Journal of Engineering Science and Technology
Vol. 17, No. 1 (2022) 0583 - 0603

TECHNIQUES TO REDUCE COST OVERRUNS DURING THE DESIGN PHASE OF CONSTRUCTION PROJECTS

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Abstract

In the recent years, many construction projects faced many challenges that hinders it success despite of much effort has been done to manage it. It is noted that, most construction projects suffer from cost overruns due to the uncertainty of available project data during the design stage. Moreover, deficiencies in the design phase resulting in failures in the construction, and project development phase, which can reduce the quality of construction work. Therefore, it is imperative to take preventive measures to reduce cost overrun causes related to design issues. This study aims to provide effective techniques at the design phase that help reduce cost overruns in construction projects. To attain this objective, the data was collected, through a questionnaire that targeted construction project engineers, and analysed, where the questionnaire dealt with two main aspects. Based on the study, it is found there are 8 critical causes of cost overruns related to design issues, such as frequent design changes, incomplete drawings/detailed design at the time of tender, mistakes in design, unrealistic contract duration. In addition, the results revealed there are 8 important techniques to reduce cost overrun, which focused on the investigation of soil test before the design process, prepares the design drawings in high accuracy and details, and importance of the availability of funds in the early stages. This research provides a database that assists researchers and industry practitioners in developing other techniques to reduce cost overruns in construction projects. The finding of this research is expected to help improve the efficiency of construction projects by reducing cost overruns.

Keywords: Construction projects, Cost overrun, Design changes, Effective strategies.

1. Introduction

It is known that construction projects are a vital sector for the growth of the national economy in developing countries as well as in developed countries. The inadequacy of many construction projects carried out in developing countries involves quality problems, cost overruns and the failure to complete the construction project within the given timeframe [1]. For most countries, construction sector is considered a suitable investment interface because it provides job opportunities in addition to improving the quality of life by providing basic services such as schools, hospitals, roads, etc. Although the construction industry plays an important role in the development of countries, there are many difficulties when trying to enhance its efficiency [2]. For example, in recent times, the issue of cost overruns in construction projects has become a source of concern for stakeholders. It has affected the outputs of the construction sector in various countries. This is due to the nature of the industry, like high divergence, volatility, low efficiency, poor regulation of quality and a lack of attention to detail [3].

Design changes are commonly recognized to be one of the most critical factors influencing the success of construction projects, regardless of their size, complexity and/or period [4]. At the design stage, about two-thirds of the costs could have been avoided due to design change as reported by [5-7]. Albtoush et al. [8] mentioned that design change is the most critical affecting cost management in construction projects which start from design stage. During this stage, a preliminary visualization of the project is generated in terms of cost and time, depending on the initial drawings created during this stage. In addition, a strategic plan is developed and an organized guide that leads to the achievement of the project's objectives. Weak design and documentation issues may also lead to poor project performance [9]. Therefore, this research not only focuses on identifying the causes of cost overrun during the design stage but also effective techniques that can reduce cost overruns caused by deficiencies at the design phase of construction projects from the perspectives of the key stakeholders, owner, consultant, and contractor.

2. Literature Review

2.1. Cost overruns

Over the last few years, the cost of construction projects has increased for various reasons. This cost escalation is due to cost increases for critical construction resources such as steel, cement, concrete, wood, sand, fine and platform aggregates and other inputs, and labour costs, as stated by Jyotheendranath [10]. The project cost overrun is calculated by taking the difference between the planned costs and the actual construction costs once completed [11]. The amount of cost overrun in relation to the initial estimated value varies from nation to nation, from industry to industry, from project to project and from time to time [12]. As each construction project is unique and includes unique challenges and risks across the different levels of the building process [13]. The issue of cost overrun is very severe in developed countries where costs often reach 100% of the planned costs [14]. The consequence of those effects is to slow down other sectors of growth. Hence, the primary stage of mitigating the challenges is to find the causes of cost overrun [15].

2.2. Causes of cost overrun

The cost overrun is contributed by one or a combination of many factors that are very necessary for cost-effective performance to be established [16]. As stated by Pourrostam and Ismail [17], cost overruns can be attributed directly to "root causes" that are often associated with preliminary stages, project planning or design involving root causes such as: poor estimate of quantities, inconsistencies in design or mistakes, changes in project schedules, changes in scope, unforeseen site conditions, rising material and labour costs (mostly due to inflation), and unforeseen events. Ineffective construction management and poorly developed cost control mechanisms are the major causes of cost overruns in many projects [18]. Moreover, Kissi et al. [19] stated that the barriers to effective cost planning in the construction industry are poor cost planning and knowledge base, low cost and understanding databases, insufficient design and planning, and external factors.

In construction projects, the effect factors on project cost efficiency that cause cost overruns are present from the estimate stage to the project's completion stage [20]. Therefore, several studies have addressed the causes of cost overruns that occur in a construction project by classifying them into different groups. Saidu and Shakantu [21] categorized causes of cost overrun into four groups namely contractor, consultant, client and other/external. While Pall et al. [22] classified the causes of cost overrun into two groups, which are non-compensable factors and compensable factors. Ahmed et al. [23] on the other hand classified the causes of cost overrun into internal and external causes. Study by Albtoush and Doh [24] classified the causes into ten major groups namely: Design and contract related factors, Estimation related factors, Planning and Schedule related factors, Project Management related factors, Labor related factors, Financial related factors, Material and Machinery related factors, Construction Phase related factors, Communication Related Factors, External related factors. To minimize these causes of cost overrun during project lifecycle, it is important first to know where the higher cost escalation or de-escalation occurred, or at what stage of the project. After this information, the next move will be to recognize the critical factors that lead to the development and finally to look for potential solutions to address excessive cost overruns and other cost-related challenges [25].

Many studies have found that during the life cycle of a construction project, the design stage is a crucial stage, and therefore serious attention to this stage to prevent cost overruns in construction projects plays an important role in improving the performance of project costs [24]. In addition, since they may fairly be predicted and prevented, the causes of cost overruns due to the design schedule or project management issues can be avoided [26].

2.2.1. Causes of cost overrun during design stage

Many construction issues are due to design problems and can be traced back to the design phase [27]. Incompetent management of client requirements at the design stage and lack of integrating the design of project systems are contributing factors to cost overruns and schedule delays [28, 29]. According to Rahman et al. [30], the workflow of the design process is one of the critical factors affecting project success. Moreover, several studies indicated that design problems in construction projects have direct impact on cost overruns [31-33]. Hemal et al. [34] revealed that 78% of cost increases are caused by design changes [35]. There are many causes

of cost overruns associated with the design phase that have been found in various studies, such as lack of coordination during the design phase [36], inaccurate quantity take-off [37], wrong or inappropriate choice of site [38], project documents [39], and bid award for lowest price [40], mistakes in design [41, 42], frequent design changes [40, 43-45], design development and incomplete design at the time of tender [46], lack of coordination at design phase [47], and short bid preparation time [48].

According to some Western countries' analysis, design cost is usually only less than 1% of the construction project's life cycle. It is the cost of less than 1%, however, that accounts for more than 75% of influences on building costs. Therefore it is obvious that design quality is vital for the benefits of the entire construction of the project [49]. In addition, the results of study [50] in Saudi Arabia revealed that design change is one of the most important cost factors. During this stage cost estimation is generated, which defined as process of forecasting costs for the construction of a physical structure [51]. The actual cost of the construction project commenced at this phase [25], due to this, the cost estimation process should be done with high accuracy in order to be as close as possible to the actual cost. Consequently, serious consideration must be given to the design process in terms of selecting a good designer and giving sufficient time to prepare the designs. In addition, there must be coordination between the owner, consultant, and designer during the preparation of the designs.

2.3. Mitigation to reduce cost overrun

For the last 70 years, the persistent issue of cost overruns in the construction industry has not been improved, where about 90% of projects worldwide face this problem with an average cost overrun of 28% [52]. As the most of construction projects in most countries still suffer from cost overruns despite the various developments in project management methods. After identifying the most important reasons for excess costs in construction projects, it is important to provide solutions to reduce the impact of these causes. Several researchers have provided some mitigation measures to reduce cost overruns in construction projects. According to Koushki et al. [53], allocation of sufficient time and money at the design phase is one of the mitigations of cost overrun. In addition, there is another mitigation considered in other studies, such as selecting reputable and experienced consultants [54]. According to Awolesi et al. [55], the measures to mitigate cost overrun that related to design stage are, proper monitoring and control, use of proper construction methods, and inter-party cooperation. Another study by Sohu et al. [56] found that inadequate planning is one of the causes of cost overruns in construction projects that can be mitigated by applying the following measures, such as (1) Before project start, client should prepare strategically, (2) Project site should be visited before tendering the planning committee, (3) Planning section should hire competent staff, (4) Project cost should be estimated properly, (5) Efficient preparation should be introduced, and (6) Project timeline should be accurately calculated.

This study carried out a literature review which helped find the main causes of cost overruns in construction projects during the design stage, as well as effective techniques to avoid these causes. Most of these literature focuses on the factors that influence the overall cost performance of projects; however, it was noted that there are limited studies that looked at techniques to reduce cost overrun in construction

projects. As this stage is considered to be critical in the project life cycle, many factors that contribute to project success can be controlled through it. In addition, it is possible, at this stage, to avoid many of the reasons that had an obvious effect on cost overruns. For this reason, this study aims to fill this gap, in an effort to identify techniques that can help avoid cost overruns resulting from deficiencies at the design stage in construction projects. To address this, the researcher identified 17 causes, and 15 techniques, which are further investigated in this study.

3. Methodology

In this study, the methodology used was a combination of a literature review and a questionnaire survey in order to find out the most effective techniques that contribute to avoid the cost overrun causes related to design stage in construction projects. As shown in Fig. 1 the main steps of the current study methodology are summarized. The first step in the research methodology was to collect data regarding the problem of cost overrun related to design stage, this was through making an extensive literature review. Through this step, 17 causes of cost overrun related to design stage were indicated in addition to 15 techniques to avoid causes of cost overruns at design stage, which used as a basis for a wide questionnaire survey. The targeted respondents for this study are the construction projects engineers working within the key stakeholders as owners, consultants, and contractors. Then the data collected have been analysed using SPSS software in order to obtain the objective of this investigation.

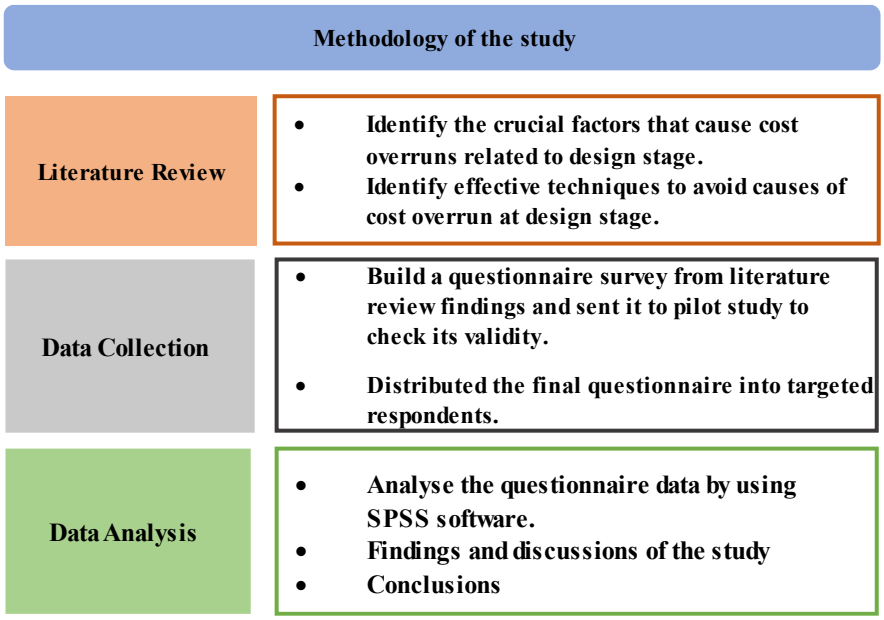

Fig. 1. Methodology flow chart.

4. Data Collection and Analysis

A total of 268 complete responses out of 350 were received, making the response rate 76.52%, which gives an indication that the study sample has an interest in this

topic. The general demographics of the respondents showed that 17.90% of respondents were owners, 38.10% consultants, and 44% contractors. Moreover, most of the respondents (80.60%) had a bachelor's degree as shown in Table 1. Also, it indicates that most of the respondents are civil engineers with a ratio of 76.10%. According to the experience work, 37.00% of the respondents have more than 10 years' experience, which gives the survey a meaningful contribution.

Table 1. Respondents' demographics.

	Parameters	Frequency	Percentage (%)
Level of Education	Diploma	9	3.4
	Bachelor's degree	216	80.6
	Master's degree	41	15.3
	Others	2	0.7
Working experience	Less than 5 years	84	31.3
	5-10 years	85	31.7
	11-15 years	43	16.1
	Above 15 years	56	20.9
Engineering competency	Civil	204	76.1
	Architecture	14	5.2
	Electrical	20	7.5
	Mechanical	23	8.6
	Others	7	2.6
Type of organization	Owner	48	17.9
	Consultant	102	38.1
	Contractor	118	44.0

The data of the study was collected and analysed, using mean item score ranking, percentages and the use of descriptive statistics. The Relative Important Index (RII) was used to rank the causes and technique to reduce cost overrun, which were found according to the fallowing equation as stated by Almaktari et al. [57]:

$$RII = \frac{\sum W}{A \times N} \quad (1)$$

where (RII) is the Relative Important Index, (W) is the weight given to each item ranging from 1 to 5, (A) is the highest weight (5), and (N) is the total number of respondents (268). In addition, the Spearman rank correlation coefficient was used to measure the strength of agreement between contractors, consultants, and owners in rankings the causes and techniques as was used by Odeh and Battaineh [58].

5. Results and Discussion

5.1. Causes of cost overruns related to design issues

As previously discussed, participants were asked to share their opinions based on their work experience in the construction industry. Participants were provided with a 5-point Likert scale and asked to weight the reasons for cost overruns at the design stage in the construction industry. In addition to techniques that help avoid causes of cost overrun at the design stage. The results of Relative Importance Index (RII) revealed that most of the causes have RII values more than 0.7000. Furthermore, the average value of RII was used to indicate the critical causes of cost overrun where, the causes with RII more than the average

value are indicated as critical causes. Accordingly, there are eight critical causes of cost overrun related to design issues that have values of RII more than average value (0.7255). These critical causes namely: Frequent design changes (CDS4), Incomplete drawings/ detailed design at the time of tender (CDS5), Mistakes in design (CDS3), Unrealistic contract duration (CDS16), Deficiencies in cost estimates prepared (CDS13), Lack of coordination at design phase (CDS7), Inaccurate quantity take-off (CDS15), and Inaccurate cost estimation (CDS12), as summarized in Table 2.

Table 2. Mean, RII, and Rank for the causes of cost overrun related to design stage.

Code	Causes of cost overrun	Mean	RII	Rank
CDS4	Frequent design changes	3.9515	0.7903	1
CDS5	Incomplete drawings/ detailed design at the time of tender	3.8246	0.7649	2
CDS3	Mistakes in design.	3.7799	0.7560	3
CDS16	Unrealistic contract duration	3.7799	0.7560	3
CDS13	Deficiencies in cost estimates prepared.	3.6940	0.7388	4
CDS7	Lack of coordination at design phase	3.6828	0.7366	5
CDS15	Inaccurate quantity take-off	3.6679	0.7336	6
CDS12	Inaccurate cost estimation	3.6343	0.7269	7
CDS6	Short bid preparation time	3.6157	0.7231	8
CDS10	Discrepancies in contract documentation	3.5560	0.7112	9
CDS9	Inadequate review and contract documents	3.5410	0.7082	10
CDS17	Lack of planning and coordination	3.5149	0.7030	11
CDS14	Ignorance and lack of knowledge	3.5075	0.7015	12
CDS2	Lack of cost planning/monitoring during pre-construction stage	3.5000	0.7000	13
CDS11	Inappropriate methods of cost estimation	3.4963	0.6993	14
CDS1	Practice of allocating contract to lowest bidder	3.4664	0.6933	15
CDS8	New designs and new systems	3.4515	0.6903	16

Note: (*) RII value more than the average value of RII.

CDS4: Frequent design changes

The results revealed that frequent design change is the most important cause affecting the cost overrun in construction projects with value of RII equal to 0.7903. It ranked the second on the point of view of consultants while owners and contractors agreed to rank it the first cause in this study, as shown in Table 3. Frequent changes in design are common in construction projects as the project is rarely devoid of them. These changes occur due to several reasons as lack of the experience of design team and lack in the site investigation. The budget allocated for the project, amount of materials needed, the type of materials required and the labour required would be influenced by any changes in the design [59]. This will inevitably result in an increase in the final cost of the project. Also, the study by Chimwaso [60] agreed with current study in considering frequent design change as critical cause of cost overrun.

CDS5: Incomplete drawings/ detailed design at the time of tender

This cause is the second cause in this study with RII of 0.7649. According to consultants it was ranked the first cause, while owners and contractors are agreed to rank it as 4th cause. Both owners and contractors do not give high importance to the details of the drawings, as each of them focuses on the completion of the project in the required time other than the consultant who attaches high importance to the details of the drawings. In construction projects it is important to complete all required drawings and detailing before starting, which prevents errors during the construction phase that lead to rework and finally cost overrun. The study by Jamaludin et al. [61] revealed that one of the factors influencing cost variance during construction is incomplete design drawings and specification.

CDS3: Mistakes in design

This cause is ranked 3rd cause in this study with RII of 0.7560, which agreed with consultants. Owners ranked CDS3 the 2nd cause, while contractors ranked it the 5th cause. Sometimes design errors are in the favour of the contractor to create change orders with additional profit. On the other hand, design errors can significantly degrade project performance by creating rework processes, requiring additional time and resource expenditures [62]. Indeed, the majority of design errors are due to insufficient experience of the designer. Designers who do not have thorough experience will create flawed designs that produce low quality work that will exaggerate the cost and time of the project [63].

CDS16: Unrealistic contract duration

Unrealistic contract duration (CDS16) is ranked the 3rd cause of cost overrun with RII of 0.7208. Only contractors agreed with overall ranking while consultant ranked it 4th and owners ranked it 8th cause of cost overruns. Realistic construct time becomes increasingly important as it often appears as a critical indicator for evaluating the efficiency of the project and the effectiveness of the contractor [64]. Moreover, delay in the completion date on construction projects adds additional cost to the project's initial budget as the extra time requires more expenses to fulfil the project requirements.

CDS13: Deficiencies in cost estimates prepared

Deficiencies in cost estimates prepared (CDS13) is the 4th cause of cost overrun related to design issues in this study. Owners and contractors agreed to rank it as 5th cause, where both of them are suffering from these deficiencies at construction stage. While, according to consultant it ranked the 7th cause in this study. According to Enshassi et al. [65], the construction industry is unique in the sense that it is particularly risky because most projects have to be bid before they are completed. Among the most prominent factors that lead to deficiencies in cost estimation are changes in the prices of materials and wages, as they are the basis for developing the initial estimate of the project. Also, the lack of certain information about the project is one of the deficiencies that affect the cost estimate in construction projects.

CDS7: Lack of coordination at design phase

Lack of coordination at design phase (CDS7) is ranked 5th cause according to the overall ranks with RII of 0.7366, whereby consultants and contractors are agreed

with this rank. On the other hand, owner ranked CDS7 the 10th cause of cost overrun that related to design issues. Due to a lack of cooperation during the design process between the owner and the designer, the designer has prepared the design according to what he considers appropriate for the project. Sometimes the owner has no clear vision of what they need and want [66]. Thus, the assumptions by design teams that turn out to be less than optimal from the owner's viewpoint and ultimately cause ' inevitable ' changes [67].

CDS15: Inaccurate quantity take-off

Inaccurate quantity take-off (CDS15) is ranked 6th cause of cost overrun related to design issues in this study with RII of 0.7336. On the other hand, all the three parties agreed to rank it as 7th cause of cost overrun, this agreement clarifies the extent of understanding the importance of accurate quantitative take-off and its impact on the interests of all parties. Moreover, it is noticed that nearly half of the additional works are due to unexpected additions and unbalanced final field measurements, which were not included in the contract offer items because the need for the work during the preparation of the schedule is uncertain [68].

CDS12: Inaccurate cost estimation

Finally, Inaccurate cost estimation (CDS12) is ranked the 7th cause with RII of 0.7269, while it ranked 3rd cause according to owner. Consultants and contractors ranked CDS12 as 9th cause of cost overrun related to design issues. The cost estimate is an important reason according to the owners as project financing is prepared according to this estimate. Therefore, any cost estimation errors will be reflected in the project financing, which ultimately leads to exceeding the estimated cost. Cost estimation is a procedure of determining the scope of work and the financial resources needed to satisfy the requirements of the project from initiation to termination. Hence, information about the projects' structural components and characteristics influences the estimation of the costs involved [69]. Pasco and Aibinu [70] referred to the estimate as a forecast of the project cost, which could be biased or consistent with the actual cost, generated by the estimator's forecast or influenced by the project conditions. The accuracy level of the estimate varies depending on the amount of information available regarding the project [71].

Table 3. Ranks of the critical causes by owners, consultants, and contractors.

Code	Overall		Owner		Consultant		Contractor	
	RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
CDS4	0.7903	1	0.8042	1	0.8059	2	0.7712	1
CDS5	0.7649	2	0.7583	4	0.8078	1	0.7305	4
CDS3	0.7560	3	0.7708	2	0.7843	3	0.7254	5
CDS16	0.7560	3	0.7208	8	0.7706	4	0.7576	3
CDS13	0.7388	4	0.7333	5	0.7569	7	0.7254	5
CDS7	0.7366	5	0.7029	10	0.7627	5	0.7254	5
CDS15	0.7336	6	0.7250	7	0.7569	7	0.7169	7
CDS12	0.7269	7	0.7667	3	0.7529	9	0.6881	9

5.2. Techniques to reduce cost overrun during design stage

Fifteen techniques were used in the design phase to reduce cost overruns in construction projects to be ranked in this study. The mean and Relative Importance Index (RII) were measured for all techniques as shown in Table 4. The average value of RII for all techniques is (0.8070), which used in this study to indicate the important techniques. Where, the techniques with RII value more than the average value are considered to be important techniques. As shown in Table 4, there are eight techniques considered as important techniques to reduce cost overrun in construction projects. These techniques are, PS11, PS8, PS2, PS3, PS4, PS5, PS7, and PS12.

Table 4. Mean, and RII for the techniques to reduce cost overrun during design stage.

Code	Description of items	Mean	RII	Rank
PS11	Ensure soil investigation is done and provide report along with tender before design phase.	4.1716	0.8343*	1
PS8	Proper and realistic approximate estimates should be obtained for cost and time of project through design stage.	4.1343	0.8269*	2
PS2	Make sure there are available funds before contracts are awarded.	4.1157	0.8231*	3
PS3	Using the professional staff to assess the project's viability and its study.	4.1119	0.8224*	4
PS4	Proper project design during design phase to prevent undue variance on-project.	4.1045	0.8209*	5
PS5	Appropriate funding levels should always be determined at the planning stage of the project so that regular payment should be paid to contractors for work.	4.0933	0.8187*	6
PS7	Managing and completing design stage before construction.	4.0821	0.8164*	7
PS12	Design the project in great detail at the beginning.	4.0709	0.8142*	8
PS15	Carryout pre project planning to minimize design errors.	4.0224	0.8045	9
PS6	Employers or owners of projects should allow more time and funds for the study phases of projects.	4.0037	0.8007	10
PS14	Refuse to accept unrealistic project time scale by client.	3.9701	0.7940	11
PS1	Improving contract award procedures by giving less weight to costs and greater weight to contractors' capacities and past results	3.9701	0.7940	11
PS13	Include contingency in budget.	3.9552	0.7910	12
PS9	Client should actively involve in design stage.	3.9030	0.7806	13
PS10	Ensure effective site assessment.	3.8172	0.7634	14

Note: (*) RII value more than the average value of RII.

As evident in Table 5, most of the eight techniques have values of RII more than 0.8000 according to respondents from the three parties. Only contractors agreed with the overall ranks in ranking the PS11 (Ensure soil investigation is done and provide report along with tender before design phase) as the 1st, while owners and contractors ranked it the 2nd. According, to the owners the most effective technique to avoid cost overrun is PS8 (Proper and realistic approximate estimates should be obtained for cost and time of project through design stage). While the consultant had another opinion in determining the most effective technique, where they ranked PS2 (Make sure there are available funds before contracts are awarded) as the 1st.

Table 5. Rank effective techniques by owners, consultants, and contractors.

Code	Overall		Owner		Consultant		Contractor	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
PS11	0.8343	1	0.8125	2	0.8333	2	0.8441	1
PS8	0.8269	2	0.8292	1	0.8196	4	0.8322	3
PS2	0.8231	3	0.8042	3	0.8431	1	0.8136	5
PS3	0.8224	4	0.8125	2	0.8157	6	0.8322	3
PS4	0.8209	5	0.8000	4	0.8157	6	0.8339	2
PS5	0.8187	6	0.8125	2	0.8275	3	0.8139	5
PS7	0.8164	7	0.8000	4	0.8333	2	0.8085	7
PS12	0.8142	8	0.8000	4	0.8176	5	0.8169	4

In addition, the spearman correlation was used to measure the agreement between two parties in ranking the techniques. The results of spearman rank correlation coefficient in Table 6 revealed that the highest degree of relationship was found between owner and contractor with correlation coefficient equal to 0.842 and P-value 0.000. It is followed by the significant relationship between owner and consultant with a correlation coefficient equal to 0.756. The weakest relationship was between the consultant and the contractor, with a correlation coefficient equal to 0.572. These results demonstrate the awareness of each of the three parties to the most important techniques that can reduce the problem of cost overruns in construction projects.

Table 6. Results of Spearman correlation for techniques to reduce cost overrun.

Pre-construction phase	Correlation Coefficient	P- value
Owner and Consultant	0.756	0.001
Owner and Contractor	0.842	0.000
Consultant and Contractor	0.572	0.026

Ensure soil investigation is done and provide report along with tender before design phase (PS11)

The most important technique in this study to reduce cost overrun is the PS11, which ranked 1st according to contractors and the 2nd according to owners and consultants. In construction projects, soil investigation is an important step to take before starting the design process. This examination determines the soil bearing capacity, which is important to determine the appropriate type of design. Thus this contributes to avoiding redesign and reduces design modifications during the

construction stage. Whereby, the selection of the appropriate type of design for the project helps to prevent redesign during the construction phase. Moreover, the site investigation may be considered a failure if the subsurface conditions required for the safe, economical design of foundations or earth structures are not accurately identified [72].

Proper and realistic approximate estimates should be obtained for cost and time of project through design stage (PS8)

The second effective technique in current study is PS8, which was ranked the 1st by owners and 3rd, and 4th by contractors and consultants respectively. Cost and time estimation at the design stage requires serious attention from the design team as the precision of this process and its consistency with reality contribute to the avoidance of cost overruns in construction projects. It is noted that the estimation process depends primarily on the competence and experience of the estimator, as well as on the reliability and accuracy of the project data and documents. Estimates must be as accurate as possible as they form the base for comparison, evaluation, or negotiation of the tender [73]. Moreover, preparing a realistic cost estimate is an essential component of any construction operation [73]. Therefore, continuous improvement of the pre-design phase is necessary in order to provide more accurate estimates and better value for money [74].

Make sure there are available funds before contracts are awarded (PS2)

According to the overall ranking, PS2 ranked as the 3rd, while consultants in current study rank it the 1st, and according to owners and contractors it ranked 3rd and 5th, respectively. Many of the reasons that led to an increase in the cost of construction projects were the result of inadequate funds available for the projects being implemented. It reflects negatively on the financial conditions for both the owner and the contractor and, consequently, on the progress of the project. Moreover, providing adequate funds is considered a basis for the project's success in completing within the time and cost specified in the contract. Therefore, the owner must provide the project financing before starting the implementation of the project, to avoid any financial problems affecting the progress of the project.

Using the professional staff to assess the project's viability and its study (PS3)

This technique was ranked the 4th according to the overall ranking, while it was ranked 2nd, 3rd, and 6th by owners, contractors, and consultants respectively. A feasibility study is the process of verifying the viability of a project in all aspects, which is carried out during the initiation of any project. To carry out a good evaluation, competent staff must be provided for that and have sufficient experience to review design drawings and bidding documents prior to referral to the contractor. In addition, they must have sufficient experience and knowledge of everything related to construction projects. Therefore, the owner must ensure that the team has sufficient experience in this area to obtain a realistic study of the project, as this greatly contributes to reducing the potential risks that increase the expected cost of the project during the implementation phase.

Proper project design during design phase to prevent undue variance on-project (PS4)

This is the 5th technique in the current study, which was ranked the 2nd, 4th, and 6th by contractors, owners, and consultants respectively. The drawings design should be in high accuracy and involving all details needed to reduce the changes in designs during construction stage. Furthermore, all needed design should be finished before awarding the project. Generally, one of the additional payment claims is defects in the initially issued design or documentation for a project [75]. Therefore, owner must focus on the design stage and give it sufficient time to be able to prepare all the details and review them accurately to avoid any omissions or errors that are negatively reflected during the implementation phase.

Appropriate funding levels should always be determined at the planning stage of the project so that regular payment should be paid to contractors for work (PS5)

According to the overall ranking this technique ranked the 6th. While it was ranked the 2nd , 3rd , and 5th according to owners, consultants and contractors respectively. Insufficient fund is one of the most critical problems facing construction projects in developing and developed countries. As the majority of contractors rely on periodic payments from the owner to cover project expenses. Moreover, any delay in payment by the owner exposes him to financial claims to compensate the contractor for delay damages. Therefore, before awarding contracts, the adequacy of the fund must be verified in order to avoid cost overrun. Another study by Frimpong et al. [76] also considered PS5 as a preventive strategy to reduce cost overrun.

Managing and completing design stage before construction (PS7)

PS7 is the 7th technique in the current study as ranked by overall, only contractors agreed with the overall ranking. While it was ranked the 2nd and 4th according to consultants and owners respectively. Nearly 73% of construction professionals agree that design management is necessary to ensure timely and efficient design within the budget [77]. The responsibilities to review and audit design are among the responsibilities of the owner, which can reduce the risk arising from cost overrun during implementation. Another study by Al-Keim [35] highlighted the need to manage and complete the design stage before construction, which helps to reduce cost overrun.

Design the project in great detail at the beginning (PS12)

This technique was ranked the 8th by the overall ranking, while owners and contractors agreed to ranked it the 4th. On the other hand, consultant ranked it the 5th. Implementation errors due to lack of detail in the designs reflected negatively on the project and often lead to re-work. 6-15% of construction costs are found to be a waste due to the re-work of identified defective components during maintenance [78]. Before awarding the contract to the contractor, it is necessary to review the design details in order to ensure that all details have been made to prevent any adjustments during the construction process. Also, the study by Olawale and Sun [43] considered this strategy as one of the preventive mitigating measures for design changes, which is one of the significant causes of cost overruns.

In order to identify a value within RII calibration as a stationary technique to reduce cost overrun at design stage, the researcher used the repetitive inquiry method by generating a unified weight by Ginni's mean measure of dispersion for the Relative Importance Index numbers. Whereby, this method of analysis was used by the study of [79] to identify the stationary cause of cost overrun in construction projects. Based on the data on Relative Importance Index numbers (RII) on the techniques to reduce cost overrun, the current study went to generate a unified weight value using the Ginni's mean difference measures of dispersion from the following equation:

$$\Delta_1 \equiv \frac{1}{n(n-1)} \sum_{i=1}^{m} \sum_{j=1}^{n} [x_i - x_j] \quad i \neq j \tag{2}$$

The results of applying the above equation are summarized in Table 8. In addition, the details of the results of the instruments used are listed in Table 7.

$$\Delta_1 = \frac{g}{m} = \frac{2.3536}{105} = 0.02242$$

$$m = \frac{n(n-1)}{2} = \frac{15(15-1)}{2} = 105$$

where (Δ_1) Ginni's coefficient of mean difference, (g) Sum of the difference, (n) Set of observation.

The outcome from this analysis gave an anti-log value of 0.8072. This value on the RII calibration as shown in Table 7 is as a stationary value between the boundary variables of Design the project in great detail at the beginning has RII value of 0.8142 and Carryout pre project planning to minimize design errors having value of RII 0.8045. This result suggests that the stationary technique to reduce cost overrun at design stage is stationary between Design the project in great detail at the beginning (PS12) and Carryout pre project planning to minimize design errors (PS15).

Table 7. results of the instruments used.

Rank	RII	w(.)= 0.02687 RII	log RII	w(.) log RII
1	0.8343	0.02242	-0.0787	-0.00176
2	0.8269	0.02222	-0.0825	-0.00183
3	0.8231	0.02212	-0.0846	-0.00187
4	0.8224	0.02210	-0.0849	-0.00188
5	0.8209	0.02206	-0.0857	-0.00189
6	0.8187	0.02200	-0.0869	-0.00191
7	0.8164	0.02194	-0.0881	-0.00193
8	0.8142	0.02188	-0.0893	-0.00195
9	0.8045	0.02162	-0.0945	-0.00204
10	0.8007	0.02151	-0.0965	-0.00208
11	0.7940	0.02133	-0.1002	-0.00214
12	0.7940	0.02133	-0.1002	-0.00214
13	0.7910	0.02125	-0.1018	-0.00216
14	0.7806	0.02097	-0.1076	-0.00226
15	0.7634	0.02051	-0.1172	-0.0024
Total		0.32526	-1.3987	-0.03025

Table 8. Ginni's difference measure iteration.

Code	Rank	RII	δi = 1	δi = 2	δi = 3	δi = 4	δi = 5	δi = 6	δi = 7	δi = 8	δi = 9	δi = 10	δi = 11	δi = 12	δi = 13	δi = 14
PS11	1	0.8343	0.0709	0.0635	0.0597	0.0590	0.0575	0.0553	0.0530	0.0508	0.0411	0.0373	0.0306	0.0306	0.0276	0.0172
PS8	2	0.8269	0.0537	0.0463	0.0425	0.0418	0.0403	0.0381	0.0358	0.0336	0.0239	0.0201	0.0134	0.0134	0.0104	0
PS2	3	0.8231	0.0433	0.0359	0.0321	0.0314	0.0299	0.0277	0.0254	0.0232	0.0135	0.0097	0.0030	0.0030	0	
PS3	4	0.8224	0.0403	0.0329	0.0291	0.0284	0.0269	0.0247	0.0224	0.0202	0.0105	0.0067	0	0		
PS4	5	0.8209	0.0403	0.0329	0.0291	0.0284	0.0269	0.0247	0.0224	0.0202	0.0105	0.0067	0			
PS5	6	0.8187	0.0336	0.0262	0.0224	0.0217	0.0202	0.0180	0.0157	0.0135	0.0038	0				
PS7	7	0.8164	0.0298	0.0224	0.0186	0.0179	0.0164	0.0142	0.0119	0.0097	0					
PS12	8	0.8142	0.0201	0.0127	0.0089	0.0082	0.0067	0.0045	0.0022	0						
PS15	9	0.8045	0.0179	0.0105	0.0067	0.0060	0.0045	0.0023	0							
PS6	10	0.8007	0.0156	0.0082	0.0044	0.0037	0.0022	0								
PS14	11	0.7940	0.0134	0.0060	0.0022	0.0015	0									
PS1	12	0.7940	0.0119	0.0045	0.0007	0										
PS13	13	0.7910	0.0112	0.0038	0											
PS9	14	0.7806	0.0074	0												
PS10	15	0.7634	0													
	Total		0.4094	0.3058	0.2564	0.2480	0.2315	0.2095	0.1888	0.1712	0.1033	0.0805	0.0470	0.0470	0.0380	0.0172

6. Conclusions

To avoid cost overruns related to the design stage, this study identifies the most prominent techniques that reduce cost overruns in construction projects by analysing the data collected by a questionnaire survey. First, the most prominent reasons related to the design process that led to cost overruns were identified, namely: Frequent design changes, Incomplete drawings/ detailed design at the time of tender, Mistakes in design, Unrealistic contract duration, Deficiencies in cost estimates prepared, Lack of coordination at design phase, Inaccurate quantity take-off, and Inaccurate cost estimation. In addition, the study identified the most eight effective techniques, which can be used to reduce the causes of cost overrun that related to design issues. The most important one is PS11 (Ensure soil investigation is done and provide report along with tender before design phase). In addition, the repetitive inquiry method was used to identify the stationary technique to reduce cost overrun in construction projects. the results identified the stationary technique to reduce cost overrun at design stage to be between Design the project in great detail at the beginning (PS12) and Carryout pre project planning to minimize design errors (PS15).

It is concluded that the owner is responsible for the deficiencies at the design stage, followed by the designer. As he is the decision-maker in choosing the designer and providing him with the data and requirements of the project to be designed. Therefore, the current study recommends the appointment of specialized experts within the owner's team so that they are qualified to follow up the construction projects from the stage of preparation and design to completion.

Acknowledgements

The authors would like to acknowledge and appreciate to Universiti Malaysia Pahang (UMP) for the financial support of Research University Grant PGRS1903139 A Comprehensive Study on Cost Overrun in Jordanian Construction Project that enabled us to conduct this research.

References

1. Bahamid, R.A.; Doh, S.I.; and Al-Sharaf, M.A. (2019). Risk factors affecting the construction projects in the developing countries. *IOP Conference Series: Earth and Environmental Science*. IOP Publishing. Kuantan, Malaysia, 1-4.
2. Soewin, E.; and Chinda, T. (2018). Factors affecting construction performance: exploratory factor analysis. *IOP Conference Series: Earth and Environmental Science*. IOP Publishing. Langkawi, Malaysia, 1-8.
3. Kim, S.Y.; and Huynh, T.A. (2008). Improving project management performance of large contractors using benchmarking approach. *International Journal of Project Management*, 26(7), 758-769.
4. Gharaibeh, L.G.; Matarneh, S.T.; Arafeh, M.; and Sweis, G. (2020). Factors leading to design changes in Jordanian construction projects. *International Journal of Productivity and Performance Management*, 70(4), 893-915.
5. Hao, Q.; Shen, W.; Neelamkavil, J.; and Thomas, R. (2008). Change management in construction projects. *Proceedings of International Conference on Information Technology in Construction*. Santiago, Chile, 387-396.

6. Bekr, G.A. (2015). Identifying factors leading to cost overrun in construction projects in jordan. *Journal of Construction Engineering, Technology and Management*, 5(3), 25-33.
7. Ibbs, W. (2012). Construction change: Likelihood, severity, and impact on productivity. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 4(3), 67-73.
8. Albtoush, A.M.F.; Doh, S.I.; Rahman, R.A.; and Albtoush, J.f.A.A. (2020). Factors effecting the cost management in construction projects. *International Journal of Civil Engineering and Technology*, 11(1), 105-111.
9. Moura, H.M.P.; Teixeira, J.M.C.; and Pires, B. (2007). Dealing with cost and time in the Portuguese construction industry. *International Council for Research and Innovation in Building and Construction*. Cape Town, South Africa, 1252-1265.
10. Jyotheendranath, C. (2015). *Management of cost-effective construction with special reference to cost ford*. Manonmaniam Sundaranar University.
11. Niazi, G.A.; and Painting, N. (2017). Significant factors causing cost overruns in the construction industry in Afghanistan. *Procedia Engineering*, 182, 510-517.
12. Habibi, M.; Kermanshachi, S.; and Safapour, E. (2018). Engineering, procurement and construction cost and schedule performance leading indicators: state-of-the-art review. *Proceedings of Construction Research Congress*. New Orleans, Louisiana: ASCE, 2-4.
13. Lee, Z.P.; Rahman, R.A.; and Doh, S.I. (2020). Success factors of design-build public sector projects in Malaysia. *IOP Conference Series: Materials Science and Engineering*. IOP Publishing. Kuala Lumpur, Malaysia, 1-9.
14. Sinesilassie, E.; Tabish, S.; and Jha, K. (2018). Critical factors affecting cost performance: a case of Ethiopian public construction projects. *International Journal of Construction Management*, 18(2), 108-119.
15. Zewdu, Z.; and Aregaw, G. (2015). Causes of contractor cost overrun in construction projects: The case of Ethiopian construction sector. *International Journal of Business and Economics Research*, 4(4), 180-191.
16. Memon, A.H.; Rahman, I.A.; Aziz, A.A.; Ravish, K.V.; and Hanas, N.M. (2011). Identifying construction resource factors affecting construction cost: Case of johor. *Paper presented at the Malaysian Technical Universities International Conference on Engineering & Technology (MUiCET 2011)*. Johor, Malaysia, 1-7.
17. Pourrostam, T.; and Ismail, A. (2011). Significant factors causing and effects of delay in Iranian construction projects. *Australian Journal of Basic and Applied Sciences*, 5(7), 450-456.
18. Endut, I.R. (2008). *Framework for minimising time overruns of Malaysian construction projects*. Glasgow Caledonian University, UK: Ph. D Thesis.
19. Kissi, E.; Adjei-Kumi, T.; and Badu, E. (2016). Critical barriers to the practice of effective cost planning in the Ghanaian construction industry. *Journal of Construction Engineering and Project Management*, 6(2), 8-15.
20. Baloi, D.; and Price, A.D. (2003). Modelling global risk factors affecting construction cost performance. *International Journal of Project Management*, 21(4), 261-269.

21. Saidu, I.; and Shakantu, W. (2017). An investigation into cost overruns for ongoing building projects in Abuja, Nigeria. *Acta Structilia*, 24(1), 53-72.
22. Pall, G.K.; Bridge, A.J.; Skitmore, M.; and Gray, J. (2016). Comprehensive review of delays in power transmission projects. *IET Generation, Transmission & Distribution*, 10(14), 3393-3404.
23. Ahmed, S.M.; Azhar, S.; Kappagntula, P.; and Gollapudil, D. (2003). Delays in construction: a brief study of the Florida construction industry. *Paper presented at the Proceedings of the 39th Annual ASC Conference*. Clemson University, Clemson, SC, 257-266.
24. Albtoush, A.M.F.; and 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.
25. Torp, O.; Belay, A.M.; Thodesen, C.; and Klakegg, O.J. (2016). Cost development over-time at construction planning phase: Empirical evidence from Norwegian construction projects. *Procedia Engineering*, 145, 1177-1184.
26. Azhar, N.; Farooqui, R.U.; and Ahmed, S.M. (2008). Cost overrun factors in construction industry of Pakistan. *First International Conference on Construction in Developing Countries (ICCIDC–I), Advancing and Integrating Construction Education, Research & Practice*. Karachi,, Pakistan, 499-508.
27. Chang, A.S.T. (2002). Reasons for cost and schedule increase for engineering design projects. *Journal of Management in Engineering*, 18(1), 29-36.
28. Abdul Rahman, I.; Memon, A.H.; and Abdul Karim, A.T. (2013). Significant factors causing cost overruns in large construction projects in Malaysia. *Journal of Applied Science*, 13(2), 286-293.
29. Jallow, A.K.; Demian, P.; Baldwin, A.N.; and Anumba, C. (2014). An empirical study of the complexity of requirements management in construction projects. *Engineering, Construction and Architectural Management*, 21(5), 505-531.
30. Rahman, R.A.; Radzi, A.R.; Saad, M.S.H.; and Doh, S.I. (2020). Factors affecting the success of highway construction projects: the case of Malaysia. *IOP Conference Series: Materials Science and Engineering*. IOP Publishing. Kuala Lumpur, Malaysia, 1-8.
31. El-Maaty, A.E.A.; El-Kholy, A.M.; and Akal, A.Y. (2017). Modeling schedule overrun and cost escalation percentages of highway projects using fuzzy approach. *Engineering, Construction and Architectural Management*, 24(5), 809-827.
32. Agyekum-Mensah, G.; and Knight, A.D. (2017). The professionals' perspective on the causes of project delay in the construction industry. *Engineering, Construction and Architectural Management*. 24(5), 828-841.
33. Polat, G.; Okay, F.; and Eray, E. (2014). Factors affecting cost overruns in micro-scaled construction companies. *Procedia Engineering*, 85, 428-435.
34. Hemal, R.; Waidyasekara, K.; and Ekanayake, E. (2017). Integrating design freeze into large-scale construction projects in Sri Lanka. *Moratuwa Engineering Research Conference (MERCon)*. Moratuwa, Sri Lanka, 259-264.
35. Al-Keim, A. (2017). *Strategies to reduce cost overruns and schedule delays in construction projects.* Walden Dissertations and Doctoral Studies, 4586, Walden University, Minneapolis, Minnesota.

36. Belachew, A.S.; Mengesha, W.J.; and Mohammed, M. (2017). Causes of cost overrun in federal road projects of Ethiopia in case of Southern District. *American Journal of Civil Engineering*, 5(1), 27-40.
37. Abusafiya, H.A.; and Suliman, S.A. (2017). Causes and effects of cost overrun on construction project in Bahrain: Part 2 (PLS-SEM Path Modelling). *Modern Applied Science*, 11(7), 28-37.
38. Naveenkumar, G.; and Prabhu, V. (2016). Factors influencing time and cost overruns in construction projects. *International Journal of Innovative Research in Science, Engineering and Technology* 5 (4), 6468-6473.
39. Rauzana, A. (2016). Cost overruns and failure in construction projects. *IOSR Journal of Business and Management*, 18(10), 80-83.
40. Alghonamy, A. (2015). Cost overrun in construction projects in Saudi Arabia: Contractors' perspective. *International Journal of Engineering & Technology, IJET-IJENS*, 15(4), 35-42.
41. Ali, A.; and Kamaruzzaman, S. (2010). Cost performance for building construction projects in Klang Valley. *Journal of Building Performance*, 1(1). 110-118.
42. Nasir, A.R.; Gabriel, H.F.; and Choudhry, R.M. (2011). Cost and time overruns in highway projects of Pakistan. *International Conference on Construction in the 21st Century*. Kuala Lumpur, Malaysia, 69-76.
43. Olawale, Y.A.; and Sun, M. (2010). Cost and time control of construction projects: inhibiting factors and mitigating measures in practice. *Construction Management and Economics*, 28(5), 509-526.
44. Long, N.D.; Ogunlana, S.; Quang, T.; and Lam, K.C. (2004). Large construction projects in developing countries: a case study from Vietnam. *International Journal of Project Management*, 22(7), 553-561.
45. Abusafiya, H.; and Suliman, S. (2017). Causes and effects of cost overrun on construction project in Bahrain: Part I (ranking of cost overrun factors and risk mapping). *Modern Applied Science*, 11(7), 20-27.
46. Jackson, S. (2002). Project cost overruns and risk management. *Proceedings of Association of Researchers in Construction Management 18th Annual ARCOM Conference*. Newcastle, Northumber University, UK, 2-4.
47. Danso, H.; and Antwi, J.K. (2012). Evaluation of the factors influencing time and cost overruns in telecom tower construction in Ghana. *Civil and Environmental Research*, 2(6), 15-25.
48. Iyer, K.; and Jha, K. (2005). Factors affecting cost performance: evidence from Indian construction projects. *International Journal of Project Management*, 23(4), 283-295.
49. Li, H. (2009). Study on construction cost of construction projects. *Asian Social Science*, 5(8), 144-149.
50. Bin Seddeeq, A.; Assaf, S.; Abdallah, A.; and Hassanain, M.A. (2019). Time and cost overrun in the Saudi Arabian oil and gas construction industry. *Buildings*, 9(2), 41-58.
51. Divakar, K.; and Britto, J. (2018). Factors affecting effective implementation of cost management process in construction industry. *International Research Journal of Engineering and Technology (IRJET)*, 5(05), 3599-3603.

52. Flyvbjerg, B.; Skamris Holm, M.K.; and Buhl, S.L. (2003). How common and how large are cost overruns in transport infrastructure projects?. *Transport Reviews*, 23(1), 71-88.
53. Koushki, P.; Al-Rashid, K.; and Kartam, N. (2005). Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics*, 23(3), 285-294.
54. Derakhshanalavijeh, R.; and Teixeira, J.M.C. (2014). Causes of cost overrun in construction projects in developing countries: Gas-oil construction industry of Iran, a case study. *Journal of Civil Engineering and Management*, 1-21.
55. Awolesi, J.A.; Fabi, J.K.; and Akinseinde, O.A. (2015). Assessment of contractors' mitigating measures for cost overrun of building projects in South-Western Nigeria. *Journal of Sustainable Development*, 8(9), 139-146.
56. Sohu, S.; Memon, B.A.; Nagapan, S.; and Bhatti, N.U.K. (2018). Mitigation measures for significant factors instigating cost overrun in highway projects. *Civil Engineering Journal*, 4(10), 2338-2344.
57. Almaktari, A.M.; Hong, R.; and Nzige, J. (2017). The factors influencing cost overrun on construction projects in Yemen. *International Journal of Scientific & Engineering Research*, 8(11), 582-589.
58. Odeh, A.M.; and Battaineh, H.T. (2002). Causes of construction delay: traditional contracts. *International Journal of Project Management*, 20(1), 67-73.
59. Enshassi, A.; Al-Najjar, J.; and Kumaraswamy, M. (2009). Delays and cost overruns in the construction projects in the Gaza Strip. *Journal of Financial Management of Property and Construction*, 14(2), 126-151.
60. Chimwaso, K. (2001). An evaluation of cost performance of public projects: Case of Botswana. Department of Architecture and Building Services. *International Journal of Project Management*, 31, 621-744.
61. Jamaludin, S.Z.H.S.; Mohammad, M.F.; and Ahmad, K. (2014). Enhancing the quality of construction environment by minimizing the cost variance. *Procedia-Social and Behavioral Sciences*, 153, 70-78.
62. Han, S.; Love, P.; and Peña-Mora, F. (2013). A system dynamics model for assessing the impacts of design errors in construction projects. *Mathematical and Computer Modelling*, 57(9-10), 2044-2053.
63. Peansupap, V.; and Walker, D.H. (2009). Exploratory factors influencing design practice learning within a Thai context. *Engineering, Construction and Architectural Management.* 16(3), 238-253.
64. Chan, D.W.; and Kumaraswamy, M.M. (2002). Compressing construction durations: lessons learned from Hong Kong building projects. *International Journal of Project Management*, 20(1), 23-35.
65. Enshassi, A.; Mohamed, S.; and Madi, I. (2015). Cost estimation practice in the Gaza Strip: A case study. *IUG Journal of Natural Studies*, 15(2), 153-178.
66. Hongtao, S. (2014). *Preventing cost overruns on building construction projects - An Investigation*, Unpublished Master's Thesis, Dublin Institute of Technology.
67. Cunningham, T. (2017). *What causes cost overruns on building projects?-An Overview*. School of the Built Environment, The University of Salford, UK.

68. Sweis, G.J. (2013). Factors affecting time overruns in public construction projects: The case of Jordan. *International Journal of Business and Management*, 8(23), 120-129.
69. Shash, A.A.; and Ibrahim, D. (2005). Survey of procedures adopted by A/E firms in accounting for design variables in early cost estimates. *Journal of King Saud University-Engineering Sciences*, 18(1), 1-16.
70. Pasco, T.; and Aibinu, A.A. (2008). *Project factors influencing the accuracy of early-stage estimates. Building Resilience*, 102. UK: The University of Salford.
71. Amade, B.; and Akpan, E.O.P. (2014). Project cost estimation: issues and the possible solutions. *International Journal of Engineering and Technical Research (IJETR) ISSN*, 2(5), 181-188.
72. Myburgh, K.S. (2018). *The minimum site investigation requirements needed to define site conditions considering the results of ground investigations and its true reflection of actual site conditions found during construction*. Doctoral dissertation, Stellenbosch: Stellenbosch University.
73. Alumbugu, P.O.; Ola-awo, W.A.; Saidu, I.; Abdullahi, M.M.; and Abdulazeez, A. (2014). Assessment of the factors affecting accuracy of pre-tender cost estimate in Kaduna state, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8(5), 19-27.
74. Azman, M.A.; Abdul-Samad, Z.; and Ismail, S. (2013). The accuracy of preliminary cost estimates in Public Works Department (PWD) of Peninsular Malaysia. *International Journal of Project Management*, 31(7), 994-1005.
75. Ramabodu, M.; and Verster, J. (2010). Factors contributing to cost overruns of construction projects. *Paper presented at the 5th Built Environment Conference Factors Contributing to Cost Overruns of Construction Projects*. Durban, South Africa, 131-143.
76. Frimpong, Y.; Oluwoye, J.; and Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing country; Ghana as a case study. *International Journal of Project Management*, 21(5), 321-326.
77. Elmualim, A.; and Gilder, J. (2014). BIM: innovation in design management, influence and challenges of implementation. *Architectural Engineering and Design Management,* 10(3-4), 183-199.
78. Waje, V.; and Patial, V. (2013). *Cost of poor quality in construction*, 1Department of Civil Engineering: MIT College, Paud Road Camp. Pune/Pune University, India.
79. Samuel, E.I.; and Ovie, A.I. (2015). Iterating a stationary cause of cost overruns in construction projects. *International Journal of Construction Engineering and Management,* 4(2), 52-59.