contractor to the subcontractor | High | 4.40 | 8 |
| B5 | Poor site management | High | 4.34 | 9 |
| B12 | Poor communication between construction parties | High | 4.31 | 10 |
| B7 | COVID-19 pandemic contributes to additional cost | High | 4.29 | 11 |
| B1 | Poor decision making | High | 4.26 | 12 |
| B10 | Poor material management | High | 4.25 | 13 |
| B13 | Conflicts among project participants | High | 4.03 | 14 |
| B8 | Fluctuation in the prices of materials and labour | High | 3.95 | 15 |
| B9 | Project materials monopoly by the suppliers | High | 3.81 | 16 |
| B16 | Weather changes | High | 3.50 | 17 |
| Average Mean | | | | 4.28 |

Malaysian contractors cite design changes and order variations as the main cause of cost overruns in construction projects. Prolonged processing of design changes negatively impacts project duration and expenses, which is essential due to project complexity [58]. Design modifications, requiring repetition and client approval, contribute significantly to cost overruns in Malaysian building projects. This factor, highly rated among cost overrun reasons, significantly influences the construction process [18].

The second important element that adversely affects the project budget and contributes to cost overruns in Malaysian construction projects is the owner's delay in making progress payments. Delays in progress payments from project owners significantly contribute to cost overruns in Malaysian construction projects. Contractors heavily rely on timely payments for cash flow, and interruptions can hinder material purchases, lower output, and lead to postponed tasks. Such delays impact project timelines, budgets, and the ability to meet high standards. Studies indicate that these issues are widespread in the Malaysian construction industry, emphasizing the need for improved payment processes and financing to mitigate cost overruns and enhance project outcomes [9].

Unexpected ground conditions stand out as a major third cause of cost overruns in Malaysian construction projects. Respondents note widespread acknowledgment of this issue, with many projects encountering similar problems. Contractors are well aware of the challenges posed by unexpected ground conditions, leading to significant and often unavoidable expenses for project reworking [14].

Insufficient contractor experience ranks Malaysian construction projects as the fourth most significant cause of cost overruns. This lack of expertise results in poor project performance, ineffective cost management, and budget strain. Inadequate contractor experience complicates projects, leading to costly rework and increased risk, disrupting schedules and causing delays. This result is supported by a similar study by Susanti and Nurdiana [15]; inadequate contractor experience is a significant cause of cost overruns in construction projects; issues during construction can halt work if the contractor lacks the expertise to address them promptly, depleting funds and impacting the overall project.

### 4.3 Causes of cost overrun in construction projects in Saudi Arabia

The findings of the mean data analysis in Saudi Arabia were reported in Table 6 along with a ranking of the factors that contributed to cost overruns in Saudi Arabian building projects. The mean for the highest rating is 4.79, while the mean for the lowest ranking is 4.12. In this section, there are five significant causes of cost overrun in Saudi Arabia that are discussed under the category of “Strongly Agree”.

Frequent design changes and order variations are the foremost causes of cost overruns in Saudi Arabian construction projects. These alterations impact the project's scope, resulting in significant budgetary consequences. Subfactors like quality deviation, non-conformance, owner dissatisfaction, and mistakes often drive these changes. Indeed, this is supported by a similar study by Alenazi et al. [5], where owners' minimal early involvement and evolving project scopes lead to frequent design revisions, disrupting schedules and increasing costs. Extended timelines and expenses are further exacerbated by the prolonged process of approving design modifications.

The COVID-19 pandemic is the second significant factor contributing to cost overruns in Saudi Arabian construction projects. The need for protective measures has introduced new roles, such as implementing social distancing and reducing workforce numbers. These changes, including project delays and increased budgets, stem from unexpected consequences as many contractors were unprepared to manage the impact of COVID-19 on construction sites. According to research by Ogunnusi et al. [24], over 90% of building projects were affected by the COVID-19 pandemic, with up to 40% completely halting and 51% partially suspending operations. These stoppages have resulted in significant losses and cost overruns across these projects.

Contractors cite fluctuating labor and material costs as the third major cause of cost overruns in Saudi Arabian construction projects. The rise in these expenses significantly impacts project costs, which are influenced by material supplier monopolies, limited local supply access, and a shortage of skilled labor. Instabilities due to imbalances in supply and demand, coupled with inflation, further drive up construction costs. Abduljawwad and Almaktoom's [23] study in Saudi Arabia aligns with the acknowledgment that projects frequently experience cost overruns due to fluctuations in labor and material costs, notably attributed to inflation, particularly in transportation and water projects.

Underestimating the original cost is the fourth major cause of cost overruns in Saudi building projects. Factors such as unreliable bid data, the absence of a national pricing database, untrained estimators, and serious errors contribute to inaccurate cost estimates. This is supported by Waqar et al. [53], highlighting the costly consequences of errors in construction estimating, including measurement inaccuracies, inappropriate units, incorrectly priced materials, and common arithmetic mistakes.

**Table 6.** Causes of cost overrun in construction projects in Saudi Arabia

| No. | Question | Category | Mean | Rank |
|---|---|---|---|---|
| B15 | Design changes and variation orders | Very High | 4.79 | 1 |
| B7 | COVID-19 pandemic contributes to additional cost | Very High | 4.63 | 2 |
| B8 | Fluctuation in the prices of materials and labour | Very High | 4.61 | 3 |
| B3 | Poor estimation of the original cost | Very High | 4.61 | 4 |
| B10 | Poor material management | Very High | 4.51 | 5 |
| B6 | Inadequate contractor experience | High | 4.46 | 6 |
| B17 | Delay in progress payment by the owner | High | 4.40 | 7 |
| B1 | Poor decision making | High | 4.39 | 8 |
| B5 | Poor site management | High | 4.39 | 9 |
| B11 | Payment delay by the contractor to the subcontractor | High | 4.39 | 10 |
| B14 | Mistakes in the contract content | High | 4.39 | 11 |
| B4 | Financial problems encountered by the contractors | High | 4.36 | 12 |
| B9 | Project materials monopoly by the suppliers | High | 4.32 | 13 |
| B12 | Poor communication between construction parties | High | 4.29 | 14 |
| B2 | Unexpected ground conditions | High | 4.23 | 15 |
| B13 | Conflicts among project participants | High | 4.11 | 16 |
| B16 | Weather changes | High | 3.73 | 17 |
| | Average Mean | | 4.275 | |

Finally, poor material management is the fifth significant cause of cost overruns in Saudi construction projects. Ineffective material management leads to excessive material consumption during planning and estimation, impacting project costs adversely [59].

Poor material management allows for worker manipulation, increasing material wastage and the need for additional purchases, directly impacting the project budget and causing cost overruns. Inadequate material statistics, shortages, and unreliable sources exacerbate the challenges of ineffective material management. Recent research by Alzara et al. [4] supports the conclusion that inadequate materials management is a primary cause of cost overruns in seventeen studies, affecting countries such as Saudi Arabia, Nigeria, Indonesia, and Ghana.

**4.4 The successful factor in reducing cost overrun during construction in Malaysia and Saudi Arabia**

In this section, only the noteworthy factors falling under the "Strongly Agree" category are considered and discussed. There are eight significant successful factors identified for reducing cost overrun in construction projects in Malaysia, whereas nine such factors are recognized in Saudi Arabia. The mean values and standard deviations (SD) from the data analysis in both countries are presented in Table 7, ranked from highest to lowest for successful factors in Malaysia. In Saudi Arabia, the mean values are coordinated to highlight the significant successful factors. Table 7 below illustrates the comparative coordination. Figure 1 presents the comparison of the ranking between Malaysia and Saudi Arabia. The crossover points in Figure 1 directly correspond to the numerical rank differences shown in Table 7: for instance, C17 and C10 exchange positions between countries, with C17 ranking 1st in Malaysia (Mean = 4.72) and 4th in Saudi Arabia (Mean = 4.59), while C10 ranks 2nd in Malaysia (Mean = 4.64) and 1st in Saudi Arabia (Mean = 4.73), indicating fundamentally different strategic priorities for cost overrun mitigation despite comparable overall mean values.

In Malaysia, contractors prioritize proper emphasis on past experience (C17, Mean = 4.72, Rank 1) as the foremost factor, with a Mean score 0.13 points higher than in Saudi Arabia (4.59, Rank 4), indicating a 2.3% stronger emphasis in Malaysia. In contrast, Saudi Arabia ranks ensuring sufficient materials on-site (C10) first with Mean = 4.73 (Rank 1), compared to Malaysia's ranking of this same factor as second (Mean = 4.64, Rank 2), representing a 0.09-point difference or 1.9% higher priority in Saudi Arabia. This comparison reveals that while both countries recognize material management importance, Malaysia places greater emphasis on experiential learning, whereas Saudi Arabia prioritizes immediate operational logistics. A study by Keng and Adzhar [21] supports this recommendation, highlighting the crucial role of focusing on prior performance throughout the project lifecycle for enhanced project performance. While in Saudi Arabia, contractors stress the importance of "ensuring sufficient materials on-site" as the foremost factor to prevent delays in material procurement, reflecting a commitment to recommended practices for cost overrun reduction. Proper material management and early delivery, as suggested by Kamaruddeen et al. [1], are acknowledged as effective strategies in this context.

In addition, in Malaysia, the second-ranked success factor is "ensuring sufficient materials on-site to prevent delays in procurement." This highlights the commitment of Malaysian contractors to recommend and adopt practices that effectively reduce cost overruns in construction projects, signaling a positive trend in cost management [29]. While in Saudi Arabia, the second-ranked success factor is "avoiding design errors through a proficient designer." This highlights the prevalent practice among contractors to appoint experienced designers, aligning with previous research recommending experienced professionals as a mitigation measure for significant causes of cost overrun in construction projects, ultimately reducing costs [31].

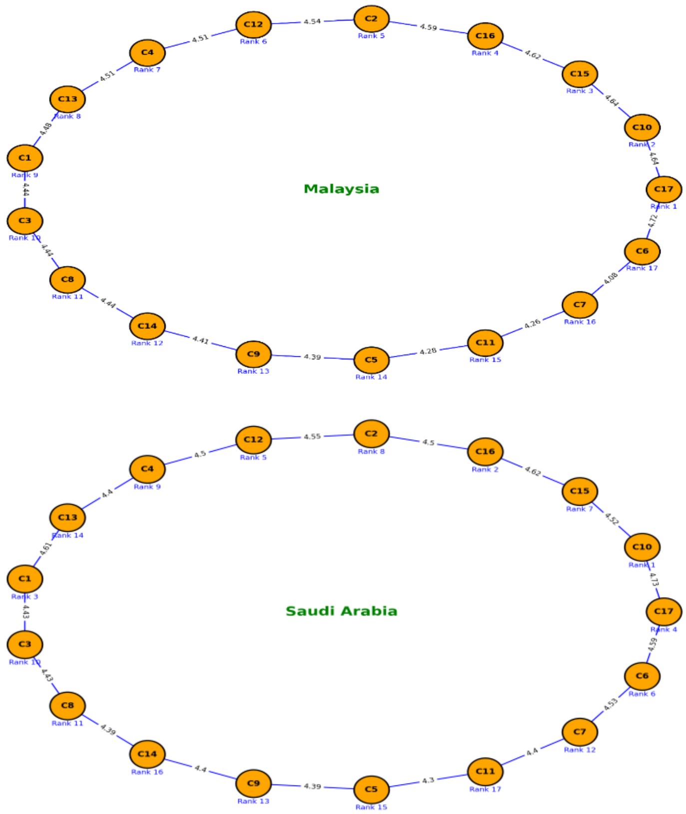


**Figure 1.** Ranking comparison among Malaysia and Saudi Arabia

**Table 7.** Successful factors reducing cost overrun in Malaysia and Saudi Arabia

| No | Questions | Category | Malaysia | | | Category | Saudi Arabia | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | Rank | SD | | Mean | Rank | SD |
| C17 | Proper emphasis on the past experience | Very High | 4.72 | 1 | 0.52 | Very High | 4.59 | 4 | 0.68 |
| C10 | Ensure sufficient quantity of materials on the construction site to avoid project delay in the material procurement | Very High | 4.64 | 2 | 0.58 | Very High | 4.73 | 1 | 0.52 |
| C15 | Employing proficient construction players such as subcontractors and suppliers | Very High | 4.64 | 3 | 0.55 | Very High | 4.52 | 7 | 0.62 |
| C16 | Avoid the design error changes by establishing proper design by a proficient designer | Very High | 4.62 | 4 | 0.51 | Very High | 4.62 | 2 | 0.58 |
| C2 | Proper project planning and scheduling at early stages of the project | Very High | 4.59 | 5 | 0.56 | Very High | 4.50 | 8 | 0.61 |
| C12 | Improve the cost estimation at the early stages of the project | Very High | 4.54 | 6 | 0.54 | Very High | 4.55 | 5 | 0.59 |
| C4 | Establishing effective material management | Very High | 4.51 | 7 | 0.57 | Very High | 4.50 | 9 | 0.63 |
| C13 | Comprehensive contract administration | Very High | 4.51 | 8 | 0.53 | High | 4.40 | 14 | 0.64 |
| C1 | Effective site management during constructing project | High | 4.48 | 9 | 0.59 | High | 4.61 | 3 | 0.55 |
| C3 | Regularly updates on the work progress | High | 4.44 | 10 | 0.60 | High | 4.43 | 10 | 0.66 |
| C8 | Frequent coordination between the parties | High | 4.44 | 11 | 0.59 | High | 4.43 | 11 | 0.65 |
| C14 | Acceleration the decision making and avoid centralization of decisions | High | 4.44 | 12 | 0.61 | High | 4.39 | 16 | 0.67 |
| C9 | Improve the communication between the project parties | High | 4.41 | 13 | 0.62 | High | 4.40 | 13 | 0.66 |
| C5 | Establishing authorities for mentoring the construction project | High | 4.39 | 14 | 0.63 | High | 4.39 | 15 | 0.68 |
| C11 | Develop the necessary human resources for the construction industry | High | 4.28 | 15 | 0.65 | High | 4.30 | 17 | 0.69 |
| C7 | Utilization of the latest technologies | High | 4.26 | 16 | 0.66 | High | 4.40 | 12 | 0.64 |
| C6 | Building information modelling BIM implementation | High | 4.08 | 17 | 0.68 | Very High | 4.53 | 6 | 0.61 |
| | Average Mean | | 4.47 | | | | 4.49 | | |

Furthermore, in Malaysia, the third success factor is "employing proficient construction players, including subcontractors and suppliers." This aligns with the prevalent practice of Malaysian contractors choosing experienced subcontractors and suppliers, consistent with prior research emphasizing the importance of expertise and experience in hiring consultants [28]. However, In Saudi Arabia, the third key factor for reducing cost overrun is "effective site management during construction." Successful site management ensures efficient resource use, quality maintenance, and strong supplier relationships. This aligns with prior research emphasizing the pivotal role of enhanced site management in decreasing cost overruns, impacting the productivity of all construction project participants [60].

Moreover, the fourth success factor in Malaysia is "avoiding design error changes through a proficient designer." This factor holds substantial importance for contractors in both Malaysia and Saudi Arabia. Design error avoidance (C16) shows Mean = 4.62 for both countries but ranking differs: Position 4 in Malaysia vs. Position 2 in Saudi Arabia, reflecting different implementation philosophies despite equal agreement levels. In Malaysia, the widespread recognition of appointing experienced designers is a positive indicator, effectively addressing key contributors to design issues during construction, and minimizing potential cost overruns [12]. In addition, Ullah et al. [31] endorsed appointing experienced designers to curb cost overruns. While in Saudi Arabia, expert contractors recognize the significance of "proper emphasis on past experience," ranking it fourth among variables contributing to cost overruns. This echoes Keng's [28] findings, underscoring its efficiency in reducing cost overruns by enhancing project performance from planning to handover.

Furthermore, in Malaysia, "proper project planning and scheduling at early stages" is the fifth crucial element to reduce cost overruns in building projects. This is vital for preventing delays and cost overruns by ensuring accurate cost estimation in the initial project phases, aligning with research emphasizing effective planning and scheduling for cost control [28]. In Saudi Arabia, the fifth-ranked factor is "improving early cost estimation." Early cost prediction is essential for project decision-making. Aslam et al. [8] confirmed its significance, identifying inaccurate early cost calculation as a major contributor to cost overruns.

In Malaysia, the sixth crucial success component is "improving early cost estimation." In Saudi Arabia, the sixth element is using BIM in construction projects [58, 61]. BIM adoption is seen as a successful factor for controlling cost overruns, indicating a positive shift in Saudi Arabia's construction projects. BIM is a advance technology with positive impacts on cost and time control in Saudi building projects.

In Malaysia, contractors emphasize "effective material management during construction projects," reflecting a positive trend linking successful cost overrun reduction to efficient material management. This recognizes the critical role of effective material management in mitigating overruns, and addressing issues like shortages and misuse. This aligns with studies recommending proper material management and early delivery to minimize cost overruns in construction projects [1]. In Saudi Arabia, the seventh significant success factor is "employing proficient construction players, such as subcontractors and suppliers." This emphasis on skilled players aligns with a study by Alshihri et al. [34], suggesting proactive measures for project execution.

Furthermore, in Malaysia, the final success factor is "comprehensive contract administration," crucial for project regularity, covering procurement, material supply, staff, labor, clients, and resources. Contract administration ranks differently (Malaysia: Rank 8, Mean = 4.51 vs. Saudi Arabia: Rank 14, Mean = 4.40), demonstrating a 0.11-point mean difference and suggesting Malaysian contractors perceive contractual clarity as more critical for cost management. Effective contract administration, per Keng and Adzhar [21], manages project risks, ensuring quality execution within the specified budget and timeline. In Saudi Arabia, the eighth success factor is "proper project planning and scheduling at early stages," vital for smooth project progression within the set cost and time. Bin Seddeeq et al. [36] emphasized close monitoring in planning to prevent deviations in time and cost from the project plan.

In Saudi Arabia, the final success factor is "establishing effective material management," signaling a positive response from contractors. This emphasis on effective material management addresses the issue of insufficient materials at the site, as highlighted by respondents, contributing to the mitigation of cost overruns.

### 4.5 Mutual significant successful factors of cost overrun in Malaysia and Saudi Arabia

Through conducting this study on the successful factors of cost overrun in construction projects in Malaysia and Saudi Arabia, it was found that there are mutually significant successful factors under the category of “Strongly Agree” in both countries. Here are the seven key mutual factors instrumental in mitigating cost overruns in construction projects:

(13) Proper emphasis on the past experience.
(14) Ensure sufficient quantity of materials on the construction site to avoid project delay in the material procurement.
(15) Employing proficient construction players such as subcontractors and suppliers.
(16) Avoid the design error changes by establishing proper design by a proficient designer.
(17) Proper project planning and scheduling at early stages of the project.
(18) Improve the cost estimation at the early stages of the project.
(19) Establishing effective material management.

## 5. CONCLUSION

In conclusion, this comparative study offers insights into successful factors for minimizing cost overruns in construction projects in Malaysia and Saudi Arabia. Quantitative analysis of data from G7 contractors in Malaysia and C1 contractors in Saudi Arabia reveals shared challenges and distinct strategies. Both countries recognize design changes and order variations as major contributors to cost overrun yet differ in recommended mitigation strategies. Malaysia emphasizes learning from past experiences, while Saudi Arabia focuses on ensuring adequate on-site materials for timely procurement. The study underscores the need for tailored approaches, considering environmental, cultural, and economic factors. These insights are valuable for practitioners, policymakers, and researchers aiming to optimize construction outcomes globally. The conclusion highlights the importance of ongoing research, suggesting the exploration of more countries, longitudinal methodologies, qualitative dimensions, and the evolving role of technology and regulations for a nuanced understanding of successful cost overrun mitigation.

It is advised to conduct more research on a particular category of construction projects, such as highway construction projects, dam building projects, etc., based on the findings of this comparative study between Malaysia and Saudi Arabia. Choosing a different contractor grade. Qualitative Insights: Supplement quantitative findings with qualitative research methods, such as interviews and case studies, to capture contextual nuances influencing cost overrun mitigation.

The research encountered several limitations. Conducting a comparative study between the two countries was hindered by a lack of detailed previous studies and literature reviewing the causes of cost overrun and successful mitigation factors in construction projects in these nations. The impact of the COVID-19 pandemic further restricted access to physical resources, such as university libraries, affecting the data collection timeline. The research, spanning two countries, required a considerable amount of time for data collection and analysis. Despite these challenges, the study was conducted as promptly as possible.

## REFERENCES


[1] Kamaruddeen, A.M., Sung, C.F., Wahi, W. (2020). A study on factors causing cost overrun of construction projects in Sarawak, Malaysia. Civil Engineering and Architecture, 8(3): 191-199. https://doi.org/10.13189/cea.2020.080301

[2] Oda, M.M.A., Tayeh, B.A., Alhammadi, S.A., Aisheh, Y.I.A. (2022). Key indicators for evaluating the performance of construction companies from the perspective of owners and consultants. Results in Engineering, 15: 100596. https://doi.org/10.1016/j.rineng.2022.100596

[3] Al-Yami, A., Sanni-Anibire, M.O. (2021). BIM in the Saudi Arabian construction industry: State of the art, benefit and barriers. International Journal of Building Pathology and Adaptation, 39(1): 33-47. https://doi.org/10.1108/IJBPA-08-2018-0065

[4] Alzara, M., Kashiwagi, J., Kashiwagi, D., Al-Tassan, A. (2020). Analysis of cost overruns in Saudi Arabia construction projects: A university case study. Journal for the Advancement of Performance Information and Value, 10(1): 84-101. https://doi.org/10.37265/japiv.v10i1.24

[5] Alenazi, E., Adamu, Z., Al-Otaibi, A. (2022). Exploring the nature and impact of client-related delays on contemporary Saudi construction projects. Buildings, 12(7): 880. https://doi.org/10.3390/buildings12070880

[6] Alhammadi, Y., Al-Mohammad, M.S. Rahman, R.A. (2024). Modeling the causes and mitigation measures for cost overruns in building construction: The case of higher education projects. Buildings, 14(2): 487. https://doi.org/10.3390/buildings14020487

[7] Kavuma, A., Ock, J., Jang, H. (2019). Factors influencing time and cost overruns on freeform construction projects. KSCE Journal of Civil Engineering, 23(4): 1442-1450. https://doi.org/10.1007/s12205-019-0447-x

[8] Aslam, M., Baffoe-Twum, E., Saleem, F. (2019). Design changes in construction projects – Causes and impact on the cost. Civil Engineering Journal, 5(7): 1647-1655. http://doi.org/10.28991/cej-2019-03091360

[9] Yap, J.B.H., Chow, I.N., Shavarebi, K. (2019). Criticality of construction industry problems in developing countries: Analyzing Malaysian projects. Journal of Management in Engineering, 35(5): 04019020. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000709

[10] Al-Emad, N.H., Rahman, I.A. (2018). Issues engulfed Saudi Arabia construction workers. IOP Conference Series: Earth and Environmental Science, 140(1): 012097. https://doi.org/10.1088/1755-1315/140/1/012097

[11] Mohsen, A., Alaloul, W.S., Liew, M.S., Musarat, M.A., Baarimah, A.O., Alzubi, K.M., Altaf, M. (2021). Impact of the COVID-19 pandemic on construction industry in Malaysia. In 2021 Third International Sustainability and Resilience Conference: Climate Change, Sakheer, Bahrain, pp. 237-241. https://doi.org/10.1109/IEEECONF53624.2021.9667984

[12] Othman, I., Al-Ashmori, Y.Y., Rahmawati, Y., Amran, Y.M., Al-Bared, M.A.M. (2021). The level of building information modelling (BIM) implementation in Malaysia. Ain Shams Engineering Journal, 12(1): 455-463. https://doi.org/10.1016/j.asej.2020.04.007

[13] Sarhan, J.G., Xia, B., Fawzia, S., Karim, A., Olanipekun, A.O., Coffey, V. (2020). Framework for the implementation of lean construction strategies using the interpretive structural modelling (ISM) technique: A case of the Saudi construction industry. Engineering, Construction and Architectural Management, 27(1): 1-23. https://doi.org/10.1108/ECAM-03-2018-0136

[14] Sarakbi, R. (2019). Root Cause Analysis of Cost Overrun in Construction Projects Under Different Market Sectors. California State University, Long Beach.

[15] Susanti, R., Nurdiana, A. (2020). Cost overrun in construction projects in Indonesia. IOP Conference Series: Earth and Environmental Science, 506(1): 012039. https://doi.org/10.1088/1755-1315/506/1/012039

[16] Albtoush, A.F., Doh, S.I. (2019). A Review on causes of cost overrun in the construction projects. International Journal of New Innovations in Engineering and Technology, 12(3): 15-22. https://files01.core.ac.uk/download/pdf/286440966.pdf.

[17] Afzal, F., Yunfei, S., Nazir, M., Bhatti, S.M. (2021). A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies: Cost overrun in construction projects. International Journal of Managing Projects in Business, 14(2): 300-328. https://doi.org/10.1108/IJMPB-02-2019-0047

[18] Foo, L.C. (2022). Importance level of management factors in affecting time and cost performance in construction projects. Tropical Scientific Journal, 1(1): 1-6. https://scientificacademic.com/index.php/tsj/article/view/7.

[19] Al-Aidrous, A.H.M., Shafiq, N., Mohammed, B.S., Al-ashmori, Y.Y., Baarimah, A.O., Al-masoodi, A.H.

(2021). Investigation of the current innovative industrialized building systems (IBS) in Malaysia. In 2021 Third International Sustainability and Resilience Conference: Climate Change, Sakheer, Bahrain, pp. 382-387. https://doi.org/10.1109/IEEECONF53624.2021.9668063

[20] Alawag, A.M., Alaloul, W.S., Liew, M.S., Musarat, M.A., Baarimah, A.O. (2023). Implementation of total quality management (TQM) in Malaysian industrialized building system (IBS) projects. Revista de la Construcción, 22(1): 74-86. https://doi.org/10.7764/RDLC.22.1.74

[21] Keng, T.C., Adzhar, W.M.A.W. (2022). Construction cost control for road projects in the context of Malaysian contractors. Journal of Architecture, Planning and Construction Management, 12(2): 85-97. https://doi.org/10.31436/japcm.v12i2.722

[22] Hu, M., Skibniewski, M. (2022). The impact of the design team characteristics on the sustainable building construction cost: Structural equation model analysis. Architectural Engineering and Design Management, 18(5): 614-630. https://doi.org/10.1080/17452007.2022.2068497

[23] Abduljawwad, T.M., Almaktoom, A. (2021). Factors behind construction delays in Saudi Arabia. PalArch's Journal of Archaeology of Egypt/Egyptology, 18(15).

[24] Ogunnusi, M., Hamma-Adama, M., Salman, H., Kouider, T. (2020). COVID-19 pandemic: The effects and prospects in the construction industry. International Journal of Real Estate Studies, 14(S2): 120-128. https://doi.org/10.11113/intrest.v14nS2.71

[25] Hassanain, M.A., Alamoudi, A., Al-Hammad, A.M., Abdallah, A. (2020). Barriers to the implementation of POE practices in the Saudi Arabian building industry. Architectural Engineering and Design Management, 16(2): 150-165. https://doi.org/10.1080/17452007.2019.1706440

[26] Pham, H., Luu, T.V., Kim, S.Y., Vien, D.T. (2020). Assessing the impact of cost overrun causes in transmission lines construction projects. KSCE Journal of Civil Engineering, 24(4): 1029-1036. https://doi.org/10.1007/s12205-020-1391-5

[27] Ikechukwu, A.C., Fidelis, I.E., Kelvin, O.A. (2017). Causes and effects of cost overruns in public building construction projects delivery, in Imo State, Nigeria. IOSR Journal of Business and Management (IOSR-JBM), 19(7): 13-20. https://doi.org/10.9790/487X-1907021320

[28] Keng, C.J. (2020). A study on the factors contributing to cost overrun problems and cost control techniques available in Malaysia. Doctoral dissertation. Tunku Abdul Rahman University College.

[29] Buniya, M.K., Othman, I., Sunindijo, R.Y., Karakhan, A.A., Kineber, A.F., Durdyev, S. (2023). Contributions of safety critical success factors and safety program elements to overall project success. International Journal of Occupational Safety and Ergonomics, 29(1): 129-140. https://doi.org/10.1080/10803548.2022.2038419

[30] Muhammad, M.T., Haron, N.A., Hizami, A., Al-Jumaa, A.T., Muhammad, I.B. (2019). The impact of BIM application on construction delays and cost overrun in developing countries. IOP Conference Series: Earth and Environmental Science, 357(1): 012027. https://doi.org/10.1088/1755-1315/357/1/012027

[31] Ullah, K., Abdullah, A.H., Nagapan, S., Sohu, S., Khan, M.S. (2018). Measures to mitigate causative factors of budget overrun in Malaysian building projects. International Journal of Integrated Engineering, 10(9). https://publisher.uthm.edu.my/ojs/index.php/ijie/article/view/2431.

[32] Al-Aidrous, A.H.M., Rahmawati, Y., Wan Yusof, K., Omar Baarimah, A., Alawag, A.M. (2021). Review of industrialized buildings experience in Malaysia: An example of a developing country. IOP Conference Series: Earth and Environmental Science, 682(1): 012003. https://doi.org/10.1088/1755-1315/682/1/012003

[33] Alaloul, W.S., Liew, M.S., Zawawi, N.A.W.A. (2016). Identification of coordination factors affecting building projects performance. Alexandria Engineering Journal, 55(3): 2689-2698. https://doi.org/10.1016/j.aej.2016.06.010

[34] Alshihri, S., Al-Gahtani, K., Almohsen, A. (2022). Risk factors that lead to time and cost overruns of building projects in Saudi Arabia. Buildings, 12(7): 902. https://doi.org/10.3390/buildings12070902

[35] Lee, S.W., Zainal, R., Rahim, M.H.I.A., Noh, H.M. (2022). Cost overruns in housing projects. Research in Management of Technology and Business, 3(1): 664-675. https://publisher.uthm.edu.my/periodicals/index.php/mtb/article/view/7202.

[36] Bin Seddeeq, A., Assaf, S., Abdallah, A., Hassanain, M.A. (2019). Time and cost overrun in the Saudi Arabian oil and gas construction industry. Buildings, 9(2): 41. https://doi.org/10.3390/buildings9020041

[37] Alsehaimi, A., Baarimah, A.O., Ramu, M.B., Alajmi, M., Ahmed, W. (2025). Integration of BIM in project management phases for achieving sustainable success in small construction projects: A SEM-based approach. Ain Shams Engineering Journal, 16(10): 103649. https://doi.org/10.1016/j.asej.2025.103649

[38] Montiel-Santiago, F.J., Hermoso-Orzáez, M.J., Terrados-Cepeda, J. (2020). Sustainability and energy efficiency: BIM 6D. Study of the BIM methodology applied to hospital buildings. Value of interior lighting and daylight in energy simulation. Sustainability, 12(14): 5731. https://doi.org/10.3390/su12145731

[39] Waqar, A., Othman, I., Saad, N., Azab, M., Khan, A.M. (2023). BIM in green building: Enhancing sustainability in the small construction project. Cleaner Environmental Systems, 11: 100149. https://doi.org/10.1016/j.cesys.2023.100149

[40] Waqar, A., Othman, I., Shafiq, N., Khan, A.M. (2023). Integration of passive RFID for small-scale construction project management. Data and Information Management, 7(4): 100055. https://doi.org/10.1016/j.dim.2023.100055

[41] Ding, Y., Ma, J., Luo, X. (2022). Applications of natural language processing in construction. Automation in Construction, 136: 104169. https://doi.org/10.1016/j.autcon.2022.104169

[42] Kang, T.W., Mo, Y. (2024). A comprehensive digital twin framework for building environment monitoring with emphasis on real-time data connectivity and predictability. Developments in the Built Environment, 17: 100309. https://doi.org/10.1016/j.dibe.2023.100309

[43] Jiang, Z., Zhang, K., Du, L., Cheng, Z., et al. (2021). Construction of chitosan scaffolds with controllable microchannel for tissue engineering and regenerative medicine. Materials Science and Engineering: C, 126: 112178. https://doi.org/10.1016/j.msec.2021.112178
[44] Waqar, A., Othman, I., Shafiq Aiman, M., Basit Khan, M., Islam, M.M., Almujibah, H., Abdul Karim, M. (2023). Analyzing the success of adopting metaverse in construction industry: Structural equation modelling. Journal of Engineering, 2023(1): 8824795. https://doi.org/10.1155/2023/8824795
[45] Bazel, M.A., Baarimah, A.O., Mohammed, F., Alaloul, W.S., Alawag, A.M., Alzubi, K.M. (2023). Blockchain Technology in construction industry: Current state and future trends through bibliometric analysis. In 2023 4th International Conference on Data Analytics for Business and Industry (ICDABI), Bahrain, pp. 114-123. https://doi.org/10.1109/ICDABI60145.2023.10629392
[46] Waqar, A., Othman, I., Shafiq, N., Deifalla, A., Ragab, A.E., Khan, M. (2023). Impediments in BIM implementation for the risk management of tall buildings. Results in Engineering, 20: 101401. https://doi.org/10.1016/j.rineng.2023.101401
[47] Alawag, A.M., Alaloul, W.S., Al-dhawi, B.N.S., Baarimah, A.O., Bazel, M.A., Mushtaha, A.W. (2024). A review and bibliometric analysis of blockchain adoption within the context of smart construction projects. In 2024 ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS), Manama, Bahrain, pp. 805-811. https://doi.org/10.1109/ICETSIS61505.2024.10459703
[48] Mortaheb, R., Jankowski, P. (2023). Smart city re-imagined: City planning and GeoAI in the age of big data. Journal of Urban Management, 12(1): 4-15. https://doi.org/10.1016/j.jum.2022.08.001
[49] Singh, R., Gehlot, A., Akram, S.V., Gupta, L.R., et al. (2021). Cloud manufacturing, internet of things-assisted manufacturing and 3D printing technology: Reliable tools for sustainable construction. Sustainability, 13(13): 7327. https://doi.org/10.3390/su13137327
[50] Waqar, A., Qureshi, A.H., Othman, I., Saad, N., Azab, M. (2024). Exploration of challenges to deployment of blockchain in small construction projects. Ain Shams Engineering Journal, 15(2): 102362. https://doi.org/10.1016/j.asej.2023.102362
[51] Al-Awag, A.M., Alaloul, W.S., Liew, M.S., Baarimah, A.O., Musarat, M.A. (2023). The potential role of industrialized building systems (IBS) in Malaysian sustainable construction: Awareness and barriers. AIP Conference Proceedings, 2848: 020015. https://doi.org/10.1063/5.0128035
[52] Al-Aidrous, A.H.M., Shafiq, N., Al-Ashmori, Y.Y., Al-Mekhlafi, A.B.A., Baarimah, A.O. (2022). Essential factors enhancing industrialized building implementation in Malaysian residential projects. Sustainability, 14(18): 11711. https://doi.org/10.3390/su141811711
[53] Waqar, A., Othman, I., Shafiq, N., Altan, H., Ozarisoy, B. (2023). Modeling the effect of overcoming the barriers to passive design implementation on project sustainability building success: A structural equation modeling perspective. Sustainability, 15(11): 8954. https://doi.org/10.3390/su15118954.
[54] Alakhali, A.K., Baarimah, A.O., Alkhadri, A.H., Gabir, A.A., Hasan, K., Alawag, A.M. (2024). Unlocking the potential of BIM for transformation in the kenyan construction INDUSTRY. In 2024 ASU International Conference in Emerging Technologies for Sustainability and Intelligent Systems (ICETSIS), Manama, Bahrain, pp. 822-828. https://doi.org/10.1109/ICETSIS61505.2024.10459431
[55] Sarstedt, M., Ringle, C.M., Hair, J.F. (2021). Partial least squares structural equation modeling. In Handbook of Market Research, pp. 587-632.
[56] Black, C., Akintoye, A., Fitzgerald, E. (2000). An analysis of success factors and benefits of partnering in construction. International Journal of Project Management, 18(6): 423-434. https://doi.org/10.1016/S0263-7863(99)00046-0
[57] Gargon, E., Crew, R., Burnside, G., Williamson, P.R. (2019). Higher number of items associated with significantly lower response rates in COS Delphi surveys. Journal of Clinical Epidemiology, 108: 110-120. https://doi.org/10.1016/j.jclinepi.2018.12.010
[58] Al-Ashmori, Y.Y., Othman, I., Rahmawati, Y., Amran, Y.M., Sabah, S.A., Rafindadi, A.D.U., Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. Ain Shams Engineering Journal, 11(4): 1013-1019. https://doi.org/10.1016/j.asej.2020.02.002
[59] Alaloul, W.S., Liew, M.S., Wan Zawawi, N.A., Mohammed, B.S., Adamu, M. (2018). An Artificial neural networks (ANN) model for evaluating construction project performance based on coordination factors. Cogent Engineering, 5(1): 1507657. https://doi.org/10.1080/23311916.2018.1507657
[60] Annamalaisami, C.D., Kuppuswamy, A. (2021). Managing cost risks: Toward a taxonomy of cost overrun factors in building construction projects. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, 7(2): 04021021. https://doi.org/10.1061/AJRUA6.0001132
[61] Musarat, M.A., Alaloul, W.S., Cher, L.S., Qureshi, A.H., Alawag, A.M., Baarimah, A.O. (2023). Applications of Building Information Modelling in the operation and maintenance phase of construction projects: A framework for the Malaysian construction industry. Sustainability, 15(6): 5044. https://doi.org/10.3390/su15065044