IDENTIFICATION OF MODERN COST REDUCTION TECHNIQUES FOR CONSTRUCTION PROJECTS IN SRI LANKA

WN Kawmudi[1*], SD Jayasooriya[2] , AH Lakmal[3]

[1,2,3]Faculty of Built Environment and Spatial Sciences (FBESS), General Sir John Kotelawala Defence University, Sri Lanka

[1]wnkawmudi@kdu.ac.lk, [2]sjayasooriya@kdu.ac.lk, [3]lakmalah@kdu.ac.lk

ABSTRACT

Cost is a basic criterion that measures the success of a construction project. Projects rarely meet the pre-estimated budget. There are many techniques available in current practices to control the cost of a project. However, there is still poor cost performance in the construction industry. Thus, this paper aims to identify the modern cost reduction techniques for construction projects in Sri Lanka. The data collection was conducted through a detailed questionnaire survey and interviews. The respondents are industry professionals and the response rate was 88%. The industry experts suggested a broad range of solutions based on their experience regarding the cost of a project. The Effectiveness Index analysis and content analysis were used to analyze the collected data. The findings are expected to bridge the gap in the current cost control practices by implementing modern techniques which are found as selecting appropriate value management approaches, implementing modern construction technologies, risk management, and sustainable construction. It was recommended to have construction risk assessments, continuous training programs on project cost control, and introduce a course module regarding modern cost reduction techniques at the academic level. While this research focused on the cost control of private sector projects, research can be extended to validate the conclusion of this study considering the public sector projects and categorise the modern techniques to reduce the time overruns in construction projects in the future.

KEYWORDS: *Cost overruns, Cost control, Cost reduction techniques*

1. INTRODUCTION

Construction Industry plays a significant role in the development of a country. It is the engine of the national economy of Sri Lanka where the overall physical improvement of the country is achieved. Construction Industry is one of the prominent sectors in the Sri Lankan context which has contributed approximately 6.8% to the GDP (Annual Report 2018, Central Bank of Sri Lanka). Due to different issues, the main problem that the Sri Lankan construction industry is currently facing is identified as “poor cost performance”.

Every project aims to finish on time within the budget, with the required quality by consuming the available resources [1]. Cost performance is one of the significant criteria which measures the success of a project because the performance of a specific project is expressed in terms of actual cost and its adjustment to the budget. This is a challenging task for Project Managers considering the necessity for measuring and evaluating the progress and taking required corrective actions when it is needed.

In most construction projects, the cost at completion is almost always higher than the anticipated cost which is pre-estimated at the initial stage. Cost overruns arise when the actual cost of the project is more than the estimated cost. Factors affecting cost overruns differ from country to country depending on economic, political, cultural as well as internal and external factors of the industry. Cost estimated at the initial stage is the most important factor [2]. It carries far more monetary value than just a normal idea about cost performance. The real cost estimate is so dynamic because it determines the financial competence of the project and provides a baseline for cost control of the project.

In some situations, acceleration of a project is required, which results in increasing of the project cost. In addressing this, monitoring of each phase of the construction is important. Controlling project cost is not an easy task which involves applications of different cost reduction methods. Hence experts in the industry need to have theoretical as well as practical knowledge of

[*]Corresponding Author: Email Address:wnkawmudi@kdu.ac.lk (WN Kawmudi)

cost control techniques. Insufficient cost control may lead to project failures and it emphasizes the need for proper control over the construction cost in the Sri Lankan construction industry.

There are diverse techniques and project management software available for cost optimization, but still they are insufficient to accomplish the desired cost parameters completely within the projects. Even with various cost control techniques, cost overrun is not uncommon all over the world. It does not sufficiently explain why the cost overrun keep happening though adequate understanding has been already shared by the industry professionals. The excess construction cost will lead to additional investment burden, negatively affect the investment related decision-making and cause wastage of national funding and ultimately bring negative impact on the overall economy of the country.

It is common to see a construction project failing to achieve its' objectives within the pre-estimated cost. None of the studies have improved on this and the cost overrun undertaken over the last 70 years [3] highlighted the need for modern cost reduction strategies. In the lack of related research in Sri Lanka, this study targets to fill a significant knowledge gap by identifying the specific modern cost reduction techniques which can be practically implemented in construction projects in Sri Lanka.

2. LITERATURE REVIEW

A. Construction Cost Overruns

There is a need for understanding the factors affecting cost overrun and identifying the mitigation measures. The public usually underestimate the costs which lead to negative impacts for the project and overestimated the benefits of the same action. It has been observed that delay and cost overruns are habitually occurring in developing countries [4]. Further Azhar [5] confirmed that poor cost performance is a shared problem worldwide.

The cost overrun of a project depends on project size, type, and location. It was emphasized by Dlakwa and Culpin [6] that the requirement of proper management of projects is greater at large scale construction projects than the smaller ones. Cost and time are inseparable since the extension of time leads to cost overrun [7]. Usually clients expect high quality and better service performance at a minimum cost. Malkanthi [8] interpreted that the main problem is not in the techniques, but in the familiarity regarding poor management of methods and more over inadequate control. "*Without keeping an eye on the real costs while in progress, the successful completion will not be possible*" [9].

Cost overrun has been a topic discussed in many previous studies which is considered problematic in projects. It is required to be addressed as early as possible. However, there is a significant lack of related literature in Sri Lankan context which address the causes and mitigating measures of cost overrun. Thus, there is an urgent need to find the best cost reduction techniques for successful project completion in the Sri Lankan context.

B. Cost Reduction Methods

The cost reduction techniques were identified and proposed through different studies. Management should take necessary steps on controlling human resources. Value and change management approaches, reducing errors in estimations, and inventory control are also beneficial to minimizing cost overrun. Further, the importance of training on cost management was emphasized, through brainstorming sessions [10]. It was further stated that a well-defined plan is necessary for the effective completion of a project with fewer disputes. It is recommended that contractors, clients, and consultants should work as a team and take collective decisions whenever necessary.

The total cost should be carefully assessed in the initial stage before signing a contract [3]. The tight control among projects can limit variations which directly affect the cost overrun. Aljohani [1] suggested controlling the cost of projects by applying effective resources and improving proper communication between internal and external stakeholders. Tam [11] highlighted the importance of procurement management and the availability of required material at the site on time. Sri Lankan authorities should inspire construction professionals to use cost reduction techniques by conducting awareness programs [8].

Durdyev [12] recommended spending more time on the pre-contract stage to clearly define the scope of the project. Further, attention is necessary to the quality of construction materials to minimize wastage and a detailed schedule of material supply should be provided. If they were properly managed the extra cost would be reduced [13]. Kaming et al. [7] recommended maintaining a cost database of materials based on research in Indonesia. According to Hafez, et al. [14], cost control can be easily attained through recruiting the right person for the right job function which is the responsibility of the project manager by delegating the responsibilities with proper understanding. The authors

further recommended that contractors should have the necessary knowledge of cost control.

3. RESEARCH METHODOLOGY

The aim of the research is to identify the modern cost reduction techniques in building construction projects in Sri Lanka. To evaluate the mitigation techniques in construction projects, a large range of communities attached to the construction industry in Sri Lanka was targeted covering the professionals and other stakeholders in the Sri Lankan construction industry. The research was completely evaluated through a questionnaire survey (quantitative) and interviews (qualitative) with the concerned authorities. The combinations of qualitative and quantitative methods are highly appreciated because it gives a comprehensive picture and enhances the study of the research area.

A. DATA COLLECTION METHODS

A web-based detailed questionnaire (Google forms) was circulated among professional groups in the construction industry in Sri Lanka, through e-mails sent to the construction firms. Questionnaires were distributed among professionals to obtain suitable responses to the questionnaire and different viewpoints were ranked accordingly on the "Likert Scale". The total number of questionnaires distributed was 60 (selected by stratified random sampling), and the response rate was 88.33% including 13 Contractors (C), 18 Quantity Surveyors (QS), 10 Engineers (Eng), 07 Consultants (CR), and 5 Project Managers (PM).

Semi-structured interviews provided the freedom to discuss numerous areas widely [15]. A purposive sample was selected for the semi-structured interviews since the objective wass to select the partakers who had better knowledge and industry experience in the area of the research study. A total number of interviews conducted was eight including one Contractor, three Quantity Surveyors, two Engineers, one Consultant, and one Project Manager.

B. DATA ANALYSIS METHODS

Data analysis was done with the use of the Effectiveness Index (EI) analysis (data gathered through a questionnaire survey) which expressed the effectiveness of each cost reduction method towards the cost overruns [16], and the content analysis was done to analyze the data which were gathered through the interviews.

The presentation was in the form of graphs, charts & tables. A coding system was used to identify the factors separately for the convenience of understanding and discussion. The Effectiveness Index was calculated by using Equation 1.

$$Effectiveness\ Index(EI) = \frac{\sum_{i=1}^{5} a_i \text{ x } e_i}{H \text{ x } N} \qquad \text{Equation 01}$$

Where:

i = Score of the factor ranging from "Unimportant = 1" to "Very Important =5"

a_i = Weight of the response for the i^{th} response

e_{is} = The frequency of the i^{th} response from all respondents

H = Highest ranking available, which is 5 in this survey

N = Total number of respondents who have answered the question

4. DATA ANALYSIS

A cconstruction project is a complex endeavour that needs the contribution of different parties who specialize in a wide range of areas. Construction ccost is a main component that affects the life cycle of a project, hence all parties must have sufficient knowledge of cost items in different degrees according to their job specifications. Therefore, it is important to get the ideas of different parties involved in a construction project regarding the "Cost" factor. The general information of respondents including their profession and experience in the industry was assessed

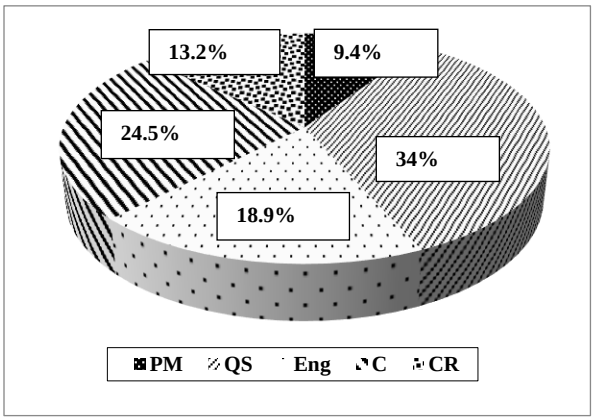

Figure 1: Respondents based on profession

as the responses may vary based on the perspective of different people due to their thinking capacity, knowledge and experience. The professions of the respondents are shown in Figure 1.

It was targeted to find out whether these professionals, experienced project cost overruns. More than 90% of respondents experienced cost overruns at construction projects as represented in Figure 2, which highlighted it as a serious problem in the construction industry and emphasizes the need for actions to mitigate the cost overrun in projects.

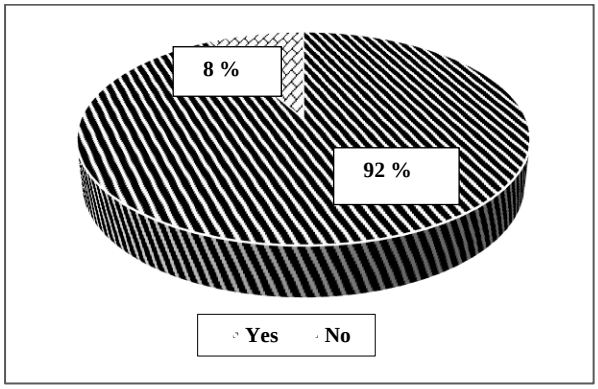

Figure 2: Experience in cost overruns on construction projects

A. EFFECTIVENESS OF CURRENT COST CONTROL PRACTICES

According to the opinion of the respondents cost control techniques can be used most effectively in pre-contract and post-contract stages. The project participants are not much focused on cost in the pre-contract stage due to the limited time allocation. Most team members of the project are going for easy and short-term plans without identifying the long-term risks. The post-contract stage is the longest period in a construction project where a series of different and complex activities take place. Controlling costs at that stage with appropriate strategies leads to reducing cost overruns.

The cost reduction techniques are identified from the literature survey and ranked according to the effectiveness of the strategy in the practical scenario of projects. The scores gained by the respondents in the questionnaire were summed up for each method of cost reduction. The Effectiveness Index was computed based on the agreement of the respondents. The cost reduction methods are noted based on a coding system as represented in Table 1 and Table 2. The main cost reduction strategies were evaluated separately in two main categories. They are Pre-Contract Management Stage-related (A) and Post-Contract Management Stage-related (B).

A.1 Pre-Contract Management

According to the analyzed data, as shown in Figure 3, A2 is the best way to control costs in pre-contract management.

A preliminary estimation will be prepared by an experienced quantity surveyor at the early stage of the project to predict the project budget [17]. It should be a properly detailed estimation based on accurate quantity take-off. Documentation including accurate drawings, specifications, and Bill of Quantities (BOQ) is to be maintained to reduce discrepancies (A6). There is a need of providing sufficient time allocation for this documentation and to cross-check the data to avoid arithmetic errors in the estimation which is also highlighted in the study done by [4]. The proper time allocation also helps to clearly define the project scope of work and reduce complexity levels which leads to reduce variations and control of the costs (A7).

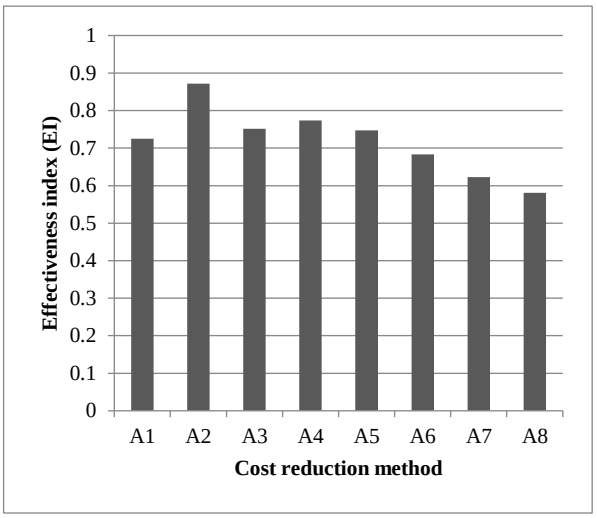

Figure 3: Ranked cost reduction methods according to the effectiveness index analysis based on "A"

Code	EI	Rank	Opinion
A1	0.725	05	Risk assessment at the tender stage
A2	0.872	01	Proper detailed and accurate estimation is done with the use of accurate quantity take-off by experienced estimators and provides sufficient time for cross-check
A3	0.751	03	Allocate adequate contingency plans for unforeseen future circumstances
A4	0.774	02	Pre-qualification assessment for selected bidders to confirm that contractor is eligible enough for the work
A5	0.747	04	Change the old-fashioned contract awarding from first lowest to the most accurate bidder
A6	0.683	06	Proper tender documentation including accurate Drawings, Specifications and BOQs to reduce discrepancies
A7	0.623	07	Proper time allocation in the pre-contract stage to clearly define the scope of the project and complexity levels
A8	0.581	08	Proper site investigations and feasibility studies to mitigate future risks

Table 1: List of cost reduction techniques based on "A"

A4 comes as the 2nd important cost reduction method which is assessing the pre-qualification of bidders at the tender stage. This will ensure the contractors' eligibility to work with the necessary resources. Selecting the most appropriate bidder through a pre-qualification assessment will mitigate the risk of future terminations and suspensions of the contractors which save cost.

Allocating adequate contingency amounts for unforeseen future circumstances (A3) come as the 3rd most effective strategy to reduce the cost of a project. To determine the contingency amount, there should be a proper risk assessment at the initial stage (A1) which ranks as the 5th factor of cost reduction. Identification of future risks will lead to construction work on a better completion of the project on time, and within the budget [18]. The risk assessment can be done with the use of proper site investigations and feasibility studies of the proposed project (A8).

Construction projects are awarded to the selected contractor through a tendering/bidding process. Tendering process totally depends on market conditions and there is a need to have a framework for the tendering mechanism. The current practice is to award the contract to the lowest bidder. It was highlighted that there is a need of changing the old-fashioned contract awarding method from the first lowest to the most accurate one (A5). Sometimes bidders purposely bid for the lower prices (front and back-end loading) with the intention of only winning the bid. The selection of the wrong contractor for a project will make a negative impact on project cost.

A.2 Post-Contract Management

Post contract stage is the longest stage in which more cost overruns could happen. There is a need to have better cost reduction strategies at this stage.

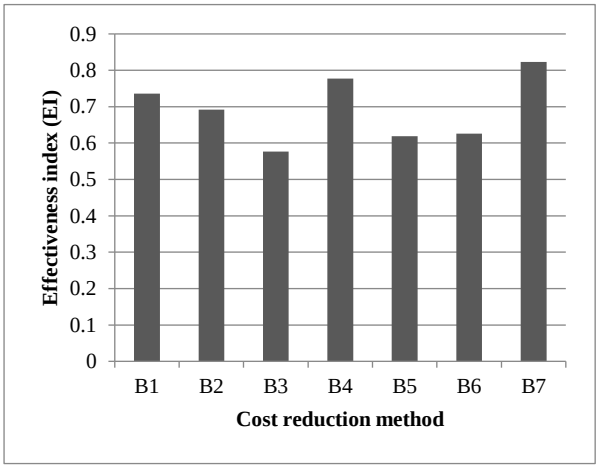

Figure 4: Ranked cost reduction methods according to the effectiveness index analysis based on "B"

Table 2: List of cost reduction techniques based on "B"

Code	EI	Rank	Opinion
B1	0.736	03	Contractors' financial stability with the availability of sufficient funding plans
B2	0.692	04	The client should prepare available funds for the project to make payment on time for the contractors & the laborers as well as to reduce delayed works & labor strikes
B3	0.577	07	Allocate flexible funds/loans by the Government with minimal interest rates on behalf of the construction industry
B4	0.777	02	Make ICTAD documents concerning the project cost control a mandatory requirement
B5	0.619	06	Proper monitoring & evaluation of site work done by conducting inspection meetings & keep necessary reports & records
B6	0.626	05	The quick decision made to reduce the chance of increasing the time of project delivery led to cost overrun
B7	0.823	01	Regular update of cost data & maintain a properly updated cash flow.

According to the analyzed data, as shown in Figure 4, B7 the best way to control cost at post-contract management is the regular update of cost data and maintaining an updated cash flow which will lead to project success. The finding was confirmed by Karunakaran et al. [15] by identifying the main reason for cost overrun as not updating the cost plan regularly. If these documents are in order, it can filter the errors easily and necessary actions can be taken accordingly. The documents reviewed based on actual project data revealed that most projects are currently practicing this method of updating cost data.

An interviewee highlighted an experience as, "*One of my projects which is at its' completion stage goes along with the estimated cost parameters due to properly detailed documentation of cost along with ICTAD guidelines*". This statement is further confirmed as making ICTAD documents related to project cost control a mandatory requirement (B4) was ranked the 2nd most effective cost reduction method. It was further stated that the site at the finishing stage was almost overrun by the budgeted amount. It was found out that though the project is not complete at that stage, still the cost overrun happened due to not updating the cost documents well. This

confirmed that B7 is an essential cost reduction method in the post-contract stage.

Contractors'–and clients' financial stability comes as 3rd and 4th effective cost reduction methods on ranking factors. The contractor must have a positive cash flow with available funding backups to make the construction work flow smoothly (B1). The client should also prepare available funds for the project to make payment on time for the contractors and for the labourers to reduce delayed work –and labor strikes (B2). For this, the government also can make adjustments by allocating flexible loans for construction projects with minimal interest rates which ranks the least weight under B3.

The other cost reduction techniques which were revealed from open-ended questions in the questionnaire were proper project formulation, applying new methods of construction with modern technology to save time, coordination among all the stakeholders, ensuring that proper planning strategies, proper time allocation for the completion of work, selecting the appropriate procurement methods by deep analysis on the type of the project and availability of resources strict to the procurement method of the project and quantity surveyors' involvement with proper cost documentations.

An interviewee stated that the cost control techniques currently practiced in the Sri Lankan construction industry were feasibility studies to check whether the work can proceed within the available budget, control expenses, monthly check-ups on actual expenses (invoices, material delivery notes), and update documents and inform management on behalf of adding additional funding plans. He further stated that "*Re-measure the quantities of projects of any procurement path (lump-sum contracts, measure & pay contracts, design & build contracts) will lead to finding the arithmetic errors in pricing of documents. This will take more time than expected at the initial stage. But it's better to eliminate the risk of cost overrun rather than take strategies to control when estimated budget exceeds the limit*".

Another interviewee highlighted the importance of controlling material cost by updating material reconciliation reports which identify the excess or fewer quantities and finding comparatively goes along with the finding of a similar study done by Holt et al. [19]. It was identified that updating the daily works with the planned program, properly maintaining the site, minimizing construction wastage, creating competition among labourers and ensuring site safety which reduces damages as cost reduction methods.

B. MODERN COST REDUCTION TECHNIQUES

The causes for cost overruns were identified and the study covered the current cost control practices in the industry. Though industry has been practicing different techniques for cost control, still cost overrun happens. The need for "Modern Cost Reduction Techniques" was identified by open-ended questionnaires and interviews with industry experts. The identified modern cost reduction techniques are discussed below.

- **Select the appropriate procurement path & suitable contractor**

There are different types of procurement strategies for projects. Main procurement methods are Traditional, Design and Build, Management and Partnering. The successful completion of any project will be highly dependent on the decision of selection procurement method [20]. An interviewee stated that engaging in more lump sum projects keeps the budget within limits than other contracts. In this type of project, the estimated budget at the initial stage is fixed. So the overrun of cost is limited. The selection of the procurement strategy for the project has to be carefully done. Further it was highlighted the importance of selecting suitable contractors at the tender stage. Pre-qualification assessment of contractor (A4) is an effective cost control method at the pre-contract stage which comes as the 2nd highest rank according to Table 1. This allows changing of the perception of selecting the lowest bidder and replacing it with the most accurate one (A5). This will affect the process of construction work positively in the future.

- **Cost planning**

Preliminary estimation is the basic, initial cost document in a project [17]. Proper detailed and accurate estimation done with the use of accurate quantities by an experienced estimator/QS (A2), is marked as the highest effective cost control method in the pre-contract stage (refer to Table 1). The importance of monitoring data by regularly updating cost data and cash flow (B7) was revealed by the study findings, which was also marked as the most effective cost control method at the post-contract stage (refer to Table 2). When the project commenced, proper cost planning have to be implemented. An interviewee stated that the use of modern estimation techniques will help to reduce cost overruns in construction. Elemental cost planning, Target cost, Activity-based cost, Earn Value Management (EVM) theory, Cost To Complete (CTC) and Cost Value Reconciliation (CVR) are some of the modern techniques identified.

- **Value management (VM)**

Value Management is a new approach to increase the value of the project by minimizing the additional unnecessary cost and reducing the time for completion. The concept of VM is becoming more applicable to the Sri Lankan construction industry [21]. Value Engineering (VE) is the best method for value management and it is a decision-making tool [22]. VM is considered from a strategic point while the VE is considered from a technical point. An interviewee stated that the value engineering team analyzed the project and identified the areas which consume high costs and selecting the best alternatives from different ideas which minimize cost and maximize the quality of function.

- **Modern construction technologies**

With the advancement of technology, there are modern techniques in building construction that can be used to complete projects in lesser time. If the time is saved, the cost overrun will be mitigated. An interviewee listed modern construction methods as off-site construction, modular construction, precision manufactured construction, pre-manufactured construction and digital/ smart construction. Holt et al. [19] confirmed this as the use of high technology machinery, plants–and developed materials also saves excess cost exchange of projects. The interviewee further stated that "The use of modern techniques in designs also help to reduce time and save cost. Some of the design methods are post-tension structures in place of typical reinforced techniques, reinforced retaining walls -and soil nailing". The use of modern techniques in mechanical –and electrical service systems in buildings for less power consumption will benefit in Whole Life Cycle Costing (WLC).

- **Sustainable construction**

With sustainability practices, more natural energy resources are used which minimizes the cost to increase the use of renewable energy systems [23]. An interviewee revealed that converting to sustainable construction will reduce the life cycle cost of the project. It was suggested to go for sustainable development, towards lean construction with low-cost housing, at affordable cost parameters and eco-friendly building which save future cost and environment itself. The concept of Lean Construction would be able to gain a substantial cost advantage by eliminating cost-consuming flow activities [24].

- **Modern software**

With the development of technology now there is new modern software which is specially designed for the construction field to ease the complex activities. The initiative of these methods was high in cost at the beginning, but beneficial during the whole construction process. An interviewee listed some software which are highly appreciated at the site as Primavera, MS Project, ERP system–and BIM. BIM has a great potential for integration into construction projects' life cycle which will lead to cost savings for construction projects [25]. This software can be used to update the project schedule along with which the cost data of the project can be updated (B7). This is the top most rank effective cost control method at the post-contract stage (refer to Table 2). With the use of new software, the project program can update and can check the actual expenses of the project along with the estimated project budget.

- **Risk management**

Risk is known as an unforeseen future event that causes significant consequences on construction, especially on the cost factor. Allocating adequate contingency plans for unforeseen circumstances (A3) is marked as the 3rd effective cost control method in pre-contract management according to Table 1. An interviewee classified construction risk areas as physical, technical, legal, contractual, financial and environmental. These can impact various types of cost, time and quality of construction. Risk management has to be done at the initial stage of a project as the main requirement to reduce future negative impacts [18]. An interviewee stated that "Most of the projects don't make a priority of the risk management at design stage and a proper approach is needed for this". This statement was confirmed by marking risk assessment at the tender stage (A1) as the highest rank among effective methods of cost control according to Table 1.

- **Research** and **Development (R&D) method**

R&D is a new strategy to control the cost of a project. This is a modern technique of cost controlling which needs training of people and changing their minds to think beyond the traditional methods. In this method, it identifies one activity of work –and researches on it to get the best option out of it with minimum cost. An interviewee explained an example, "This method was experienced at a proposal of constructing pile foundation. The feasibility study was done to identify the risk which can caused to the nearby neighborhood. This initial research process eliminates compensation amount which can be given to the people after the damage". This is a better way to reduce the cost of a project by minimizing future extra costs.

- **Proper dispute resolution**

According to Baccarini [26], disputes are a common phenomenon in construction due to the complexity and involvement of different parties. Dispute resolution is a process that consumes a large amount of money. It is essential to mitigate those to reduce cost overruns. If the dispute resolution was not practicable for a problem, then the parties have to go for litigation which consumes a considerable amount of time and consumes a lot of money. It is better to mitigate arising of disputes by maintaining better communication among members of the project, having better management approaches and clearly defining the scope of the project. Making a quick decision on this kind of event is essential to avoid time overruns (B6) which directly affect the cost of the project, which is also marked as a top rank effective method of construction according to Table 2.

- **Government involvement**

Institute of Construction Training and Development (ICTAD) is the Sri Lankan authority governed by the Construction Industry Development Authority (CIDA) on behalf of construction involvement for a better unique framework. The government could make amendments and general arrangements to control costs at the site. Proper documentation regarding cost data has to be maintained with ICTAD guidelines to reduce cost overruns. It is confirmed with the statement "Make ICTAD documents with reference to the project cost control as a mandatory requirement (B4)", by ranking 2nd most effective method of cost control according to Table 2. Government can involve with funding plans for both clients (B2) and contractors (B1), which is also effective in the long term. Though these methods are highlighted as the most effective methods according to Table 2, allocating flexible funds/loans by the Government with minimal interest rates on behalf of the construction industry (B3), is marked as the least effective method of cost control from the listed methods.

5. CONCLUSION

Based on a questionnaire survey, current practices of cost control were identified. It was found out that though there are practicing types of cost control techniques, still cost overruns happen, and it highlighted the need for modern cost reduction techniques which were also confirmed by [8]. According to an interviewee, "*Time, cost and quality are the main pillars of the construction, and change of those one parameter will effect on the other two*". As per the key intention of the research, when controlling the cost of the project, one has to think about the other *two* factors as well because Le-Hoai [16] stated that cost control is not effective if the time exceeds and it damages the quality of the product.

The main objective of the research was to identify the modern cost reduction techniques for construction projects in Sri Lanka. When considering the data gathered and analyzed above, it emphasized the need for monitoring the current practices of cost controlling and identifying modern methods to reduce cost overruns. There may be barriers when implementing those trends in practical scenarios and precautions have to be taken against them. Corrective cost controlling is a critical requirement in the Sri Lankan construction industry [8].

Karunakaran [15] mentioned the need of studying the mitigation of cost overruns. This gap was filled by the objective of the research by identifying modern cost reduction techniques for the Sri Lankan construction industry. The research study reviewed different techniques, including various mathematical methods (estimations) and software-based models (planning) to optimize the cost of projects. Risk management, research and development method, applying proper procurement management systems, value engineering approaches and government involvement are among the key findings of modern cost reduction techniques.

6. RECOMMENDATIONS

According to the study, although there are traditional techniques available to control cost, the parties of the construction projects have not properly implemented those. The problem of cost control was not the techniques being used, but rather the poor management of techniques and practical adaptability of those in the industry. Project cost needs an efficient and effective control process and corrective actions where necessary to ensure the successful accomplishment of the estimated budget [20]. Based on the results of the study, the following were recommended for the management of cost performance in the construction industry.

Applying better risk management plans for the construction projects and having an adequate contingency plan, which is calculated with pre-feasibility studies will help to reduce the cost of unforeseen events. A well-defined budget, based on the accurate plan of the project, at the initial stage, is essential. The project managers should have tight control over the project budget.

There should be continuous training programs and awareness programs on the importance of project cost control to update the knowledge of the project partake (top-level to middle level). Introducing a course module

regarding modern cost reduction techniques for construction projects at the academic level will increase the importance of the cost factor at the very basic level. Involvement of the Government sector with flexible loans regarding construction work and allocating proper funding plans for the project stakeholders will also help to conduct construction work along with the forecasted cash flow.

7. FUTURE RESEARCH DIRECTIONS

While this research focused on the modern mitigation methods of cost overruns in Sri Lankan private sector projects, a study can be done to validate the conclusion of this study considering the public sector projects. A similar study can be done to categorize the most vital causes of cost overruns in construction projects, and also a study can be done to identify the modern techniques to reduce the time overruns in construction projects. Further research can be done to measure the cost of training against the cost of saving from proper training on the subject matter of "Cost Control".

8. ACKNOWLEDGMENT

A special thanks go to the Faculty of Built Environment & Spatial Sciences (FBESS), Southern Campus of General Sir John Kotelawala Defence University (KDU) for their assistance and guidance in the betterment of the research and all the questioned and interviewed parties who have given primary data on the selected issues.

9. REFERENCES

1. A A. Aljohani, "Construction Projects Cost Overrun: What Does the Literature Tell Us?," *International Journal of Innovation Management Technology*, vol. 8, no. 2, pp. 137–143, 2017, doi: 10.18178/ ijimt.2017.8.2.717.

2. A. Cindrela Devi and K. Ananthanarayanan, "Factors influencing cost over-run in Indian construction projects," *MATEC Web Conferences*, vol. 120, no. 2017, pp. 1–8, 2017, doi: 10.1051/ matecconf/ 201712002023.

3. H. A. M. Abusafiya and S. M. A. Suliman, "Causes and Effects of Cost Overrun on Construction Project in Bahrain: Part I (Ranking of Cost Overrun Factors and Risk Mapping)," *Modern Applied Science*, vol. 11, no. 7, pp. 20-25, 2017, doi: 10.5539/ mas.v11n7p20.

4. N. Ejaz, I. Ali, and M. Tahir, "Assessment of Delays and Cost Overruns during Construction Projects in Pakistan," *Civil Engineering Department University Engineering Technology Taxila – Pakistan Abstract*, pp. 1–9, 2013, [Online]. Available: http:// dl.lib.mrt.ac.lk/handle/123/9431.

5. N. Azhar, R. Farooqui, and S. Ahmed, "Cost overrun factors in construction industry of Pakistan," *First Internatioanl Conference on Construction of Developing Countries*, pp. 499–508, 2008, [Online]. Available: http://www.neduet.edu.pk/Civil/ICCIDC-I/Complete Proceedings.rar#page=510.

6. M. M Dlakwa and M. F Culpin, "Reasons for overrun in public sector construction projects in Nigeria," *International Journal Project Management*, vol. 8, no. 4, pp. 237–241, 1990, doi: 10.1016/0263-7863(90)90032-7.

7. P. F. Kaming, P. O. Olomolaiye, G. D. Holt, and F. C. Harris, "Factors influencing construction time and cost overruns on high-rise projects in Indonesia," *Construction Management Economics*, vol. 15, no. 1, pp. 83–94, 1997, doi: 10.1080 /0144619 97373132.

8. S. N. Malkanthi, A. G. D. Premalal, and R. K. P. C. B. Mudalige, "Impact of Cost Control Techniques on Cost Overruns in Construction Projects, *Engineer, The Institution of Engineers Sri Lanka*, vol. 50, no. 4, p. 53, 2017, doi: 10.4038/ engineer. v50i4.7275.

9. A. H. Memon, I. A. Rahman, and A. A. A. Azis, "Preliminary Study on Causative Factors Leading to Construction Cost Overrun," *International Journal Sustainable Construction Engineering Technology*, vol. 2, no. 1, pp. 57–71, 2011, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/IJSCE T/article/viewFile/49/65.

10. M. Ramabhadran, "An Investigation into Cost Overrun in Construction Projects in United Arab Emirates," *International Journal of Construction Engineering Management*, vol. 7, no. 1, pp. 1–21, 2018, doi: 10.5923/j.ijcem.20180701.01.

11. T. Vivian, "Editorial: Cost Effective Methods for Sustainable Construction Practice," *Open Waste Management Journal*, vol. 4, no. 1, pp. 20–20, 2011, doi: 10.2174/1876400201104010020.

12. S. Durdyev, M. Omarov, S. Ismail, and M. Lim, "Significant contributors to cost overruns in construction projects of Cambodia," *Cogent Engineering*, vol. 4, no. 1, pp. 1–10, 2017, doi: 10.1080/23311916.2017.1383638.

13. O. E. Ayodele and M. O. Alabi, "Effect of Cost Control on Building Projects Delivery in Nigeria," *Civil & Environmental Research*, vol. 6, no. 2, pp. 76–79, 2014.

14. S. Mohamed Hafez, “Optimal Techniques for Cost Reduction and Control in Construction Sites,” *Journal of Human Resource Management*, vol. 3, no. 3, p. 17, 2015, doi: 10.11648/ j.jhrm. 20150303.11.
15. P. Karunakaran, A. H. Abdullah, S. Nagapan, S. Sohu, and K. K. Kasvar, “Categorization of potential project cost overrun factors in construction industry,” *IOP Conference Series Earth & Environmental Sciences*, vol. 140, no. 1, 2018, doi: 10.1088/1755-1315/140/1/012098.
16. L. Le-Hoai, Y. D. Lee, and J. Y. Lee, “Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries,” Korean Society of Civil Engineers (*KSCE) Journal Civil Engineering*, vol. 12, no. 6, pp. 367–377, 2008, doi: 10.1007/s12205-008-0367-7.
17. Olawale A. Y, and Sun M, “Cost and time control of construction projects: inhibiting factors and mitigating measures in practice” *Construction Manaement Economics*, vol. 28, no. 5, pp. 509–526, 2010.
18. G. Forster, “Construction Site Studies Production, Administration & Personnel,” *Construction Site Studies*, 2017, doi: 10.4324/9781315846606.
19. D. G. Proverbs, G. D. Holt, and P. E. D. Love, “Logistics of materials handling methods in high rise in-situ construction,” *International Journal of Physical Distribution & Logistic Management*, vol. 29, no. 10, pp. 659–675, 1999, doi: 10.1108/09600039910300037.
20. G. Otim, F. Nakacwa, and M. Kyakula, “Cost Control Techniques Used On Building Construction Sites in Uganda,” *Second International Conference Advanced Engineering Technology*, pp. 367–373, 2012.
21. S. Perera, G. Karunasena, and K. Selvadurai, “Application of value management in construction,” *Built Environment Sri Lanka*, vol. 4, no. 1, p. 3, 2006, doi: 10.4038/besl.v4i1.7647.
22. G. Karunasena and K. Rajagalgoda Gamage, “A decision-making formula for value engineering applications in the Sri Lankan construction industry,” *Journal of Financial Management of Property & Construction*, vol. 22, no. 1, pp. 77–91, 2017, doi: 10.1108/JFMPC-01-2016-0001.
23. D. Lowe, “Economic Challenge of Sustainable Construction,” *RICS Construction & Building Research Conferece*, January 2003.
24. S. Senaratne and D. Wijesiri, “Lean construction as a strategic option: Testing its suitability and acceptability in Sri Lanka,” *Lean Construction Journal*, 2008, pp. 34–48, 2008
25. G. Nagalingam, H. S. Jayasena, and K. A. T. O. Ranadewa, “Barriers to Implementation of Building Information Modelling (BIM),” *International Journal of Construction Project Management*, vol. 8, no. 2, 2016, 2016.
26. D. Baccarini, “The concept of project complexity - A review,” *International Journal of Project Management*, vol. 14, no. 4, pp. 201–204, 1996, doi: 10.1016/0263-7863(95)00093-3.