

**TIME OVERRUN EVENTS ACCOUNTABLE TO
THE CLIENT IN BRIDGE CONSTRUCTION
PROJECTS, SRI LANKA**

**MASTER OF SCIENCE
IN
CONSTRUCTION PROJECT MANAGEMENT**

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PROJECTS, SRI LANKA**

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“This dissertation was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfilment of the requirements for the Master of Science in Construction Project Management”

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DECLARATION

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ABSTRACT

The bridge construction industry in Sri Lanka has been severely affected by the time overrun events in the past. The trend is continuing and the requirement of taking mitigation measures in the industry is a high priority. Once a time overrun event occurs, it will be analysed by the consultant of the contract. If the accountability of it is on the client, the contractor will be granted an Extension of Time and the relevant compensations. Therefore, identifying the causes of the time overrun events and the accountable party of those is a high necessity for forecasting and taking mitigation measures.

The research is on identifying the key time overrun events accountable to the client in bridge construction projects, Sri Lanka. Seventy (70) time overrun events in bridge construction projects have been found by literature review and case studies of 18 projects. These time overrun events are analysed from the responses by the professionals through a questionnaire survey and found out nineteen (19) time overrun events accountable to the client using the Relative Importance Index. The analyses have been continued through interviews with the key experts of the field as well to understand the probability and impact of the events. Accordingly, by using the Frequency Index and Severity Index, the events were prioritized and the use of Probability-Impact Matrix, it has been identified the five (5) most critical events accountable to the client in the bridge construction projects which are Possession of site, Unclear scope (Variation Orders), Land acquisition matters, Utility shifting matters and Design changes.

Further, it has been observed that around 70% of time overrun events accountable to the client can be forecasted in the planning phase (before awarding the contract) of the project. Therefore, the research recommends several methods for conducting a proper planning phase of a project by highlighting the current drawbacks and hence avoiding or mitigating the risk of time overrun events that would be generated during the construction phase of the project.

Key Words: Time overrun, Accountability, The client, Bridge construction, Sri Lanka, Mitigation measures, Relative Importance Index

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LIST OF ABBREVIATION

Abbreviation	Description
SL	Sri Lanka
RDA	Road Development Authority
MOH	Ministry of Highways
ADB	Asian Development Bank
JICA	Japan International Cooperation Agency
GOSL	Government of Sri Lanka
PMU	Project Management Unit
CIDA	Construction Industry Development Authority
FIDIC	International Federation of Consulting Engineers
RII	Relative Importance Index
FI	Frequency Index
SI	Severity Index
PI	Priority Index
EOT	Extension of Tim

1 INTRODUCTION

1.1 Background

In the current world, infrastructure development is considered as one of the main criteria defining a country's wealth. Not only the financial stability of the people and the country but the infrastructure development will always be a key factor to analyse the growth and stability of any country. Therefore, a major part of the world economy is on these infrastructure projects in the world. The scenario is not different in Sri Lanka as well. For the past few years, the country has put a lot of effort to improve the infrastructure. The trend has not been changed by the different governments where it seems to continue for the future also.

Infrastructure can be defined in several ways. In general view, infrastructure is public and private structures such as bridges, roads, highways, water supply, buildings, railway lines, electricity...etc. Sri Lanka is a developing country where wealthy investors for infrastructure are rarely be found. In that sense, all the main infrastructure developments, especially bridges, roads, highways, water supply, railway projects are done by the government (Torrise, 2009). The funds for these projects are from either the government of Sri Lanka (GOSL) or donor agencies. The most involved donor agencies in Sri Lanka are Japan International Cooperation Agency (JICA), Asian Development Bank (ADB), World Bank, the Exim Bank of China...etc.

The case is the same for the industry the study is focusing on. The bridge/elevated highway construction industry has been acquiring a mega portion of infrastructure development in Sri Lanka where all the related projects are funded either by GOSL or donor agencies. The majority of multinational donor agency funds for bridge construction in Sri Lanka comes as loans. If the funds are from GOSL, obviously it is public funds. If the funds are from donor agencies or local banks, ultimately the public has to pay the debt. Therefore, in the long run, the taxpayers of Sri Lanka will have to bear the cost of these projects.

The project management units (PMUs) of the government of Sri Lanka has been the client for all the bridge/elevated highway construction projects in Sri Lanka. The PMUs are the main body of managing the project and the most important funds. Then the main question arises. Do the project management units in Sri Lanka manage the public funds properly? The government officials in these units are the professionals who are answerable to the public. This implicit the importance of handling the public funds in a controlled safe manner. Therefore, the proper management of the public funds in these bridge construction projects is a challenging and much-needed task that must be implemented by the professionals in the government.

While maintaining the required quality of a bridge construction project, the allocated funds for a particular project can be exceeded for several reasons. One of the main reasons is the delays of projects which are called time overruns. The time overruns are generated due to the different events that occurred in the contrasting phases of the project life cycle. Some of these events are unavoidable but most of them can be forecasted and mitigated. These time overrun events initiate huge financial losses to the projects directly and indirectly.

Indirect losses due to the time overruns in a construction project may cause financial losses to the public or the government in terms of loss of opportunities, loss of income, disturbance, downgrade the level of life and level of service, time value of money...etc. during the period of the delay. On the other hand, there are direct losses to the project. the burden of the losses on the client, the contractor, the consultant, any other stakeholder or a combination of the parties. For any given time overrun event, the burden of the delay is identified by analysing the event according to the terms and conditions of the contract. Accordingly, the burden of the time overrun event, the cause of the time overrun event or in other words the accountability to a time overrun event will be analysed and accepted by all the parties.

Mainly, in any bridge construction contract, the two main parties who hold the accountability of its time overrun events are the client and the contractor. If the accountability is on the contractor, the delay has to be absorbed into the contractor's work program and the associated cost for the delay must be borne by him. If the accountability of a time overrun event is on the client, the client of the project has to bear the financial

charges of the delay as well as the consequences of exceeding the original duration of the contract. This is where the public funds are being wasted without an acceptable reason. Being the client of the bridge construction projects in Sri Lanka, most of the government agencies and officials will have to answer the public on these cases.

The study focuses on reducing the unnecessary outflow of public funds by mitigating the risk of time overrun events accountable to the client of a bridge construction project in Sri Lanka.

1.2 Problem Identification

With all the developments in technology, the infrastructure construction industry has been upgrading rapidly. Even though the construction industry develops very high phase, time overrun events in any project is almost inevitable. The case is even worst in the bridge/elevated highway construction sector in Sri Lanka. The bridge construction industry not only hits with these time overrun events but also the repetitive nature of the events in each project is a heavy burden to bear.

The need for identification of the main project party accountable to the majority of time overrun events that dried out the public funds is a high priority in bridge construction projects in Sri Lanka. Further, an investigation of the time overrun events and the most critical time overruns accountable to the client will be highly valuable to forecast the risk and take necessary action during the pre-contract awarding stage. Also, the mitigation measures which can be taken, before the event meets the project is another important factor where it will save not only the time but the money of the client hence the public funds.

Studies have been carried out on delay causes of construction projects in general. But a study on causes of time overruns specifically to bridge construction projects in Sri Lanka is yet to be commenced. Further, an investigation of the time overrun events accountable to the client and assessment of the criticality has not been performed for bridge projects. In addition, the mitigation measures which can be taken to reduce the repetitive nature of these events is an industry requirement.

1.3 Research Objectives

The main research objective is,

- Identifying the time overrun events accountable to the client in bridge construction projects, Sri Lanka and proposing mitigation measures that can be taken at the planning phase of the project.

The sub-objectives are,

- Identifying time overrun events in bridge construction projects, Sri Lanka
- Categorizing the time overrun events accountable only to the client of a bridge project
- Recognizing the most critical time overrun events accountable to the client
- Examine the mitigation measures that can be taken for the time overrun events before awarding the contract

1.4 Significance of the Study

Currently, the bridge construction industry has been affected by a lot of time overrun events which results in extra cost as well as an extension of time. Even with the development of the technology in all aspects, the amount of time overrun events hence project delays are inevitable. The majority of bridge construction projects are financed by public funds. Therefore, the requirement of managing the funds effectively is a high priority. The government agencies that handle the funds represent the client side of the bridge construction contracts.

One of the major ways to successfully manage a contract is to reduce the time overruns accountable to the client since time is one of the key factors of any project. For this, first, the identification of the causes of time overrun events is very much a necessity. Secondly, categorizing those according to the responsibility will allow the study to focus on critical time overrun events accountable to the client. Not only the categorization but the

importance of prioritizing the most critical time overrun events will also free the study to focus on the mitigation measures for it before the awarding of the contract.

By examining the most critical time overrun events accountable to the client in bridge construction projects and finding the relevant mitigation measures will be highly beneficial to the organizations which represents the client side of these projects. Further, the study will allow the experts to forecast the risk of the time overrun events and even avoid those in full with proper planning. Even though the research focus on the Sri Lankan bridge construction industry, the finding will not be limited to the country. More or less, the time overrun events and its' accountability is closely related to the bridge projects all over the world where the finding will be highly beneficial to the global construction industry.

The main government body in Sri Lanka which implements bridge/elevated highway construction projects in Sri Lanka is Road Development Authority (RDA). According to the records, the organization has already met a lot of time overrun events in almost all the bridge projects. Therefore, RDA will be benefited a lot from the study and be able to put more effort into planning work in the pre-contract awarding stage by adopting the anticipated research findings.

1.5 Method of Study

Through a comprehensive literature survey, the identification of time overrun events will be commenced initially. From the fundamentals of a time overrun event to identifying the contractual background of the events will be assessed accordingly, an investigation will be done to find all the causes of time overrun events in bridge projects.

Then the investigated time overrun events will be categorized according to the responsibility of the events by using the case studies of past project records, claim registers and unstructured interviews with the professionals. The observed time overrun events will be submitted to the professionals representing all the contractual parties by a questionnaire to further filter the events according to the nature and the composition of the accountability of each event. The questionnaire will also assess the mitigation measures that can be taken to reduce the effect of these time overrun events. Here, the target will only be on identifying

the mitigation measures which can be implemented in the planning stage of the bridge project by the client or the employer of the project.

After properly refining the time overrun events exclusively accountable to the client, the events will be prioritized according to the probability and impact of each of them. This will be done by semi-structured interviews with the expertise of the field. Further, the validation of the previously recognized mitigation measures for the time overrun events accountable to the client will also be completed in this phase of the study by using the same expert interviews.

Finally, the study will deliver the causes of time overrun events accountable to the client in bridge construction projects, Sri Lanka. Also, the study will consist of the identification of the most critical time overrun events accountable to the client in the bridge construction industry in Sri Lanka and the validated mitigation measures for the risk of those.

1.6 Literature and the Identified Gap for the Study

Many pieces of research have been done all over the world to make the construction life cycle more efficient. Hence, studies have been completed on identifying the causes of delay events in construction projects. The case is not different in Sri Lanka as well. Researches have been conducted to identify the causes of delays in construction projects, Sri Lanka.

Even though the previous studies focus on time overrun events in projects, research has not been done yet on time overrun events specific to the bridge construction industry in Sri Lanka. So the study will fill the initial gap that has been found. As mentioned earlier, a lot of researches have been done to identify the causes of time overrun events in the construction field, the industry lags a study on examining the accountability of each cause of the time overrun. This is the major research gap that is going to be filled by this research. The work will be based on the client of the projects whereby analysing all the possible time overruns, the output of the research will identify the critical time overrun events that are accountable to the client in the bridge construction project.

Further, there are research studies all over the world that have been already finalized on understanding the solutions in general for time overruns in construction projects. This study will differ from those because the study will address the possible mitigation measures which can be implemented before awarding the contract. Therefore, at the end of the research, several mitigation measures will be introduced to reduce the risk of time overrun events for the client of bridge construction projects in Sri Lanka.

1.7 Expected Outcomes of the Research

- Identifying the time overrun events accountable to the client of a bridge construction project in Sri Lanka
- Further examining the accountability of different time overrun events based on sole accountability and joined accountability to the client
- Ranking the most critical time overrun events accountable to the client according to the impact concerning only the time factor
- Proposing possible mitigation measures that can be implemented for the critical events identified
- Proposing a generalized methodology to the planning phase of a project for forecasting and mitigating the risk of regeneration of the time overrun events accountable to the client of the bridge construction project in Sri Lanka

1.8 Summary of the Report Arrangement

This research report consists of five (5) main chapters which are Introduction, Literature review, Methodology, Analysis & Discussion and Conclusions & Recommendations.

Chapter 1 – Introduction

This chapter consists of the background of the study. The research gap identified and its significance is also explained in this chapter where a summary of the procedure of the research is briefly presented.

Chapter 2 – Literature Review

This chapter consists of the literature examined on behalf of the study. Researches all over the world are briefed here where the relevant knowledge required has been gathered and presented in the chapter. Further, it shows the depth in the field which has already been examined and the basis of time overruns in contractual form.

Chapter 3 – Methodology

This chapter consists of the methodology which has been adopted to the research. The methods of analysing the data have been elaborated in the chapter where the logical approach that has been taken to the analysis is further justified.

Chapter 4 – Analysis and Discussion

All the analyses are recorded in this chapter. The chapter consists step by step approach to the final results of the study. Further, It presents the figurative details of the research. At the back end, the chapter provides a discussion on the findings and the adaptability of those to the research work.

Chapter 5 – Conclusions and Recommendations

This chapter provides the conclusions of the total study where it represents the outcomes of the research. Further, it will elaborate on the proposed recommendations based on the results observed. Also, the chapter brief what has been achieved during the study and the possibility of future study areas relevant to the topic.

2 LITERATURE REVIEW

2.1 General

This chapter focuses to extract the relevant knowledge that already exists on the subject and understanding the depth of the detailed analyses done by the researchers in the world. The primary objective of this chapter is to find out the gap of knowledge which needs to be filled through this research work. Therefore, the chapter discusses the fundamentals of a time overrun, the type of time overruns, its adverse effect on the projects, which party initiated (Client, Consultant & Contractor) a particular variation, and the mechanisms already identified to mitigate it. Even though the research is based on time overruns accountable to the client in bridge construction projects, Sri Lanka, the literature review has been done on the construction projects in the world to get a thorough idea about it.

2.2 Infrastructure Development Projects

Infrastructure development projects are one of the biggest construction industries in the whole world and it has got the power to directly influence the global economy as well as a country's economy. These infrastructure projects can be divided into several categories such as roads, bridges, high rise buildings, elevated highways, ports, airports...etc.

This study is based on bridge construction projects. Therefore, a bridge is defined as a structure carrying a road or path across a waterway, road or any other obstacle. These bridges can be any structure over a small canal up to elevated highways which provides valuable connectivity and mobility to a country. Sri Lanka is a country that has been paying huge attention to transport infrastructure projects in the last few years and it will continue to be so in future as well according to the current trends of the governments. The impact which can generate by these development projects on the growth of a particular country is undoubtedly enormous. Yet, the previous researches show that this is not a straightforward case in all the scenarios. Almost all of these projects are funded by governments and ultimately these are public investments. The primary debate is whether these public

investments in transport infrastructure provides the required return especially when the country is categorized as a developing country and the demand for investments is very high social sector such as education, health, poverty...etc. (Meersman and Nazemzadeh, 2017).

In this scenario, the main question is whether these projects are being managed properly concerning the money spent and the time allocated. After carrying out the required feasibility studies, a particular project will be awarded to a contractor assigning a defined scope, budget and duration. Since these are highly sensitive public projects, the main focus should be on the timely completion of the project within the provided cost.

Construction industry personnel, all over the world, have been trying to figure out how to deal with this problem, but the repetitive behaviour of these time overrun events continues. One can argue that time overrun events badly strike the construction projects in developing countries since these countries are behind the technology in construction compared to the developed countries. But this is not a correct argument because many literature details can be observed and understood that the problem is continuing all over the world.

2.3 Time Overruns in Construction Projects

As mentioned, the three key factors (scope, cost & time) which need to be managed in a project, time overrun is the most common situation in the construction industry all over the world. Generally, a construction project is categorized as successful when it is completed on time, within the cost to the satisfaction of the scope. Literature reveals that construction projects are severely affected by time overruns and ultimately the budget overruns. Many researchers have identified the causes of time overruns and factors affecting them in construction projects. Evidence of literature presents a measurement of delays in construction projects around the world and how significant it is in the industry.

Public projects that were performed in Qatar 72% time overrun (Senouci, Ismail and Eldin, 2016). The surveys done in Saudi Arabia shows that 70% of the high scale construction projects experienced time overruns (Assaf and Al-Hejji, 2006). A study in Malaysia reveals that 80% of the construction projects strike time overruns (Yap *et al.*, 2021). The

same situation is highlighted in India as the time overruns in these projects are around 50% (Hetal and Tushar, 2018). The situation is the same in Nepal as well since 78% of projects are completed with time overruns (Suwal and Shrestha, 2016).

This is the same in Sri Lanka as well since it has been found that transportation projects experience around 56% - 88% of average time overrun compared to the original (planned) duration of the project (Pathirana and Halwatura, 2010). Another literature shows that the average time overrun of road construction projects goes up to 40% - 68% compared to the original duration in Sri Lanka (Gunawardana, 2019).

2.4 Bridge Construction Projects in Sri Lanka

In the recent past, transportation infrastructure development projects have concurred the Sri Lankan economy. Bridges such as steel bridges, concrete bridges, viaducts, extradosed...etc. has taken a major portion of constructions in the country. All of these bridge projects are government-funded projects which can be either directly financed by the Government of Sri Lanka (GOSL) or a loan borrowed from a funding agency such as ADB, JICA, World Bank...etc. on the other hand, all the projects have been funded by the general public of the country unless it is a grant from another source which happens rarely.

The main organization which implements all the main bridges and elevated highways in Sri Lanka is Road Development Authority (RDA) via the Ministry of Highways (MOH). A large amount of funds is pumped into RDA and MOH since RDA currently holds the ownership of all the elevated highways, viaducts and 4662 bridges as of January 2018. Any structure that carries a path over waterways that spans over 3m is categorized as a bridge by RDA (RDA website, 2021). During these projects, the organization holds the roles of client, consultant, contractor or the combination of these three roles. When it comes to the main bridges in the country and all the elevated highways, this organization plays the client or the employers role in the projects. Therefore, RDA is the most experienced 'client' in bridge construction projects in Sri Lanka.

2.5 Time Overrun in Bridge Construction Projects

Time overrun is commonly known as delays in construction projects. Time overrun could be defined as either the time required to complete a project beyond the original completion date specified in the contract or beyond the date that the parties are agreed upon for the completion of a particular project. For a client in construction projects, a time overrun means a loss of income which could be generated through the project, disruption to future programs, additional payments to the contractor and consultants...etc. On the other way, for a contractor, a time overrun means a higher construction cost, a contractual extra payment for the delay damages, higher material and labour cost through inflation...etc (Assaf and Al-Hejji, 2006). Some of the causes of time overruns are highly complicated where the compensations need to be settled through an adjudication process, arbitration or even in courts by the main parties of a contract. Therefore, most of the time overruns involved an additional cost to one of the parties.

2.5.1 Activity Level Analysis of Time Overrun

The project time overrun happens because of the delays in construction activities over the planned program. If the delay in activities occurs due to the contractor's fault or inefficiency, the whole project may get delayed and the amount of time overrun in days will have to be paid according to the contract to the client. But the delay of activities occurs due to an action of the client or any other party except the contractor, the Cumulative effect of all the time delay events are analyzed and the extended completion date of the project will be announced consequently (Anastasova, Yanev and Ivanov, 2020).

2.5.1.1 Master Program and Revised Programs

Once a construction project commenced, the contractor of the project should provide a program that consists of all the activities required to complete the project. This activity level program is called the Master program of the project. Every activity should be linked to its' predecessor or successor. The chain of activities should provide a critical path with

a scheduled date and duration for all the activities. In addition to that, the allocation of resources must be included in these programs.

MS Project Software for Project Planning

Early days, these programs were created manually but in the current world, these construction programs are developed by using the software. The most popular ones are MS Project and Primavera. The inputs required to run the software are the activity labels, resources (labour and material), probable durations and links to the predecessor or successor. Then the program will automatically provide us with the total duration of the project with the critical path activities. These are the fundamentals the software can generate where a lot of other valuable outputs can be extracted from it by properly feeding the required data (Chen *et al.*, 2012).

Microsoft Project has been changed and updated a lot in recent years where It has developed to a construction project requirement. Today, almost all the contract documents specifically mentioned the requirement of providing a comprehensive project plan through MS Project. (Subramani and M.Karthick, 2020) has shown that the software is not limited to sequencing and identifying the critical path of the project but assigning labour and material to activities, assigning responsibilities to a workgroup, tracking the activities, financial management, financial forecasting, managing work calendar...etc. This has been a prime example of involving technology in construction project management. Further, the software has been developed to provide reports, charts, tables...etc. in graphical view where it has been a key project planning tool in the construction industry. In addition to those, the software plays a key part in the analysis of time overrun events.

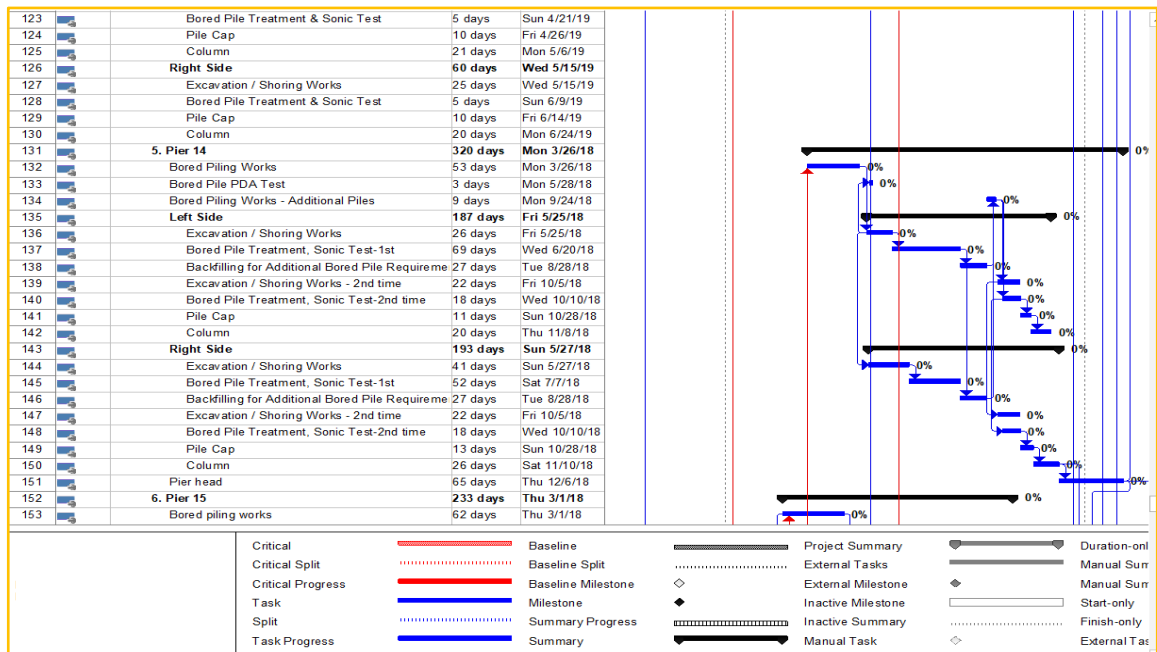


Figure 2.1: Construction Program in MS Project - Gantt Chart View

2.5.1.2 Critical Path of a Program and Analyse the Time Overrun by Critical Path Method

In all construction programs, there will be a critical path that will define the critical activities of the project, the time required for those activities and the minimum project duration. Therefore, the critical path is the longest path of work activities in a program. This provides a clear view of the amount of scheduling flexibility on the logical paths within the program. The technique calculates the early start, early finish, late start and late finish dates for all the construction activities which lead to identifying the activities with a float and the duration of float. Activities with a float are termed as non-critical items where a delay in these activities will not affect the total project duration (Project Management Institute, 2013).

2.5.1.3 Critical Activity Delays and Non-Critical Activity Delays

Among a large number of activities in bridge construction projects, every activity with time overrun will not cause a delay in project completion. The major activities which are in the critical path will only direct the project to extend the time of completion. All the other delays in non-critical activities will not cause an extension of time for the project. Yet again, in a complex project, this scenario is a bit complicated where critical paths are interchangeable during the project.

2.5.1.4 Float and Slack in Activities

The non-critical activities in a program are often recognized by its flexibility of time to complete. An activity that can be started later than the originally planned date is called the Slack activities. The other way around, an activity that can be finished later than the originally planned date is called the Float activities.

Therefore, these activities will not be placed in the critical path of the project where the activities can be delayed in the start as well as delayed in the finish. The slack or float will not be indefinite. The program will allow to quantify a particular float or slack where the people who manage the project must stick to it.

2.5.1.5 Concurrent delays

Concurrent delay is defined as two or more delays of a project overlapping one another. In a concurrent delay case, the occurrence of delay may not happen at the same time but the delaying effects of it are felt at the same time. The situation is highly complicated as the responsibility of two delays is on both the client and the contractor. In these situations, the contractor aims to claim an extension of time with compensation in place of the employer's risk and the client aims to claim delay damages for delay caused by the contractor (Yang and Kao, 2012).

2.5.1.6 Crashing and Fast Tracking of Activities

If an activity or a set of activities are delayed in a project, Crashing and Fast Tracking are the two methods that a contractor can adopt to catch up the delay. Crashing is a technique to shorten the activity durations hence the overall project duration by increasing the resources. This method adds up an additional cost to the contractor. Fast Tracking is a technique to compress the schedule by working the sequence activities in parallel. This method adds up an additional risk to the contractor (Project Management Institute, 2013).

If a delay event accountable to the client occurs in a project and it affects the activities in the critical path, that will be noted as a time overrun event and the consultant (the Engineer) will determine the extension of time allowable for the event as well as the cost compensations if there is any.

2.6 Contractual Background of Time Overrun

As in any other project, a bridge construction project is also handled by signing an agreement with the set of conditions of contract and specifications between the client and the contractor. In most cases, the bridge construction work becomes a part of the total contract which includes asphaltic road construction, culvert construction, slope protection works...etc. In low scale bridge projects, which are mostly of the construction cost of

below 1,000 million rupees, often done by local contractors, follows the condition of contracts, published by ICTAD or CIDA. Most of the other instances, when the construction cost is above 1,000 million rupees and the involvement of international contractors, follows the condition of contracts published by FIDIC.

When the time overrun occurs in a particular bridge project, there will always be an extra cost to the contract for that time overrun. Therefore, a time overrun that leads to a cost overrun is inevitable. Ultimately, either a client or the contractor or both the parties will be subjected to an additional cost due to the particular cause of the time overrun. Accordingly, identifying the cause of the time overrun and the accountable party for it is a major part of any construction project which is the same for a bridge construction project also.

From a contractual perspective, Głuszek and Leśniak (2015) divide a cause of delay into three categories namely justifiable delays with compensation to the contractor, unjustifiable delays with compensation to the client and justifiable delays without compensation.

In an event of a time overrun or the delay accountable to the client, that can be called a justifiable case of time overrun where the contractor will be compensated by the client for any loss which could occur due to that event. Such events time overrun include delay in allowing the possession of the site, delay in providing designs or drawings, client-initiated variation orders, delay in payments, utility diversion and public matters...etc.

The exact opposite of the coin, in an event of a time overrun or the delay accountable to the contractor, that can be called an unjustifiable case of time overrun where the client will be compensated by the contractor for contractual delay damages occurs due to the event. Such events of time overrun include contractor's cash flow problems, lack of machinery or skilled personnel, defective workmanship and reworks, low efficiency of equipment..etc.

Apart from the two scenarios, there can be time overruns that are justifiable but either of the parties is not compensated, since non of the parties are accountable for the particular event. This category of time overrun events includes adverse weather, natural catastrophes, unpredictable site conditions, pandemics, discoveries of explosives...etc.

2.6.1 Time Overrun in FIDIC Condition of Contracts

When the client, contractor or consultant (the Engineer) observes a potential time overrun (risk) event in the project, the party should notify the relevant other parties about the event as soon as possible (favourably within 28 days). Then a detailed claim must be submitted to the consultant (the Engineer) within the reasonable period agreed within the contract. In case of a time overrun event continues for a particular period, the affected party can submit interim detailed claims in regular intervals until the cause of the event is over. There are several clauses in FIDIC where an affected party can claim through in a time overrun event. Since the study focuses only on time overruns accountable to the client, the following clauses will be applied in a contractor's claim.

Table 2.1: Clauses in Conditions of Contract of FIDIC Related to a Time Overrun Event

Clause	Description
1.9	Delayed Drawings or instructions
2.1	Right of Access to the Site
4.7	Setting Out
4.12	Unforeseeable Physical Condition
4.24	Fossils
7.4	Testing
8.4	Extension of Time for Completion
8.5	Delay caused by authorities
8.9	Consequences of Suspension
10.2	Taking Over Parts of the Works
10.3	Tests on Completion
11.8	Contractor to search
12.4	Omissions
13.7	Adjustments for Changes in Legislation
16.1	Contractor's Entitlement to Suspend Work
17.4	Consequences of Employer's Risks
19.4	Consequences of Forces Majeure

The main clauses of FIDIC-conditions of contract, the construction industry of Sri Lanka has been using.

2.7 Causes of Time Overruns in Construction Projects

As discussed earlier, the bond between time overruns or delays and the construction industry is inseparable. Consequently, many pieces of research have been focused on the causes of time overruns in construction projects. Further, works of literature can be found on causes of time overruns in transportation infrastructure projects but the specific researches on causes of time overruns in bridge construction projects are limited.

A research survey was done by Assaf and Al-Hejji (2006) outlined seventy-three (73) causes of time overruns in large construction projects in Saudi Arabia. They assessed the frequency and severity of the causes concerning the different parties of the projects. Eventually, they found nine (9) causes of time overruns which ranked according to the importance index. Owner related factors got the highest ranks in the study where delay in payments, change of scope due to variation orders, delay in reviewing designs and not checking enough of resources and capabilities of the contractor before awarding the project concurred the top places.

A survey conducted by Yap and Goay (2021) found fifty-six (56) causes of time overruns in construction projects in Malaysia. From those, they outlined the main cause of time overrun is the contractor's lack of planning and scheduling. Incompetent site supervision and financial problems of the contractor also add as contractor's faults while events such as issuing change orders and slow in making decisions by the client contributing the top five factors of the time overruns in projects.

Another survey was done on bridge construction projects in Nepal by Suwal and Shrestha (2016) observed that among several factors affecting the time overrun, the unusual low bids category take the highest rank. This indicates the importance of following a proper procurement procedure by the client. The second and the third ranks in the list are land acquisition, utility relocation and delay in receiving approvals from different agencies.

Therefore, the first three causes are accountable to the client and then comes the poor site management by the contractor and causes like material shortages, labour shortages...etc.

Research conducted on delays in Egyptian construction projects by Marzouk and El-Rasas (2014) found out forty-two (42) events and categorized those according to the different parties involved in a project. In terms of frequency index, out of the top five causes ranked, four of them were related to the client of a project. In terms of severity index, material shortage (categorized as 'material related') conquered the top position. Yet, in terms of the overall importance index, owner related events such as payment delays and scope changes were among the top two positions.

Gardezi, Manarvi and Gardezi (2014) mentioned 27 key events that leads to time overruns in the construction industry of Pakistan. Among those, they observed that the client of the project has been the major cause of the time overruns compared to the original project duration. The main events were the client's lack of planning for design works, availability of funds and avoiding political influence. Further, the results showed that the law and order situation in the country, War, inflation and terrorism which were categorized into external factors also contributed largely to the construction delays.

Gunawardana (2019) has done a survey on road construction projects in Sri Lanka where he identified the scope changes, delay of utility relocation and land acquisition were the top three delay events. All of those were related to the client and the accountability of the events on the client.

Pathiranage and Halwatura (2010) also finalized thirty-one (31) key factors that influenced the delays in road construction in Sri Lanka. During the study, delayed payments and other clients' financial problems came up as the most influenced factor for the delays. Poor site management and contractor's cash flow matters came second and third positions where adverse weather conditions came up fourth. Then again, the fifth most critical factor for the delays were the changes in contract specification which includes additional works, new works, changes in specification...etc. by the client.

2.8 Identifying causes of time overruns in bridge construction projects

Even though this study is based on causes of time overruns accountable to the client of bridge construction projects in Sri Lanka, it has been a difficult task to find literature on the exact topic, because of the unavailability of relevant past surveys. In that case, initially, all the causes of delays in bridge construction projects have been identified. After a thorough review of the literature, seventy (70) events have been recognized.

Those events are possession of site delays, adverse weather, unrealistic project duration, contractor's cashflow problems, land acquisition matters, lack of required machinery, utility shifting works, lack of cooperation of utility agencies, estimation errors by the contractor on rates, estimation errors on quantities by the engineer, delays due to other inter-related projects, unclear scope, delay in payments, conflict in specifications and other documents, change in economic conditions of the country, new regulations of government, technology changes, client's influence on changing the contractor's work plan, client's design changes, errors in contractor's designs, shortage of labour, contractor's lack of skilled employees, shortage of materials, poor soil investigations, delay in testing, authority delay, delay in site mobilization, delay in approvals, poor performance of sub contractors, coordination delays with other agencies, conflict in quality control or quality assurance processes, delay in design submissions by the contractor, over hiring machinery and labour, natural disaster, lack of communication with subcontractors, defective workmanship, terrorism, riots, pandemic, misusing advance payment, delay in inspections by third party organizations, contractual variation orders, workmanship does not comply with quality requirements and reworks, lack of coordination with main project parties, the contractor's internal company issues, delay in material transportation, public matters & traffic management, site safety issues, labour disputes and strikes, sudden increase of the cost of material, political influence, ineffective planning of the engineer, incompetency of consultant/engineer, delay in approving shop drawings, change in scope, inadequate or unclear instructions by the engineer, unforeseen site conditions, inadequate working drawing details, inadequate design team experience, ineffective delay penalties, types of bidding processes, suspension of works by the owner, poor planning of the contractor, frequent change in sub contractors, inflexibility of consultants, late procurement of

materials, low efficiency of equipments, effect of social and cultural factors, delay in inspections involved by third parties , ineffectiveness of client's representatives.

The above-mentioned events can be further merged into higher groups since some of the events are interrelated. These interrelated events occur one after the other or simultaneously in a single case of time overrun. Also, the previous surveys have categorized these causes of time overruns into several groups. Assaf and Al-Hejji (2006) divided these causes of delays into projects, owner, contractor, consultant, design, materials, equipment, labour, external. While Aziz (2013) categorized the delay factors into consultant related factors, contractor related factors, design-related factors, equipment-related factors, external related factors, labour-related factors, material related factors, owner related factors, project-related factors. Islam *et al.* (2015) separated groups as rules and regulations, contractor, managerial, financing, owner, project, consultant, manpower and resources, environmental.

All the time overrun cases are assigned with an additional cost. As explained earlier, the relevant additional cost for the case has to be borne by either one of the main projects parties (client & contractor) or both. Therefore, whichever way, an event of delay is categorized, results will be an additional cost to either of the two main parties (client & contractor) and extended completion date for the project. In that sense, contractually, all of these time overrun events can be divided into the main project parties. Generally, a bridge construction project consists of a client, consultant and contractor. Since a construction contract or civil works agreement is signed by a client and a contractor, these two parties will ultimately face the consequences of time overruns. Consultant of a construction project acts on behalf of the client and the group of consultant's personnel are classified as the client's personnel (FIDIC, Conditions of Contract, Plant and Design-Built, 1st edition, 1999 – FIDIC defined the main parties of a contract as the Employer, the Engineer & the Contractor).

Due to the above-mentioned argument, in this study, all the time overrun events will be categorized into three main groups which will be, the causes of time overruns accountable to the client, the causes of time overruns accountable to the contractor and the causes of time overruns accountable to the combination of the client and the contractor.

2.9 Financial Effect on the Bridge Construction Projects in an Event of Time Overrun

Construction contracts are signed between a client and a contractor for a defined scope of work with an allocated time and cost. Industrial level, these terms are called project scope, project duration and project cost. In case of a delay event, there will be an assessment of it in a contractual manner where a Determination will be given by the consultant of the contract. In the determination, it is clearly stated that the party responsible for a particular time overrun event, which party must be compensated as well as the extension of time (EOT) allowed for the project due to the event (Niazi and Painting, 2017).

When preparing the determination document of the project, first an assessment will be done about the event and derive the number of days allowable for the event to extend the original project completion. A lot of factors are considered fairly when assessing a time claim and ultimately the consultant decides the duration that the original completion date must be extended. Contractually, this scenario is called Extension of Time (EOT). After finalizing the EOT, the next step is to analyze the cost claim submitted by the contractor.

2.10 Accountability of the Time Overrun Event

If the accountability of the time overrun event goes to the client, the cost claim will be analysed by the consultant (Engineer) and provide the loss incurred to the contractor due to the event. This cost may include the idling cost, prolongation cost, loss of profit, overhead cost...etc. Cumulative of all these costs must be compensated by the client to the contractor. These are generally called justifiable time overruns.

If the accountability of the time overrun relies on the contractor, any cost claim from the contractor will be rejected. Instead of that, the consultant will analyse the amount of Delay Damages or Liquidated Damages due to the client and inform the contractor accordingly. These are called unjustifiable time overruns (Mohan and Al-Gahtani, 2004).

There are cases where the time overrun is justifiable, yet either of the parties will not be compensated by the other. These are the events such as adverse weather, earthquakes,

natural catastrophes, pandemics, new regulations by the government...etc. Some of these events are highly complicated contractual matters. These are the events that attract third-party involvement to the contract like insurance agencies. Even though the client or the contractor will not be compensated by these events, indirect costs such as prolongation cost or overhead cost components can be involved with these types of time overrun events.

2.11 Determination by the Consultant/Engineer in a Time Overrun Event/Delay Claim

Once the client or the contractor notifies about a time overrun event, from their onwards, all the related parties keep contemporary records on the event. In the detailed claim, the affected party must provide the information and evidence recorded, based on a delay event during the construction phase. These events can be initiated at any time of the project from the commencement date completion date. Some of those initiate at the commencement date and continue till the completion date of the project. Therefore, the analysing procedures of these claims are not the easiest things in the construction industry hence a portion of events ends in an Adjudicator, a Dispute Board (DB) or an Arbitration process. The primary reason for this is the complicated nature of the events and the difficulty of assessing these practical events time relatedly and cost relatedly. Currently, these time overrun events is analysed based on the information and evidence provided by the affected party. However, the current time overrun analysing methods have the following shortcomings which are the difficulty of analysing concurrent time overruns, critical path changes cannot be identified easily, the relative cost of float consumption will not be considered and only concentrated on delay events rather than as a whole (Yang and Kao, 2012).

As mentioned before, there are three types of time overruns namely justifiable time overruns, justifiable but non-compensation time overruns and unjustifiable time overruns. The United States generally accepts the calculation of various delays according to the categorization of non-excusable delays (NE) and excusable delays (ED), in a contractor's perspective, excusable delays will be further divided into excusable compensable delays

(EC) and excusable non-compensable (EN) delays. In a complex bridge construction project, these types of time overruns might exist simultaneously. Therefore, the first assessment of a time overrun event to identify it as justifiable/excusable or unjustifiable/unexcusable event leads to which party is responsible for the cause of it (Braimah, 2013).

In this study, a detailed analysis of time overrun event will not be considered since it is a broader area of knowledge which a lot of studies has already been done. But the understanding of the accountability of a time overrun is highly important since the study is focused on time overrun events accountable to the client of a bridge construction project. The primary objective of a particular time overrun event which is to identify the accountability of an event is assessed by previously stated methods, techniques and procedures.

In this study, one of the main objectives is to identify and categorize time overrun events that are accountable only to the client of a bridge construction project. Therefore, the understanding of justifiable delays will be a prime focus during the study.

2.11.1 The Process of Time Overrun Analysis

When a project is delayed, the below-mentioned basic sequence will be followed by the consultant/Engineer of the contract (Kamandang and Casita, 2018).

- As discussed, the first step of a time overrun event is the initiation of notice of claim from the affected party by following the conditions of the contract.
- Contemporary records must be kept by all the relevant parties of the event. If the event is ongoing, the records must be kept throughout the event.
- Then the detailed claim will be followed within the stipulated time in the contract.
- The analysis will start at this point by the Consultant/Engineer of the contract.
- The consultant/engineer may request further details from parties about the event and discussions will be held whenever required.
- The consultant/engineer then analysed the effect from the event to the critical path of the project.

- If the event is affected the critical path activities of the project, the ultimate result will be a delay of the total project. If it is not affected to the critical path activities of the project, the project will not be delayed by the event and the particular claim will be rejected.
- The next step is the assessment of the accountability of the event.
 - If the event is a non-excusable (NE) delay, then the accountability of the event will be on the contractor and obviously, it will be a non-compensable event.
 - If the event is an excusable delay (ED), the accountability of the time overrun event might be on the client or a third party.
 - If the accountability is on the client, it will be an excusable compensable delay (EC). If the accountability of it is on a third party, the most probable scenario is to identify the event as an excusable non-compensable (EN) event.
- Finally, the delay will be analysed in terms of time. The delay analysis contains a lot of factors such as concurrent delay, serial delays, independent delays...etc. Accordingly, the consultant/engineer will provide his determination on the exact time overrun of the event and the relevant cost for it.

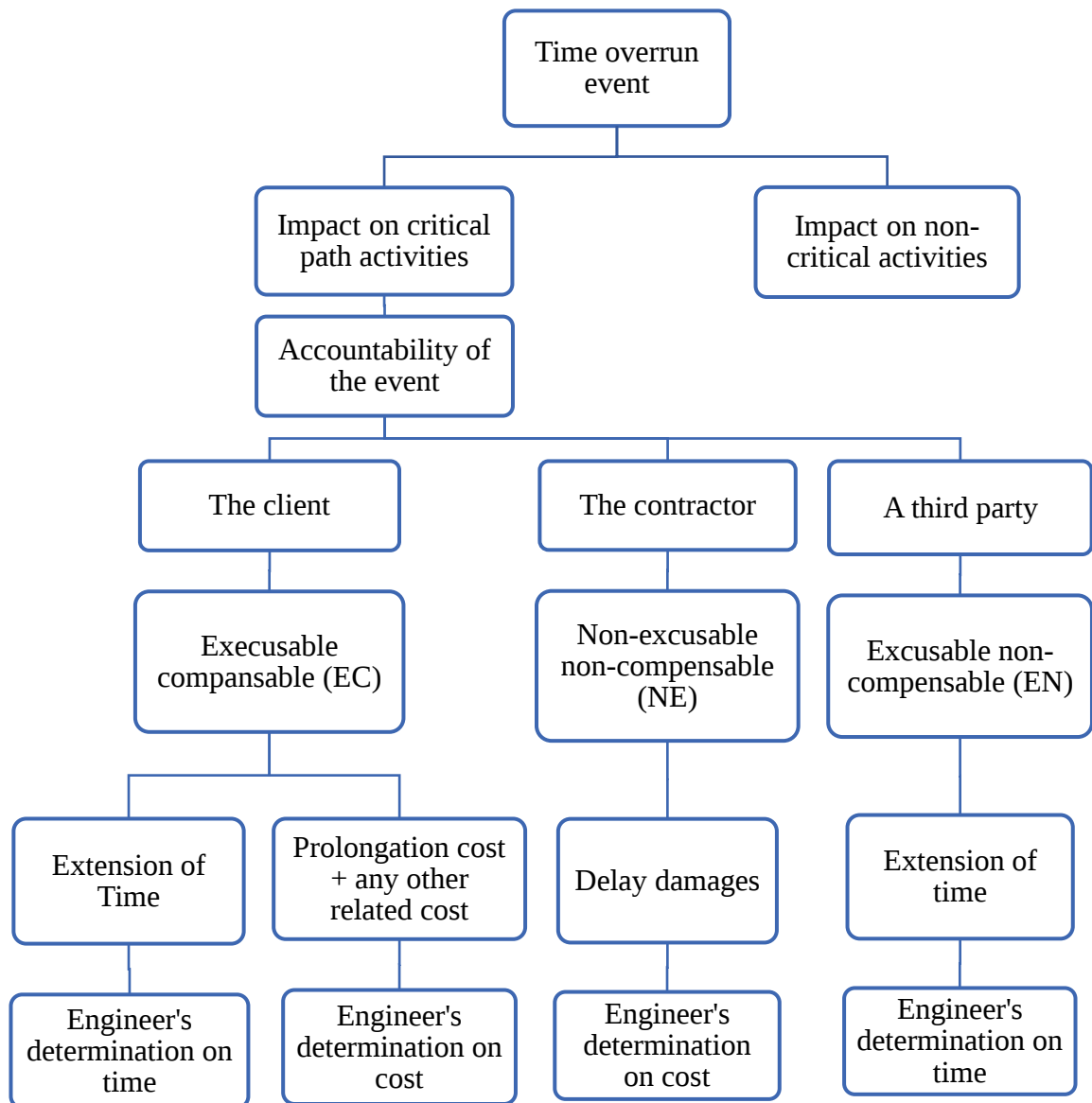


Figure 2.2: Process of Analyzing a Time Overrun Event

2.12 Accountability Assessment of a Time Overrun Event Sri Lanka, Bridge Construction Projects

A bridge construction project can be divided into different scales in terms of project cost, duration, complexity, implementing agency...etc. There isn't a globally accepted method to divide projects. CIDA Sri Lanka has divided construction contracts according to the contract cost. For this study, the contracts will be divided under the contract cost to identify the causes of time overruns in different scale bridge projects.

2.12.1 Low Scale Bridge Construction Projects in Sri Lanka

A bridge construction project, a contract sum of below 600 million rupees, implemented by divisional RDA offices (Provincial office, District office) are categorized as low scale projects. These projects are mostly done by CIDA grade C2 or below companies (CIDA website, 2021). In the surveys, six (6) projects were studied with a contract cost of below 600 million rupees. During the study, it has been noted that the proper details of the time overrun events of these projects are rarely be found. In a time overrun case occurs, a basic assessment was done by the nominated Engineer's representative of the project to identify the accountable party of the case.

If the accountability of the time overrun event relies on the client, accordingly, the project was granted an extension of time. But there were no records for a cost claim on behalf of any cause of time overrun other than the prolongation costs. The reason for this might be the lack of contractual knowledge with the contractor, lack of resources to generate a detailed claim by the contractor or an unofficial amicable settlement with the client.

On the other hand, interestingly, there wasn't a single event of time overrun accountable to the contractor at the end of these projects. in other words, there wasn't a single project out of the selected sixteen projects which had been applied liquidated damages or delay damages.

Contractually, these projects were completed before the official extended date of completion. Due to the above-mentioned reasons, in low scale bridge construction projects, there wasn't any compensation appeared for the time overrun events.

2.12.2 High Scale Bridge Construction Projects in Sri Lanka

In bridge construction projects, a contract sum of above 600 million rupees, implemented by the Project management Units (PMU) of the ministry of Highways are categorized as high scale projects. These projects are mostly done by CIDA grade C1 or above companies (CIDA website, 2021). In the surveys, twelve (12) projects were studied with a contract cost of above 600 million rupees.

These contracts are properly documented and the data available is very well organized. Unlike the low scale projects, most of the time overruns in these projects involved a cost claim as well as the prolongation cost. In these projects, a large number of time overrun claims were processed. Some of those were resolved at the contract level whereas the other claims were resolved through Adjudication, Dispute Boards and Arbitration. The Dispute Board level was the last stage where a time overrun issue can be solved without permitting a long time and huge cost. Therefore, it is always better to resolve the issues contractual in the project period. But it can be seen that some of these disputes have been solved through arbitration and the process was very long and costly. Therefore, if a project can mitigate the causes of the time overrun events especially in the planning stage of the project, it will be a huge benefit to the client of the project.

3 METHODOLOGY

3.1 General

This chapter includes the methods and different tools used in the analysis of time overrun events which are accountable to the client of the bridge construction project. Further, the chapter will elaborate on the reasons to adopt the selected methods of study and how they will influence the outcome of the study. In this research study, several methodologies were taken into consideration during the data collection phase. Ultimately, a combination of different methods will be explained and adopted to fine-tune the data collected which will suit the identified problems of the study. Primarily, both the quantitative and qualitative analysis will be used to assess the data and the chapter will elaborate on the complete methodology of the work.

3.2 Data Collection

3.2.1 Through Literature Review

The primary objective of the study is to identify the time overrun events accountable to the client in bridge construction projects. According to the literature review, a set of seventy (70) causes of time overruns has been identified. The accountability of these time overruns are not only within the client but the consultant, contractor and other external factors.

3.2.2 Through Case Studies

A review has been done for eighteen (18) projects consisting of high and low scale bridges or elevated highways by using the project's completion reports and claim registers. A total of 173-time overrun events were identified. According to the Engineer's Determination of the above events, the responsibility of those has been grouped and extracted only the events related to the client of the project.

Table 3.1: Project Details of the Case Studies

No.	Bridge/Elevated Project	Project Cost (LKR)	Time Overrun % to the Original Duration
1	OCH -Section 1 (Kottawa to Kaduwela)	Bn. 24.98	43%
2	OCH-Section 2 (Kaduwela to Kadawatha)	Bn. 44.88	17%
3	OCH-Section 3 (Kadawatha to Kerawalapitiya)	Bn. 77.70	33%
4	Sothern Extension Section-1 Matara - Beliatte	Bn. 103.28	17%
5	Sothern Extension section-3 Wetiya to Andarawewa	Bn. 31.57	63%
6	Sothern Extension Section-4 Mattala to Hambantota via Andarawewa	Bn. 52.15	17%
7	New Kelani bridge project (PK 1)	Bn. 31.53	31%
8	New Kelani bridge project (PK 2)	Bn. 9.86	28%
9	B1-Polathumodara Bridge	Bn. 1.39	13%
10	B3-Goviyapana Bridge	Mn. 624	4%
11	B4-Kathaluwa Bridge	Mn. 670	4%
12	Port Access Elevated Highway	Bn. 28.0	25%
13	Hammaliya- Agaliya-Mulkada Bridge	Mn. 235	56%
14	8/4 Kottawa-Batemulla Bridge	Mn. 106	122%
15	24/4 Horawala-Pelawatta-Pitigala Bridge	Mn. 144	58%
16	1/5Elpitiya-Awittawa-Lewwanduwa Bridge	Mn. 63	133%
17	Reconstruction of Bridge No.99/1 CGHW Road	Mn. 15	67%
18	H-B-N Road Bridge	Mn. 182	39%

3.3 Delphi Method

Delphi method is an iterative procedure to refine and figure out solutions by multiple questionnaires or interviews with professionals in the relevant field. The results of the first round will be assessed and provided to the panel anonymously. Based on the summary of the results, another round of judgements will be taken from the professionals by using a modified set of questions. After several rounds, the goal is to find out a solution that all the professionals agree with. Therefore, the Delphi method will also be taken to the study to properly identify the client accountable time overrun events and mitigation measures for those. First, the seventy (70) number of time overrun events identified by literature review and case studies were discussed with the professionals to group the events based on the accountability of those. Accordingly, twenty-four (24) client accountable time overrun events were grouped and formed a questionnaire to verify the sole accountability of those with few possible mitigation measures. The results of the questionnaire were brought to the selected expertise of the field to understand the impact of the critical time overrun events (nineteen (19) events) in keeping with the accountability. Further, in this final round, the expertise was questioned on the results of mitigation measures identified from the first questionnaire by formulating open-ended questions. Therefore, the fundamentals of the Delphi method were applied in different scenarios during the study and it enhanced the analysis of results greatly.

3.4 Quantitative Method

As the name implies, in this approach, the collected data will be quantified. The method will develop the relationship among variables. The samples taken for the method will be large and considered as a representation of the relevant population of the study. The method adopts structured formats and the data collection methods will be highly formal. The data will be collected systematically and analyzed to achieve a particular object (Queirós, Faria and Almeida, 2017).

The method is mainly considered when the requirement arises to identify the factors which affect the relevant outcome. One of the main advantages of this method is the effectiveness

of taking a large number of details from relevant entities by using questionnaires or datasheets. Due to a large number of surveys that can be done through the method, there will be enough data to analyse the case scientifically and arriving logical conclusions.

3.4.1 Multiple Indicator Measure

Multiple indicator measure is applied to a quantitative analysis whenever we are required to get a set of views to a particular statement. This is called the Likert scale. Generally, the scale consists of choices of answers from ‘strongly agree’ to ‘strongly disagree’ where the respondent can select an answer for a statement according to their view. Therefore, the Likert scale is a multiple indicator of a set of views for a particular area of research. The main purpose of the method is to understand the intensity of feeling for a question. Researchers can adopt a five-point scale or seven-point scale to elaborate the feeling of a statement. Each selection of a respondent is scored and the aggregate score of the respondents to a particular question will be taken to have an overall score (Bryman, 2012).

3.4.2 Relative Importance Index

The Relative Importance Index (RII) has been taken as the method to measure the participant’s responses to the questionnaire provided. The RII is fairly useful for the analysis of Likert-scale type evaluation.

The basic relationship of Relative Important Index is,

$$\text{Relative Importance Index (RII)} = \frac{\sum w}{A \times N}$$

Where,

w = weightage given for each selection of the respondents under the Likert-scale

A = The highest weight given for the particular Likert-scale

N = The total number of the respondents

3.4.3 Mode and Mean Values

In the analysis of responses to the questionnaire survey, the mode and mean values will be utilized to understand the quantified perception of the respondents on statements with Likert-scale selections.

The five-point Likert-scale choices will be counted and separated according to the respondent's selection varied from 'Strongly agree' to 'Strongly disagree'. Then the mode value will be found out by identifying the highest number of choices on the Likert scale.

As mentioned, the Likert-scale choices will be counted and separated according to the respondent's selection in each category. Then the mean value will be calculated by the below equation,

$$\text{Mean} = \frac{\sum w}{N}$$

Where,

w = weightage given for each selection of the respondents under the Likert-scale

N = The total number of the respondents

3.5 Application of Quantitative Method

This study uses a questionnaire survey on the professionals of the bridge construction in all three parties which includes client, consultant and contractor to filter the time overrun events that are accountable to the client. Further, a Likert scale of five-point (strongly

agree, agree, neutral, disagree, strongly disagree) is adopted to identify the specific problems related to the time overrun events and mitigating techniques which can be used to reduce the effect of those. A questionnaire has been formed this way and circulated to seventy-eight (78) professionals and forty-one (41) responses were received. Since the study area covers a contractual background, the questionnaire was submitted to professionals who were above a certain level of qualification. The benchmark for the qualification was set to the basic degree and posts they had held. This has been done solely to maintain the standards of the findings of the questionnaire, but not to discriminate any field or position in the bridge construction industry in Sri Lanka.

3.5.1 Content in the Questionnaire Survey - 01

To achieve the primary objective of the study of understanding time overrun events accountable to the client, twenty-four (24) delay events have been selected through case studies and literature surveys. The professionals were requested to give their answers on each event with three (3) options. The responses for the events were limited to three options based on their accountability. Those options were, 'the client', 'combination of client and any other party' and 'any other party'. Accordingly, the use of the Relative Important Index will be applied to group the most critical time overrun events accountable to the client.

Further, a set of statements regarding the mitigation measures which can be taken to reduce the risk of occurrence of a time overrun event will be evaluated by the professionals in the same manner by using the Likert scale. This Likert-scale consists of five (5) options that were, 'Strongly agree', 'Agree', 'Neutral', 'Disagree', 'Strongly disagree'. All the choices will be assigned a weightage and accordingly, the Relative Important Index will be used to understand the view of the professionals for a particular statement.

The statements are about the mitigation measures which can be taken prior to the awarding of the project. This approach has been specially studied in this research because it is understood that most of the time overrun events accountable to the client can be forecasted before awarding the project hence the mitigation measure would be more effective and easy to adopt at that period. (Appendix 1 – Questionnaire Survey 01)

3.6 Qualitative method

A qualitative approach is defined as a method of research work uses to obtain data by open-ended questions. The method is mostly followed by conversations or interviews with the selected group of people where it allows one to understand the reasons behind a particular answer to a problem. The method can take the research to an in-depth analysis compared to the quantitative approach. The collected data by using this method must be analysed and interpreted in a fair way to achieve the exact meaning. Therefore, the final results of this method will have a flexible structure compared to the quantitative approach (Creswell, 2012).

3.6.1 Thematic Analysis

Thematic analysis is widely applied to analyse qualitative data in the world. Analysing qualitative data such as the data collected from interviews are somewhat confusing because it contains a pool of data that may not directly point out the specific topics. Therefore, This method can be used to analyse the data gathered from qualitative methods in an efficient manner.

The method is widely used for qualitative analysis where it has the recognition of being the foundation of all the qualitative data analysis methods. Further, it is a method of understanding, clarifying, describing and evaluating the themes associated with the data set. Two main categories of thematic approach are inductive and deductive coding. An inductive method permits the data to nominate a theme for it whereas deductive coding permits to assess data with having a predefined theme someone anticipated to discover (Nowell *et al.*, 2017).

3.6.2 Probability-Impact matrix

Probability-Impact Matrix is widely used to assess the risk of a particular event. This method is very popular among risk managers. Any risk event has got two main components. The first one is the probability of the event which is the frequency of the event that can occur in a particular bridge/elevated highway project. The second one is the impact which is the effect of the event concerning cost and time for the client/Employer of

the project. Although these are two different conditions, the Probability-Impact matrix combines the conditions and evaluate the risk level. Eventually, the method will provide a graphical view of the critical events considering both the Probability and Impact of the risk event which will be very helpful to understand the magnitude and sequence of attending to those (A. Kassem, Khoiry and Hamzah, 2019).

3.6.3 Frequency, Severity and Importance Index

The Frequency Index (FI) is an equation that can be applied to evaluate the probability of a risk event. It will quantify the probability of occurrence of a particular risk where the study will adopt the method to prioritise the time overrun events over the probability of occurrence. The choices of the probability of occurrence of particular time overrun will be ‘Very High’, ‘High’, ‘Medium’, ‘Low’, ‘Very Low’.

$$\text{Frequency Index (F.I.)} = \frac{\sum w}{5 \times N}$$

Where,

w = the constant for the choice of the probability ranges from 1 for Very Low to 5 for Very High

N = The total number of the respondents

The severity Index (S.I) is an equation that can be applied to evaluate the impact of a risk event. Since the study is based on time overrun events, the impact will be quantified considering the time factor only. The choices of the impact of a time overrun event considering only the time factor will be ‘Very High’, ‘High’, ‘Medium’, ‘Low’, ‘Very Low’.

$$\text{Severity Index (S.I.)} = \frac{\sum w}{5 \times N}$$

Where,

w = the constant for the choice of the impact ranges from 1 for Very Low to 5 for Very High

N = The total number of the respondents

The Priority Index (P.I) is an equation that can be applied to calculate an overall value for a particular risk concerning the probability and impact. The Importance Index will be calculated by multiplying the Frequency Index and Severity Index. By the results of the equation, the events will be prioritized.

$$\text{Priority Index (P.I.)} = \text{F.I.} \times \text{S.I.}$$

3.7 Application of Qualitative Method

Even though studies have been done on identifying accountability of different time overrun events all over the world, studies on mitigating those events in the planning stage of a project are rare to be found. For this reason, this study adopted a qualitative approach to assessing the risk of selected time overrun events accountable to the client of the project and mitigation measures that can be adopted.

The selected time overrun events accountable to the client of a project through the questionnaire survey has been further investigated by examining the probability and impact of those to a project. This has been done through face to face semi-structured interviews with ten (10) selected expertise of the field. The reason behind selecting only the ten key personnel for the survey is because the professionals who have dealt with time overrun claims are limited in the field. This knowledge area is highly valued in the industry where only experienced specialists are involved with it. In that sense, having data gathered from a large professional audience can mislead the outcome of the study. Therefore, ten

(10) key personnel in the industry has been selected to assess the probability and impact of time overrun events.

3.7.1 Content of Questionnaire Survey 02

A set of semi-structured questions were given for them to identify the improvements and laggings of mitigation measures that had been already identified through the questionnaire survey.

The interviews consist of nineteen (19) time overrun events accountable to the client of the project where a series of semi-structured questions were asked to understand the probability and impact of each of the time overrun events in a bridge construction project in Sri Lanka. Further, a set of open-ended questions were delivered to them on the object of finding mitigation measures that can be taken to the risk events. These will be analysed by using the Thematic approach. The data gathered from the interviews will be noted according to the key points, the codes. From that, the themes of codes will be identified and categorized. Then the themes will be again checked with the compatibility of answers provided. After that, the themes will be modified to properly describe the problem and consequently, the final evaluation will be written. (Appendix 2 - Questionnaire 02)

Table 3.2: Details of the Key Experts Interviewed

No.	Expertise	Project	Experience (in years)
1.	Claim/Contract Specialist	New Bridge Construction Project over Kelani River	Over 30
2.	Claim/Contract specialist	Port Access Elevated Highway	Over 30
3.	Former Project Director	World Bank Funded Projects	Over 35

4.	Deputy Project Director	United kingdom Steel Bridge Projects	Over 25
5.	Deputy Project Director	Integrated Road Investment Program	Over 25
6.	Resident Engineer (1)	Port Access Elevated Highway	Over 30
7.	Resident Engineer (2)	Port Access Elevated Highway	Over 28
8.	Senior Quantity Surveyor	Port Access Elevated Highway	Over 20
9.	Project Manager	Integrated Road Investment Program	Over 20
10.	Project Manager	Priority Road projects	Over 25

The above table reflects the position, project and experience of experts that have been interviewed.

4 DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 General

This chapter of data analysis and discussion is arguably the most valuable part of a research study where all the gathered data will be analysed and processed to have a conclusion. The analysis will be done in different stages by using already discussed methodologies. Primarily the Delphi method has been used throughout the different phases of analysis to narrow down the findings according to the objectives of the study. In the beginning, all the data gathered from the literature review and case studies will be evaluated. The next step was the development of a questionnaire survey. The data from the questionnaire survey will be analyzed by using multiple Indicator Measures and the Relative Importance Index. Then the results will be further analysed on the data collected from the semi-structured interview done with the field expertise. This analysis will be based on the Thematic approach and the use of the tools like Probability-Impact matrix. The Probability-Impact matrix will be taken to evaluate the critical time overrun factors where the Thematic approach will be used to understand the best possible mitigation measures to stop the repetitive behaviour of these time overrun events.

4.2 Case Study

Case studies have been done for eighteen (18) low scale to high scale bridge construction projects in Sri Lanka. The reports of those projects have been analysed and found out twenty-four (24) types of events which the accountability of it is on the client of the project.

In a time overrun event, when the contractor believes that the event is beyond his control, a claim will be generated by him for extra time and cost in a project. Under the clauses of conditions of contract, the particular claim will be quoted to the accountable party of the event where most of the cases it is the client of the project. Then the consultant/engineer of the project will analyse the claim and give the determination. The engineer's determination concludes the cause of the event and the responsible party for the delay.

Further, an extension of time (EOT) will be granted for the contract. If the client or the contractor is in disagreement with the determination, either of them can move to the next step where the events can be taken to the Dispute Board (DB). Still, if either of the party is not in agreement with the dispute board decision, the event can be taken to arbitration. Whichever the level, if the client is accountable for a particular delay event, an extension of time and extra cost may include it. Even though an extra cost is not involved, the prolongation cost will have to be borne by the client. Therefore, all the time overrun events accountable to the client will consist of an extra cost.

By analysing one hundred seventy-three (173) time overrun events accountable to the client from the eighteen (18) bridge/elevated highway projects and the literature review, it has been identified twenty-four (24) causes for the delay-events of bridge construction projects in Sri Lanka.

4.3 Analysis of the Questionnaire Survey

The questionnaire survey was prepared and circulated among seventy-eight (78) qualified professionals. The analysis has been done among the forty-one (41) responses received. The questionnaire survey consisted of three parts which are the demography of the respondents, analysing the accountability type of the selected events and analysing the responses for the mitigation measures.

4.3.1 Demography of the Respondents

Demographics are the basic characteristics of the respondents of the questionnaire survey. The importance of the demography of the respondents is to understand the background, the contractual party which they are representing, the total experience of them, specific experience of them, the scale of projects they have been involved in...etc. These details are valuable to the study where the data provided by the respondents can be further divided and grouped according to their professional background.

4.3.1.1 Representing Party of the Respondents

The forty-one respondents were primarily grouped according to the contractual party which they were representing at the time of the questionnaire. Accordingly, the participants have been divided into the client/employer, the consultant/engineer and the contractor to have a better understanding of their contractual background.

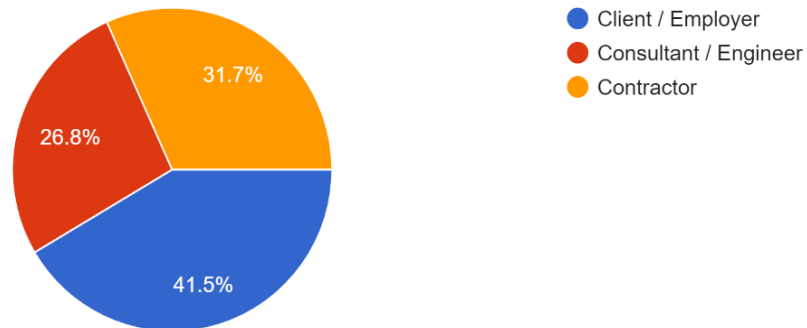


Figure 4.1: Diversity of the Contractual Party that the Respondents Represent

According to the analysis, from all the forty-one (41) respondent's, 41.5% of them represent the client of the construction industry. Further, 31.7% represent the contractor and 26.8% represent the consultant/engineer. The balance of the respondents concerning the contractual party that they are representing is well diversified into three main parties of bridge construction projects. Even though the study is focused on the time overrun events accountable to the client, it is important to have the opinion for the study covering all the project parties where the partiality of the results will be minimalized.

4.3.1.2 Qualification of the Respondents

The respondents have been categorized according to their educational and professional qualifications where different levels of qualifications were found as below.

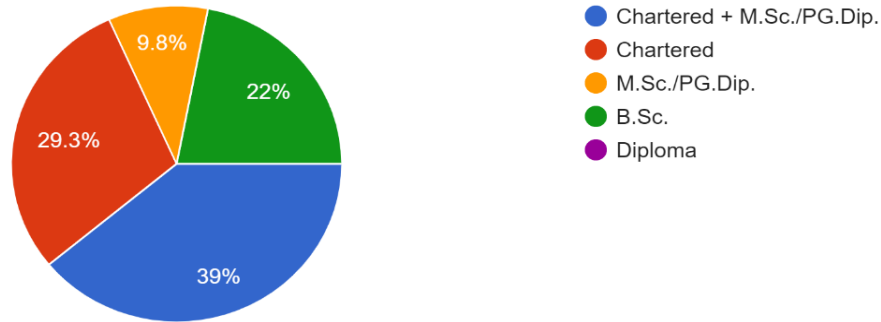


Figure 4.2: Diversity of the Professional and Educational Qualifications of the Respondents

According to the qualifications, it has been found that the respondents with the highest professional qualification in the country which is a chartered qualification with the educational qualification of M.Sc./PG.Dip. are 39%. The respondents with only the professional chartered qualification are 29.3%. The respondents with educational qualifications such as M.Sc./PG.Dip. are 9.8% and the others who are having the educational qualification of B.Sc. are around 22%. Considering the qualifications of the respondents, it has been found that all the respondents are professionally qualified and around 40% of them has got the highest qualification in the construction industry in Sri Lanka. The study area of this research which is the time overrun events accountable to the client is directly related to the contractual claim section of a project. Therefore, the reliability of the data is a high priority on a questionnaire survey like this where the respondents were selected carefully. The basis of the selections of the respondents was on their educational and professional qualifications where the gathered data has successfully proved the case.

4.3.1.3 Current Carrer Position of the Respondents

The purpose of extracting the job position of the respondents was to identify the managerial levels they were holding.

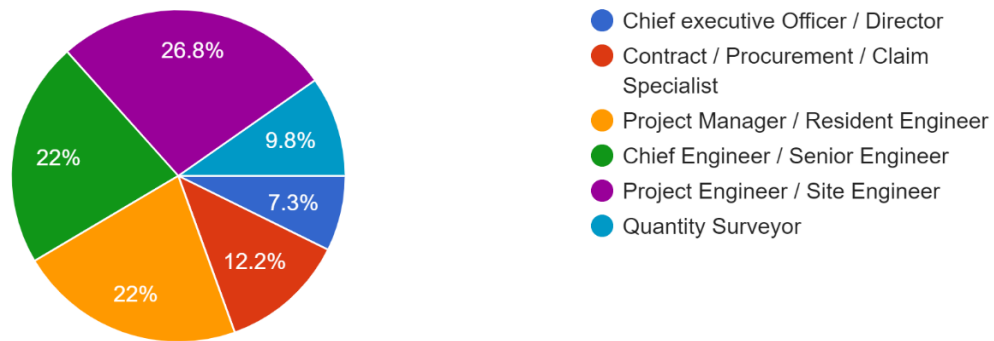


Figure 4.3: Diversity of the Career Positions of the Respondents

The career positions have been well-diversified among the respondents where all the commonly known job positions in different levels of the industry which have been involved in evaluating time overrun events in Sri Lanka can be seen in the population.

4.3.1.4 Overall Experience of the Respondents

The overall experience of the respondents is another important factor where the questionnaire is developed around experienced professionals.

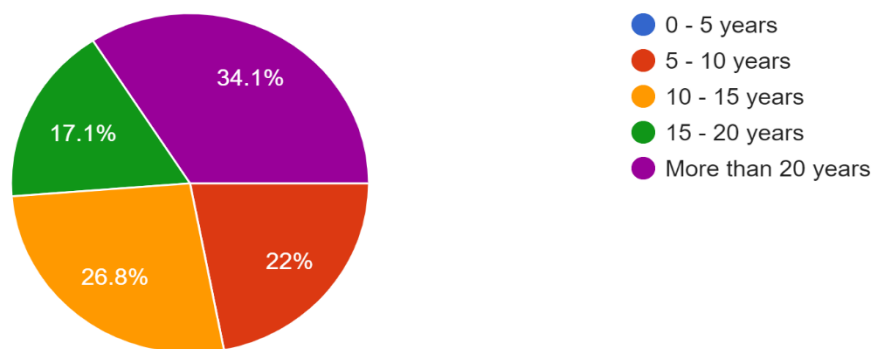


Figure 4.4: Overall Experience of the Respondents

Since the study is mainly based on a contractual matter, the overall experience of the respondents will be very valuable for the study. Yet, the diversity of the experience levels of the respondents is required where different views will be assessed. The analysis of the overall experience of the respondents shows that the respondents above twenty (20) years of experience are about 34.1% whereas none of the respondents were below five (5) years of experience.

4.3.1.5 Bridge Construction Experience of the Respondents

The relevant experience for the study is another important factor where the research is based on time overrun events accountable to the client in specifically to the bridge (or elevated highway) construction projects.

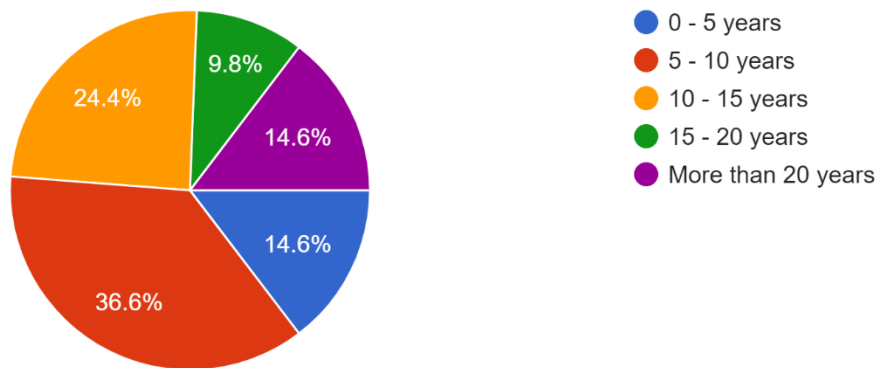


Figure 4.5: Bridge Construction Experience of the Respondents

It can be seen that the relevant experience of around 50% of the respondents is higher than ten (10) years. From the above, 14.6% of respondents have got more than 20 years of relevant experience who can add a lot of value to the data gathered from the questionnaire survey.

4.3.1.6 Value of the projects involved by the respondents

The scales of the projects involved by the respondents were also assessed through the questionnaire and the results are given below.

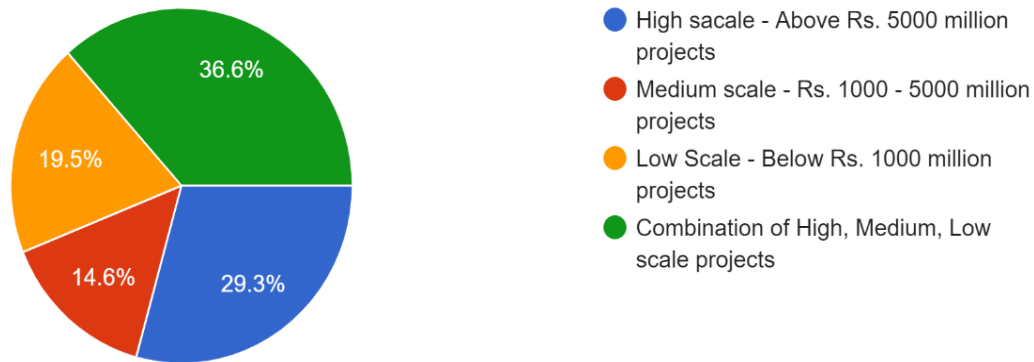


Figure 4.6: Value of the Projects Involved by the Respondents

The importance of evaluating the scale of the project the respondents involved in is necessary to the study because the time overrun events accountable to the client can be different according to the scale of the project. Therefore, the involvement of different scale project personnel is highly valuable to the study for identifying each time overrun event accountable to the client in any bridge/elevated highway projects. The analysis shows that 36.6% of the respondents have been involved in a combination of all three scale projects.

4.3.2 Identifying the Accountability of a Time Overrun Event

The primary objective of the study is to identify the time overrun events accountable to the client of a bridge construction project in Sri Lanka. In a time overrun case, the accountability of it can rely solely on the client. But in complex scenarios, the accountability of a particular event can be with not only the client but also any other party involved in the project. In this study, these types of events are named as events with joined accountability.

4.3.2.1 Recognizing the key Project Party With the Highest Overall Accountability of Time Overrun Events in a Bridge Construction Project

The time overrun event assessment was started in the questionnaire survey with a question to understand the general view towards the time overrun events in bridge construction projects in Sri Lanka. The question was given to rank the contractual party which holds the overall highest accountability of all the time overrun events in a particular bridge construction project. Accordingly, all the respondents representing the client, the consultant and the contractor with different qualifications, experience and positions ranked the highest to the lowest overall accountability from the selections of ‘the client’, ‘the consultant’, ‘the contractor’ and ‘any other party’.

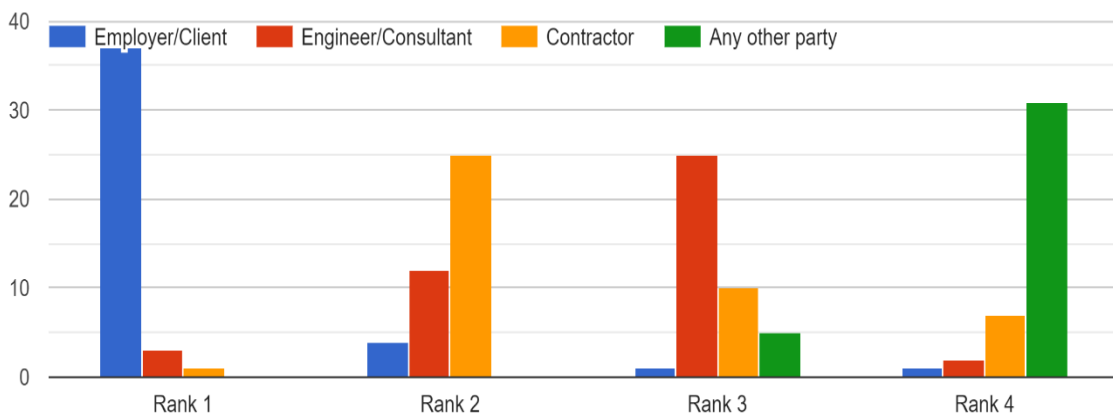


Figure 4.7: Ranking of the Accountability of Time Overrun Events in Bridge Construction Projects, Sri Lanka

Out of forty-one (41) responses, thirty-seven (37) respondents which is over ninety percentage (90%) of all the respondents, top-ranked on the client/employer category which implies that the highest accountability of total project delays is on the client according to their experience. This provides a clear view of the professionals about the bridge construction industry in Sri Lanka where the client of a project has the highest drawbacks when it comes to time overrun events as a whole. The assessment is based on the professional's general view on the topic where detailed analysis will be done later.

4.3.2.2 Analysing and Separation of Time Overrun Events with according to sole Accountability and Joined Accountability

Twenty-four (24) time overrun events accountable to the client has been filtered from case studies and initial interviews with the professionals. Yet, some of the identified events have got mixed characteristics where the accountability relies on not only the client but also the other parties. Therefore, the questionnaire survey has been used to identify the causes of delay events solely accountable to the client. The selected time overrun events are,

1. Possession of site
2. Land acquisition matters
3. Utility shifting works
4. Estimation errors
5. Unclear scope (Variation Orders)
6. Delay in payments
7. Conflict in specifications and other documents
8. New regulations and changes in economic conditions of government
9. Design changes
10. Shortage of labour & materials
11. Poor soil investigations
12. Delay in approvals
13. Coordination delays with other agencies
14. Conflict in quality control or quality assurance processes
15. Natural disaster
16. Terrorism, riots...etc.
17. Pandemic
18. Lack of coordination with main project parties
19. Public matters & traffic management
20. Political influence
21. Incompetency of Consultant/Engineer
22. Unforeseen site conditions
23. Adverse weather
24. Ineffectiveness of client's representatives

Accordingly, the above mentioned time overrun events were provided with the questionnaire survey to the professionals to divide those based on sole accountability and joined accountability. The selections were grouped according to the responsibility of a particular time overrun event where the groups were named as ‘The client’, ‘Combination of client and any other party’, ‘Any other party’. Any respondent was allowed a single selection on each event. A weighted average score was given for each response for identifying the total score of each event.

4.3.2.2.1 Time Overrun Events Concerning the Sole Accountability on the Client

The below equation has been applied to evaluate each of the responses to analyse the sole accountability of a particular event.

$$\text{Total Score} = \frac{\sum(a_i n_i + b_i n_i + c_i n_i)}{N}$$

a = Response on ‘the client’

b = Response on ‘combination of the client and any other party’

c = Response on ‘any other party’

n = Frequency of response

N = Total number of respondents

The analysis is carried out to find the events with sole accountability on the client where the responses of each event on ‘the client’ (a) are assigned as one (1) and any other responses on ‘combination of client and any other party’ (b) or ‘any other party’ (c) is assigned as zero (0).

Table 4.1: Ranking of Time Overrun Events Concerning the Sole Accountability on the Client

Rank	Time Overrun Event	Total Score
1	Possession of site	0.974
2	Ineffectiveness of client's representatives	0.921
3	Unclear scope (Variation Orders)	0.923
4	Land acquisition matters	0.912
5	Delay in payments	0.868
6	Utility shifting works	0.794
7	Political influence	0.778
8	New regulations and change in economic conditions of government	0.765
9	Delay in approvals	0.697
10	Terrorism, riots...etc.	0.590
11	Estimation errors	0.579
12	Coordination delays with other agencies	0.529
13	Poor soil investigations	0.514
14	Public matters & traffic management	0.514
15	Incompetency of Consultant/Engineer	0.441
16	Adverse weather	0.410
17	Lack of coordination with main project parties	0.281
18	Conflict in specifications and other documents	0.229
19	Unforeseen site conditions	0.229
20	Design changes	0.206
21	Pandemic	0.162
22	Conflict in quality control or quality assurance processes	0.111
23	Natural disaster	0.111
24	Shortage of labour & materials	0.026

Considering the above analysis, rank one (1) to rank fourteen (14) has scored more than 0.5 (50%) from responses. Therefore, these have been taken as the most influential events which direct the sole accountability on the client of a bridge construction project.

The most influential fourteen numbers of time overrun events which the sole accountability relies on the client are, Possession of site, Ineffectiveness of client's representatives, Unclear scope (Variation Orders), Land acquisition matters, Delay in payments, Utility shifting works, Political influence, New regulations and change in economic conditions of government, Delay in approvals, Terrorism, riots...etc., Estimation errors, Coordination delays with other agencies, Poor soil investigations, Public matters & traffic management.

4.3.2.2.2 Time Overrun Events Concerning the Joined Accountability with the Client and Any Other Party

The below equation has been applied to evaluate each of the responses to analyse the joined accountability of a particular event.

$$\text{Total Score} = \frac{\sum(a_i n_i + b_i n_i + c_i n_i)}{N}$$

a = Response on ‘the client’

b = Response on ‘combination of the client and any other party’

c = Response on ‘any other party’

n = Frequency of response

N = Total number of respondents

The analysis is carried out to find the events with joined accountability where only a part of the accountability is on the client. Therefore, the responses of each event on the ‘combination of client and any other party’ (b) are assigned as one (1) and any other response on ‘the client’ (a) or ‘any other party’ (c) is assigned as zero (0).

Table 4.2: Ranking of Time Overrun Events Concerning the Joined Accountability on the Client and Any Other Party

Rank	Time Overrun Event	Total Score
1	Design changes	0.735
2	Lack of coordination with main project parties	0.719
3	Conflict in specifications and other documents	0.657
4	Adverse weather	0.543
5	Pandemic	0.514
6	Coordination delays with other agencies	0.441
7	Poor soil investigations	0.432
8	Public matters & traffic management	0.429
9	Incompetency of Consultant/Engineer	0.382
10	Conflict in quality control or quality assurance processes	0.361
11	Natural disaster	0.306
12	Delay in approvals	0.303
13	Estimation errors	0.289
14	Unforeseen site conditions	0.257
15	Utility shifting works	0.176
16	Delay in payments	0.105
17	Land acquisition matters	0.088
18	Ineffectiveness of client's representatives	0.079
19	Unclear scope (Variation Orders)	0.077
20	Terrorism, riots...etc.	0.077
21	New regulations and change in economic conditions of government	0.059
22	Political influence	0.056
23	Possession of site	0.026
24	Shortage of labour & materials	0.026

Considering the above analysis, rank one (1) to rank five (5) has scored more than 0.5 (50%) from responses. Therefore, these have been taken as the most influential events which show the joined accountability on the client and other parties of a bridge construction project.

The most influential five numbers of time overrun events which the joined accountability relies on the client are, Design changes, Lack of coordination with main project parties, Conflict in specifications and other documents, Adverse weather, Pandemic.

4.3.3 Analysing the Mitigation Measures for the Time Overrun Events Accountable to the Client

The questionnaire consists of mitigation measures for the identified time overrun events concerning the client. The mitigation measures for the risk of identified time overrun events that are accountable to the client can be separated into two stages of a bridge construction project. one is the pre-contract awarding stage and the other is the post-contract awarding stage. Most of the client accountable time overrun events can be managed in the pre-contract awarding stage. Not only these can be effectively managed in the pre-contract awarding stage but also it will be highly beneficial to the client of a bridge construction project. Therefore, the study focuses on avoiding or controlling the risk of a time overrun event in the pre-contract awarding stage.

The questionnaire was handed with several statements on mitigation measures of client accountable time overrun events in the pre-contract awarding stage. In other words, the study aims to understand the mitigation measures for the risk events generated by the client of a bridge construction project in the planning phase.

The selections of ‘Strongly agree’ has been awarded five (5) marks, ‘Agree’ has been awarded four (4) marks, ‘Neutral’ has been awarded three (3) marks, ‘Disagree’ has been awarded two (2) marks and ‘Strongly disagree’ has awarded one (1) mark on each statement. Then the Likert-scale statements have been analyzed by using the Mode and Mean of the results and accordingly, the highest number of responses category for a statement is taken as the results in the Mode section and the average value of the responses

were rounded down to the integer to get the results in Mean section. If both the mode and mean values are above four (4) has been taken as the acceptance criteria of statements where mode and mean values below three (3) has been taken as the rejection criteria of the statements.

Table 4.3: Overall Respondent's View on Mitigation Methods Proposed for Time Overrun Events Accountable to the Client\

No.	Statement	Mode	Mean	Acceptance of professionals
1	Most of the client-initiated time overrun events can be settled before awarding the Contracts rather than after	4	4	Accepted
2	Before awarding the project, lack of project planning by the client is the main cause for the time overrun events accountable to the client in bridge construction projects	4	4	Accepted
3	The project procurement process and selection of the Contractor has a direct influence on the origin of the client-based time overrun events	2	2	rejected
4	Time overrun events accountable to the client has the biggest impact concerning all the time overruns for a particular bridge project	4	4	Accepted
5	Most of the client-accountable time overrun events can be forecasted and estimated before awarding the project	4	4	Accepted

6	Recruiting an experienced staff to the Client in the project planning stage (before awarding the Contract) can mitigate the risk of Client-based time overrun events in a project	5	4	Accepted
7	Investing more by the client in assessing the risk of time overrun events and mitigating those in the pre-contract awarding stage (before awarding the project) would be highly beneficial to the Client as well as the project	5	4	Accepted
8	In almost all bridge construction projects, the Client/Employer role holds by a government body. In this case, nominating a private firm to represent the Client will be a better solution for the higher number of time overrun events accountable to the client	3	3	Neutral

The questionnaire survey has been circulated to the professionals representing all the key parties, the client, the consultant and the contractor of a bridge construction project. The mitigation measures provided in the questionnaire survey will be further analysed according to the perspective of key parties. This will be done to understand the level of acceptance of mitigation measures proposed and analyse the reasons of different responses concerning their contractual party which respondents were representing at the time of submitting the survey.

Accordingly, the responses for the statements have been grouped under the contractual party which the particular respondent represents and RII has been calculated to compare the different perspectives. Further, the acceptance of a mitigation method has been measured relative to the base level of RII which equals the value of 0.6 because the value of 0.6 or below of RII implies the negative attitude of respondents towards a statement that eventually consists of a majority of 'Neutral', 'Disagree' or 'Strongly disagree' selections.

Therefore, the value of RII is higher than 0.6 has been taken as acceptance criteria for the statements which consist of a majority of ‘Strongly agree’ or ‘Agree’ selections by the respondents.

The client/employer is assigned as ‘I’, the consultant/engineer is assigned as ‘II’ and the contractor is assigned as ‘III’ in the table. Further, the acceptance of a statement is assigned as ‘A’ and the rejection of a statement is assigned as ‘R’ in the table.

Table 4.4: Respondent’s Perspective Concerning the Contractual Party They Represent on Mitigation Methods Proposed for Time Overrun Events Accountable to the Client

No.	Statement	RII			Respondent’s view		
		I	II	III	I	II	III
1	Most of the client-initiated time overrun events can be settled before awarding the Contracts rather than after	0.776	0.818	0.892	A	A	A
2	Before awarding the project, lack of project planning by the client is the main cause for the time overrun events accountable to the client in bridge construction projects	0.835	0.800	0.877	A	A	A
3	The project procurement process and selection of the Contractor has a direct influence on the origin of the client-based time overrun events	0.576	0.673	0.385	R	A	R
4	Time overrun events accountable to the client has the biggest impact concerning all the time overruns for a particular bridge project	0.812	0.818	0.846	A	A	A

5	Most of the client-accountable time overrun events can be forecasted and estimated before awarding the project	0.824	0.818	0.862	A	A	A
6	Recruiting an experienced staff to the Client in the project planning stage (before awarding the Contract) can mitigate the risk of Client-based time overrun events in a project	0.894	0.873	0.846	A	A	A
7	Investing more by the client in assessing the risk of time overrun events and mitigating those in the pre-contract awarding stage (before awarding the project) would be highly beneficial to the Client as well as the project	0.882	0.909	0.892	A	A	A
8	In almost all bridge construction projects, the Client/Employer role holds by a government body. In this case, nominating a private firm to represent the Client will be a better solution for the higher number of time overrun events accountable to the client	0.576	0.673	0.723	R	A	A

4.3.4 Discussion on Mitigation Measures Analyzed of the Time Overrun Events Accountable to the Client

Most of the previously identified client-based time overrun events in bridge construction projects in Sri Lanka can be forecasted since most of the events are not construction activity related. The mitigation measures for the risk of these repetitive time overrun events accountable to the client can be divided into two phases of a project. The mitigation

measures can be taken pre-contract awarding period (planning stage) and post-contract awarding period (implementing stage).

Out of the identified fourteen (14) numbers of critical time overrun events in the category of sole accountability, the risk of Possession of site, Ineffectiveness of client's representatives, Unclear scope (Variation Orders), Land acquisition matters, Delay in payments, Political influence, New regulations and change in economic conditions of government, Delay in approvals, Estimation errors, Coordination delays with other agencies, Poor soil investigations can be avoided or mitigated by proper planning in pre-contract awarding stage. Also, out of the identified five (5) numbers of time overrun events in the category of joined accountability, the risk of Design changes, Lack of coordination with main project parties, Conflict in specifications and other documents can be handled efficiently in the pre-contract awarding stage. Therefore, the study is mainly focusing on mitigating the risk of occurring the above mentioned time overrun events since those can be fairly forecasted and are not related to the construction activities or unforeseen site conditions. The statement related to this from the questionnaire has been accepted by all the respondents who represent different parties.

The main cause of these foreseeable time overrun events in bridge construction projects in Sri Lanka related to the client is the lack of planning in the pre-contract awarding stage. This statement has been accepted by the majority of respondents irrespective of the party they represent.

The overall response to the statement on observing the link between the contract procurement process and the origin of time overrun events accountable to the client has been rejected by the majority. Yet, the respondents representing the consultant's side of projects believed a reasonable level of relationship between the procurement process with client-initiated time overrun events but the respondents representing the contractor side thoroughly rejected the statement. Therefore, the idea of interconnection between the project procurement process and the origin of client-based time overrun events are rejected by the study as well.

Further, the respondent's agrees with the statement that the biggest impact to time overrun events in a bridge construction project is on the client where the respondents again prove the previous selection of highest accountability on time overrun events in the ranking question.

As mentioned earlier, the majority of time overrun events accountable to the client can be forecasted. By the identified fourteen (14) solely accountable events and five (5) joined accountable events, fifteen (15) events can be effectively forecasted and the risk of those can be estimated concerning the delay to a bridge construction project. The statement on this has been accepted by the professionals.

Recruiting experienced staff for the client in the pre-contract awarding stage has been another solution that was accepted by the professionals. In Sri Lanka, all the bridge construction projects are implemented through government organizations. Therefore, the position of the client of the bridge construction project is always held by a government organization. On the other hand, recruiting staff may not be limited to internal recruitments of the government organization but external recruitments as well. This may result in extra costs to the project in the planning stage. But in the questionnaire, the professionals in all the parties including government officers who represent the client agree on spending more on this. The statement on investing more by the client on assessing risks has been accepted by the respondents where recruiting experienced personnel will be a major part of it.

Another solution for the above-mentioned scenario is to outsource the planning works in the pre-contract awarding stage to a professional body. The overall response to the proposal is in a neutral state where the professionals neither agree nor disagree with it. When the results of the statement are grouped into the main contractual parties, it can be visible that the respondents who represent the client in Sri Lanka disagree with the statement whereas the respondents who represent the contractor agree with it. This may hint that the reluctance to a change in the government sector in Sri Lanka where the private sector professionals appreciate the change which may ultimately direct the project to a well-planned project with lesser time overruns initiated by the client-side in bridge construction projects.

Since the study will not perform an in-depth analysis on the amount of the time overrun events accountable to the client that can be avoided fully in the pre-contract awarding stage, a statement was provided with the questionnaire to find out a generalized view of the professionals related to Sri Lankan bridge construction industry. The statement was on observing the amount of time overrun events accountable to the client that can be avoided in the pre-contract awarding stage. The multiple choices of the statement were, '0-25%', '25-50%', '50-75%', '75-90%', 'It depends on contract to contract'. The mode value of the responses were 25-50% whereas the mean of the responses on 50-75%. Since this is not an in-depth analysis, the results direct the idea of around 25-75% of client accountable time overrun events can be identified, avoided or mitigated by proper planning in the pre-contract awarding stage.

4.4 Analysis of Interviews With the Expertise

4.4.1 Analysing the Most Critical Time Overrun Events Accountable to the Client in Bridge Construction Projects

After the Case studies, literature review and questionnaire survey, it has been identified fourteen (14) main time overrun events accountable to the client. The speciality of these events are the sole accountability of it relies on the client. Another five (5) time overrun events has been found where part of the accountability relies on the client. In those joined accountability events, the client and any other party jointly hold the responsibility for the same event. The joined accountability of an event may not be equally distributed to the client and other parties but it may vary case by case.

4.4.1.1 Through Probability and Impact Indexes

One of the main goals of the study is to analyse the criticality of the selected events. Through the semi-structured interviews with the expertise, the probability and impact of each event in a bridge construction project in Sri Lanka have been analysed. All the experts were asked to vote for the nineteen (19) important time overrun events which are accountable to the client based on the frequency of occurrence and the impact which can

generate concerning the extension of time to a project. Accordingly, for each event, experts marked the probability and impact on a scale of ‘Very High’, ‘High’, ‘Medium’, ‘Low’, ‘Very Low’.

The probability of a time overrun event is the frequency of the event that can occur in bridge/elevated highway projects. The probability of an event is calculated by using the frequency index.

Table 4.5: Ranking List of Time Overrun Events Accountable to the Client Concerning the Frequency Index

Rank	Event	F.I.
1	Possession of site	0.889
2	Utility shifting works	0.852
3	Unclear scope (Variation Orders)	0.821
4	Conflict in specifications and other documents	0.811
5	Coordination delays with other agencies	0.781
6	Public matters & traffic management	0.731
7	Land acquisition matters	0.722
8	Delay in approvals	0.689
9	Design changes	0.644
10	Adverse weather	0.586
11	Delay in payments	0.567
12	Poor soil investigations	0.551
13	Lack of coordination with main project parties	0.489

14	Political influence	0.416
15	Estimation errors	0.389
16	Ineffectiveness of client's representatives	0.234
17	Pandemic	0.214
18	Terrorism, riots...etc.	0.188
19	New regulations and changes in economic conditions of government	0.176

The above table reflects the ranking of all the main time overrun events accountable to the client in bridge construction projects concerning the likelihood of the occurrence.

The impact of a time overrun event is evaluated considering only the effect of the time in bridge/elevated highway projects. The impact of an event is calculated by using the severity index.

Table 4.6: Ranking List of Time Overrun Events Accountable to the Client Concerning the Severity Index

Rank	Event	S.I.
1	Pandemic	0.921
2	Possession of site	0.867
3	Terrorism, riots...etc.	0.824
4	Land acquisition matters	0.821
5	Design changes	0.814
6	Unclear scope (Variation Orders)	0.789
7	Adverse weather	0.721

8	Utility shifting works	0.638
9	Poor soil investigations	0.567
10	Delay in approvals	0.439
11	Delay in payments	0.385
12	Public matters & traffic management	0.359
13	Estimation errors	0.344
14	Coordination delays with other agencies	0.312
15	Lack of coordination with main project parties	0.306
16	Conflict in specifications and other documents	0.296
17	New regulations and change in economic conditions of government	0.221
18	Political influence	0.188
19	Ineffectiveness of client's representatives	0.112

The above table reflects the ranking of all the main time overrun events accountable to the client in bridge construction projects concerning the impact of the time factor.

The prioritized time overrun events according to the priority index which is the multiplication of F.I. and S.I. are listed in the table.

Table 4.7: Ranking List of Time Overrun Events Accountable to the Client Concerning the Priority Index

Rank	Event	P.I.
1	Possession of site	0.771
2	Unclear scope (Variation Orders)	0.648

3	Land acquisition matters	0.593
4	Utility shifting works	0.544
5	Design changes	0.524
6	Adverse weather	0.423
7	Poor soil investigations	0.312
8	Delay in approvals	0.302
9	Public matters & traffic management	0.262
10	Coordination delays with other agencies	0.244
11	Conflict in specifications and other documents	0.240
12	Delay in payments	0.218
13	Pandemic	0.197
14	Terrorism, riots...etc.	0.155
15	Lack of coordination with main project parties	0.150
16	Estimation errors	0.134
17	Political influence	0.078
18	New regulations and changes in economic conditions of government	0.039
19	Ineffectiveness of client's representatives	0.026

The above table reflects the ranking of all the main time overrun events accountable to the client in bridge construction projects concerning both the probability and impact.

4.4.1.2 Through Probability-Impact Matrix

The Probability-Impact Matrix is an efficient way to understand the most critical events for a particular scenario in a graphical manner. The method will let the study have a clear idea of the most critical events considering both the probability of occurrence of the event as well as the impact of the event concerning the time factor.

The probability of each event has been recorded and calculated through F.I. and the impact has been recorded and calculated through S.I. as described earlier.

Table 4.8: Linear Scale Identification for Probability and Impact

Rating	Probability	Impact
0.0 - 0.2	Rare	Negligible
0.2 – 0.4	Unlikely	Minor
0.4 – 0.6	Moderate	Medium
0.6 – 0.8	Likely	Major
0.8 – 1.0	Very Likely	Catastrophic

Table 4.9: Probability and Impact Level of Each Event following the Linear Scale

No.	Event	Probabiltiy	Impact
1	Possession of site	Very Likely	Catastrophic
2	Unclear scope (Variation Orders)	Very Likely	Major
3	Land acquisition matters	Likely	Catastrophic
4	Delay in payments	Very Likely	Minor
5	Utility shifting works	Moderate	Major
6	Coordination delays with other agencies	Moderate	Minor

7	Delay in approvals	Moderate	Medium
8	Public matters & traffic management	Likely	Minor
9	Political influence	Likely	Negligible
10	Poor soil investigations	Likely	Medium
11	New regulations and change in economic conditions of government	Very Likely	Minor
12	Lack of coordination with main project parties	Moderate	Minor
13	Estimation errors	Unlikely	Minor
14	Design changes	Rare	Catastrophic
15	Terrorism, riots...etc.	Moderate	Catastrophic
16	Pandemic	Unlikely	Catastrophic
17	Conflict in specifications and other documents	Moderate	Minor
18	Ineffectiveness of client's representatives	Rare	Negligible
19	Adverse weather	Unlikely	Major

Accordingly, the developed Probability-Impact matrix is shown below

Impact	Catastrophic	15	16	14	3	1
	Major			19		2,5
	Medium			10	7	
	Minor	11	13	4,12	6,8	17
	Negligible		18	9		
		Rare	Unlikely	Moderate	Likely	Very Likely
Probability						

Figure 4.8: Probability-Impact Matrix of Time Overrun Events Accountable to the Client

According to the probability-impact matrix, the most critical time overrun events accountable to the client of a bridge construction project in Sri Lanka are, Possession of site, Unclear scope (Variation Orders), Land acquisition matters, Utility shifting and Design changes.

4.5 Discussion on the Most Critical Time Overrun Events Accountable to the Client

The results of Priority Index analysis and Probability-Impact analysis prioritized that the nineteen (19) most important time overrun events accountable to the client in a bridge construction project.

Those events according to the criticality are,

1. Possession of site
2. Unclear scope (Variation Orders)
3. Land acquisition matters
4. Utility shifting works

5. Design changes
6. Adverse weather
7. Poor soil investigations
8. Delay in approvals and permits
9. Public matters & traffic management
10. Coordination delays with other agencies
11. Conflict in specifications and other documents
12. Delay in payments
13. Pandemic
14. Terrorism, riots...etc.
15. Lack of coordination with main project parties
16. Estimation errors
17. Political influence
18. New regulations and changes in economic conditions of government
19. Ineffectiveness of client's representatives

Among those, Possession of site, Unclear scope (Variation Orders), Land acquisition matters, Utility shifting, and Design changes are the most critical events under both the Priority Index analysis and Probability-Impact analysis methods.

I. Possession of site

The client should be able to give possession of the site to all parts of the project according to the dates agreed in the contract. If the client is unable to provide the possession to the contractor, accordingly, he will be eligible for an extension of time for the particular part of the project. A bridge construction project which consists of a single location bridge construction, the possession of it must be provided according to the agreement with the contract without any delay. If not, the consequences will be an extension of time to the contractor for the whole project. The case is different to an elevated highway construction project. if the client is unable to provide part of the possession, the analysis will be done

considering critical path work in that location and accordingly, for the particular part of the whole project will have an extension.

The event can be occurred because of different scenarios such as public protests, interruptions of other agencies, a discrepancy with other government organizations, difficulties to provide access roads to the site, delays of concurrent projects...etc. This event can be forecasted and evaluate the risk in the pre-contract awarding stage. Therefore, proper planning before awarding the project can avoid the risk of the event in full.

II. Unclear scope (Variation Orders)

The scope of work is pre-defined and detailed in all the bridge construction projects. yet, the scope changes are occurring in almost all the bridge projects due to the lack of clarity in the defined works. The consultant with the approval of the employer can issue a variation order where the additional scope has to be done to successfully complete the project. The scenario is very common in the Sri Lankan construction industry.

An unclear scope may direct a variation order due to several reasons such as changes to the quantities of the items, changes in the items, changes to the quality, additional works, additional materials, changes to the work sequence...etc. The event directly affects the critical path of a project if the change of scope is within it. If not, still the variation orders will damage the flow of the contractor and the sequence of assigning materials and labour. Hence a contractual claim will be generated from the contractor's side and the results will be a time overrun for the project. Proper planning of a competent staff of the client can largely mitigate the risk of the event.

III. Land acquisition matters

Almost all the bridge or elevated highway projects are conducted through government organizations in Sri Lanka. In most cases, the bridges are built in residential, developed areas. Therefore, land acquisition work is inevitable. The acquisition must be commenced

to succeed the project where any delay in completing the land acquisition work will affect the progress of the project in that particular location.

Land acquisition work may consist, acquiring residential lands, buildings, crops, estates...etc. The scenario is common in the Sri Lankan bridge construction industry where the event will lead up to an extension of time to the contractor because it may affect the critical construction works.

IV. Utility shifting

Utility shifting is another usual event that can cause serious time overruns in bridge construction projects. The lack of planning and utility investigation is the main cause for the event where the groundworks of the bridge construction are highly influenced by it. Any bridge construction has to be started from the ground by constructing foundations. These foundation works are always on the critical path of the project where any difficulty of unforeseen utility will inject an extension of time to the project.

The difficulty of identifying the utilities and after the identification, the delay of utility agencies, approvals, supervisions...etc may cause severe time overruns to the project. In general, shifting of utility involves water lines, sewer lines, electrical cable lines, telecommunication lines, stormwater lines, oil lines, railway lines...etc. Inability to supply correct drawings of the utilities is the major cause of time overruns where the accountability of it is on the client unless the contract specifies something else. By recruiting experienced professionals and proper coordination of utility agencies can highly mitigate the causes of the time overrun during the pre-contract awarding stage.

V. Design changes

Design changes are another repetitive time overrun event in the bridge construction industry, Sri Lanka. The accountability of the event can be different from contract to contract. A Measure & Pay contract, a situation where all the contract drawings are provided by the client, the sole accountability will be on him for any design change. The

scenario is slightly different in Design and Built contracts. In Design and Built contracts, any design delay has to be absorbed into the construction program by the contractor but if the change occurs due to the conceptual level design change from the client, yet again the accountability will be on the client. All in all, in all the major bridge construction contract types in Sri Lanka, the design changes are kept on generating where the client will be the main party when it comes to the responsibility of it hence the extension of time for the project is unavoidable.

4.6 Discussion on Mitigation Measures of the Time Overrun Events in Bridge Construction Industry, Sri Lanka

Time overrun events accountable to the client in bridge construction projects all over the world is inevitable. But minimizing the probability and impact of these will be highly beneficial to the client as well as the project. In other words, the benefit will be directly related to the general public of the country. In the Sri Lankan bridge construction industry, there is a huge tendency on repeating most of the time overrun events in every project. The risk of occurring the five (5) critical events and the other fourteen (14) events can be safely mitigated or even avoided by proper planning in the pre-contract awarding stage of the project.

The argument might be different for a few non-critical time overrun events accountable to the client such as adverse weather, pandemic, political influence, terrorism, riots...etc., lack of coordination with main project parties, new regulations and changes in economic conditions of government. Even though some of these can be forecasted, the tendency to occur the risk in different scale during the construction period is highly possible.

4.6.1 Forecasting Time Overrun Events Accountable to the Client Before Awarding the Contract

Most of the time overrun events can be forecasted before the awarding of the contract. Time overrun events such as possession of the site, unclear scope (variation orders), land acquisition matters, utility shifting works, design changes, poor soil investigations, delay

in approvals and permits, public matters & traffic management, coordination delays with other agencies, conflict in specifications and other documents, delay in payments, estimation errors, the ineffectiveness of client's representatives can be forecasted, analysed and mitigated before the awarding of the contract. Since none of the above-mentioned events including the most critical time overrun events accountable to the client is related to construction works or construction period. If a contract does not focus on the risk of time overrun events accountable to the client in the planning phase of the project, the effect of those in the construction phase will be enormous.

4.6.2 Fitting Planning Phase of the Project Pre-Contract Awarding

The pre-contract awarding stage which is the planning phase of any project is far more important than the industry looks at it. It has been understood that the fitting planning phase of a bridge construction project is the most important phase when it comes to time overrun events accountable to the client. The proper planning phase can fully avoid the majority of time overrun events because of the mentioned reasons.

Even if the project cannot avoid the risk of a time overrun event, forecasting and planning the mitigation measures for a particular time overrun event will be highly beneficial to the client as well as the project. The study has not focused on the cost overrun effect of these events, but mitigating these risks in the planning stage will save a considerable amount of money from the client. Therefore, competent professionals who are experts in the field will play a major role in the succeeding of the planning phase of a bridge construction project.

4.6.3 Recruiting Experts in the Field for the Planning Phase of a Bridge Project

The client role in the Sri Lankan bridge construction industry is always held by the government of Sri Lanka. Therefore, the project planning phase which is the pre-contract awarding stage is handled by government officers. The planning phase of the project is such a key period of the project where proper planning will mitigate the time overrun events accountable to the client by a considerable margin.

The expert panel works in the planning phase of a project must contain a combination of people who has experience not only in project planning, procurement or administration but construction technology, construction sequence, construction methodology...etc. Therefore, a lack of construction work-related experience with expertise can cause severe damage to the planning phase of the project. Hence, a panel of expertise covering all the areas of the project can make a huge difference to the time overrun events accountable to the client because with the experience they will be able to forecast the risk of time overrun events accountable to the client more accurately.

The questionnaire results and the interviews with the experts agreed with the proposal of recruiting professionals with field experience on a contract basis for the planning phase of a bridge construction project. Another suggestion was to outsource the planning phase of the project from the government agency to a private firm. But the proposal has got neutral to disagree level votes where most of the respondents representing the client-side has not agreed to it. Yet, the interviews with key experts have indicated positive signs to the proposal where this study will only emphasise the importance of recruiting professionals with construction work-related experience for the project basis on the pre-contract awarding stage to properly assess the time overrun events accountable to the client.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Overall Summary

The study has been initiated with the primary purpose of identifying the time overrun events accountable to the client in bridge construction projects in Sri Lanka. The secondary purpose of the study was to propose a methodology to mitigate these events by forecasting and planning the project in the pre-contract awarding stage.

The study was started with literature reviews to examine the time overrun events in the construction industry. In this phase of the study, an investigation was commenced to understand the basics of the time overrun events in the bridge construction projects and their contractual background. After recognizing the procedures of analysing a time overrun event contractually, different assessment methods were found. Further, the literature survey allowed to scrutinize the causes of seventy (70) time overrun events in bridge construction projects.

By the assessment of the records of eighteen (18) bridge construction projects in Sri Lanka and discussions with the professionals, it has been found twenty-four (24) events which the accountability of those is on the client of the project. Then the questionnaire was prepared and sent to the different qualified professionals in the field to further filter the accountability of the events as well as to understand the dissimilar levels of accountability. In the analysis, nineteen (19) time overrun events accountable to the client has been found and from those, fourteen (14) of them has covered the sole accountability by the client and five (5) of them has covered a joined accountability. Then with further analysis through the interviews of the experts in the field, the study has ranked all the time overrun events according to the probability and impact. By doing so, it has been identified five (5) most critical time overrun events which the accountability relies on the client.

Another goal of the study has been to find out methods to mitigate those time overrun events before awarding the contract. Therefore, a set of mitigation measures was proposed with the initial questionnaire to check the respondents view on those. Through analysis,

several methods have been found out to mitigate the risk of the time overrun events and the selected methods were validated by the interviews with the experts in the field.

5.2 Conclusions

Time overrun events are a common scenario in the bridge construction industry in Sri Lanka. The study has identified seventy (70) causes for the time overrun events by literature review and case study of eighteen (18) bridge construction projects in Sri Lanka.

Once any of these time overrun events occurred, they will be analysed contractually by the engineer/consultant of the project. Accordingly, the initial assignment is commenced to examine the accountability of a time overrun event. This will be done by following the conditions of the contract of the project. Since the contract agreement is with the client and the contractor, one of the parties will be accountable for any time overrun event. After the initial assessment, the consultant will quantify the effect of the time overrun event in days. The critical path method is the most popular method to analyse the time overrun event where the event must generate a delay to a critical path activity. Ultimately one of the parties will have to compensate the other on account of the time overrun event. But there are some cases where both the parties will have to bear the losses due to a time overrun event in which this study separates those with the general. If either of the party does not agree to a particular determination of the consultant for a time overrun event, any of the parties can move to the next levels. The next level is the Dispute Board and then the arbitration. All of these levels have got its' own cost and that needs to be borne by the client or the contractor.

If the accountability of the particular time overrun is with the contractor, the burden of delay will have to be borne by the contractor. Not only that but also the contractor will have to pay the contractual Delay Damages to the client. But this study focus on the other side of the coin where the accountability of a time overrun event relies on the client of the bridge construction project. when the accountability of a time overrun event is determined and if the client holds the responsibility for it, the client would need to compensate for any loss incurred to the contractor. Also, the project will be granted an extension of time which

officially delay the date of completion of the project. This is a very serious issue in the bridge construction industry in Sri Lanka.

The study has identified the importance of recognizing the time overrun events accountable to the client of a bridge project. by studying eighteen (18) bridge projects' records, claim registers and discussions with the officials, it has been identified twenty-four (24) time overrun events accountable to the client. These time overrun events have been further filtered through questionnaire surveys and recognized the nineteen (19) key time overrun events accountable to the client.

Out of these nineteen (19) time overrun events, fourteen (14) of them which are the possession of the site, unclear scope (variation orders), land acquisition matters, delay in payments, utility shifting works, coordination delays with other agencies, delay in approvals, public matters & traffic management, political influence, poor soil investigations, new regulations and changes in economic conditions of government, estimation errors, terrorism, riots...etc., the ineffectiveness of client's representatives divided as the time overrun events which have the sole accountability on the client. That means the accountability of it will not be shared with other contractual parties and the client must bear any loss or compensations to the other party. There are five (5) other time overrun events that have combined accountability to them. That means the client and another contractual party will (in most cases it is the contractor) have to jointly bear the losses. These events are lack of coordination with main project parties, design changes, pandemic, conflict in specifications and other documents, adverse weather. When the causes of time overrun events are the above, both the client and the contractor has to bear the losses in accordance with the contract. Yet the case is different in design changes. If it is a Design and Build contract, the delays due to design changes have to be borne by the contractor. But if it is a Measure and Pay contract, the responsibility for designs are with the client and any delay due to a design change will have to be borne by the client. In this study, the time overrun event called design changes concludes as the time overrun event in which the sole accountability relies on the client to make the event move in line with the topic.

By the interviews with the experts and the results of the probability impact matrix, the nineteen (19) time overrun events ranked according to the criticality of those. The five (5) top-ranked items or the most critical time overrun events are possession of the site, unclear scope (variation orders), land acquisition matters, utility shifting, and design changes.

Most of the key time overrun events including, possession of the site, unclear scope (variation orders), land acquisition matters, delay in payments, utility shifting works, coordination delays with other agencies, delay in approvals, poor soil investigations, estimation errors, the ineffectiveness of client's representatives, lack of coordination with main project parties, design changes, conflict in specifications and other documents can be avoided or mitigated at the planning phase of a project. Since none of these is a construction-related event, they can be fairly forecasted and estimated the impact.

But for the forecasting of the risk and taking mitigating measures for those needs experienced personnel who had been involved not only in project management but also the construction. If the client can analyse and mitigate the events, it will be highly beneficial to the client in the long run even it takes time at the planning phase.

Due to the several restrictions such as sticking to a time frame, the difficulties of contacting the field experts and the intention to narrow down the scope, proposing a methodology that can be adopted to forecast and mitigate the risk of time overrun events has not been included in the research work. This is the only expected outcome that has been lagged during the study.

5.2.1 Summary of Key Findings on Time Overrun Events Accountable to the Client

- Seventy (70) causes of time overrun events in bridge construction projects has been found.
- Nineteen (19) causes of time overrun events has been identified as the client accountable time overrun events. The responsibility of these time overrun events is with the client of the bridge construction project.

- Fourteen (14) of the above nineteen causes are having sole accountability on the client. The responsibility of these time overrun events is with the client entirely. Those time overrun events are,

possession of the site, unclear scope (variation orders), land acquisition matters, delay in payments, utility shifting works, coordination delays with other agencies, delay in approvals, public matters & traffic management, political influence, poor soil investigations, new regulations and changes in economic conditions of government, estimation errors, terrorism, riots...etc., the ineffectiveness of client's representatives.

- Five (5) of the above nineteen causes are having joined accountability to the client. The responsibility of the time overrun events is in sharing basis with another party in the project. Those time overrun events are,

lack of coordination with main project parties, design changes, pandemic, conflict in specifications and other documents, adverse weather.

(In a Measure and Pay contract, the sole accountability of design changes are with the client, but the scenario is different in Design and Build contracts. In this study, the scenarios where the client who provides the design is only considered for the clarity of the results. Therefore, the design change is also categorized as a solely accountable item to the client in time overrun events.

- The most critical time overrun events that are accountable to the client in bridge construction projects are,
 - Possession of the site
 - Unclear scope (variation orders)
 - Land acquisition matters
 - Utility shifting
 - Design changes
- Thirteen (13) causes out of nineteen (19) key time overrun events (around 70%) including the five (5) most critical factors are not based on the construction phase

of the project. Therefore, those can be possibly mitigated during the planning phase of the project.

- The absence of experts with construction-related experience at the client-side is a considerable drawback for building a properly arranged planning phase of a project.
- The deficiency of the progress reviewing on mitigation measures taken for the identified risks of time overrun events during the planning stage of the contract is a major snag for the timely completion of a bridge project.
- The construction industry disagrees with the option of fully outsourcing the project planning work to a private organization as a solution to the repetitive nature of client-based time overrun events.

5.3 Recommendations

With the identification of the main causes of time overrun events accountable to the client of a bridge construction project, several recommendations can be made for mitigating the impact and even avoiding the occurrence of most of the time overrun events. These recommendations have been verified by the questionnaire surveys and further validated through the interviews with the selected experts in the field.

- Around 70% of time overrun events are not related to the construction phase of a bridge construction project. In other words, these time overrun events is related to the pre-contract awarding stage in a project life cycle. Therefore, the events including the critical events identified can be avoided and mitigated through a proper, well-structured planning phase of the project.
- Forecasting and estimating the probability and impact of possible time overrun events in the planning phase of the projects are highly beneficial to the client as well as the project itself. Therefore, investing more time and money in planning works will be a long term advantage for the client.
- Even though government organizations are enriched with the expertise of contract administration and contract management, it has been found that the lack of

expertise in construction technology can adversely affect the success of a planning phase of a bridge construction project. Therefore, recruiting the expertise of construction technology for the planning phase of a project on a contract basis will be highly valuable to form a balanced planning team for the client that will ultimately allow a comprehensive assessment of the client's risk on time overrun events.

- Allocating an appropriate time frame to mitigate the forecasted time overrun events and a total review of the progress of the planning phase prior to the procuring work of the contract will largely reduce the overall risk of time overrun events in the contract period.

5.4 Recommendations for Future Research

Future research studies can be focused on several areas mentioned below which will be highly beneficial to the bridge construction industry in Sri Lanka.

- A methodology to forecast the probability and impact of the possible time overrun events accountable to the client in the planning phase of a project.
- A process including a time frame to follow before awarding the contract to properly review the actions taken to mitigate the risk of time overrun events in the planning stage.
- A study on delay events accountable to the client in bridge construction projects concerning the impact on the cost factor of the project.

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APPENDIXES

Appendix 1: Questionnaire Survey No.01

Appendix 2: Questionnaire Survey No.02

Appendix 01 – Questionnaire Survey No.01

Time Overrun Events Accountable to the Client in Bridge Construction Projects, Sri Lanka

Dear Sir/Madam/Colleagues,

Request for obtaining information for the thesis on “Time Overrun Events Accountable to the Client in Bridge Construction Projects, Sri Lanka”

I'm a postgraduate student of the Department of Civil Engineering, University of Moratuwa following a M.Sc. in Construction Project Management. As a part of the degree course, I'm conducting a research on the topic of “Time Overrun Events Accountable to the Client in Bridge Construction Projects, Sri Lanka”

For the research work, I have developed a questionnaire which will be an integral part of the study. Accordingly, I invite you to participate in this research survey by completing the following questionnaire referring to your experience in the Sri Lankan Construction industry. When you have completed the questionnaire, please return it to me by clicking the “ Submit” button at the end of it.

Further, I would like to thank you for dedicating your valuable time to fill this questionnaire. The information which will be provided by you is highly valuable since it will enhance the quality of my research work. All the information gathered from this questionnaire will be kept strictly confidential and this research is intended for educational purposes only, and not for any commercial or other purposes.

*Required

1. Your email

Respondent's Information

2. Currently which party your organization is representing? *

Mark only one oval.

- ☐ Client / Employer
- ☐ Consultant / Engineer
- ☐ Contractor
- ☐ Other: _____

3. Your highest educational & professional qualifications *

Mark only one oval.

- ☐ Chartered + M.Sc./PG.Dip.
- ☐ Chartered
- ☐ M.Sc./PG.Dip.
- ☐ B.Sc.
- ☐ Diploma
- ☐ Other: _____

4. Please choose your current position in the organization *

Mark only one oval.

- ☐ Chief executive Officer / Director
- ☐ Contract / Procurement / Claim Specialist
- ☐ Project Manager / Resident Engineer
- ☐ Chief Engineer / Senior Engineer
- ☐ Project Engineer / Site Engineer
- ☐ Quantity Surveyor
- ☐ Other: _____

5. How many years of total experience do you have in the construction industry *

Mark only one oval.

- ☐ 0 - 5 years
☐ 5 - 10 years
☐ 10 - 15 years
☐ 15 - 20 years
☐ More than 20 years

6. Please state your working experience related to bridge construction / elevated highway projects *

Mark only one oval.

- ☐ 0 - 5 years
☐ 5 - 10 years
☐ 10 - 15 years
☐ 15 - 20 years
☐ More than 20 years

7. Value of executed bridge construction / elevated highway projects *

Mark only one oval.

- ☐ High scale - Above Rs. 5000 million projects
☐ Medium scale - Rs. 1000 - 5000 million projects
☐ Low Scale - Below Rs. 1000 million projects
☐ Combination of High, Medium, Low scale projects

Topic Based
Discussion

Time overrun events - The delay events in bridge construction projects
Accountable to the client - The responsibility of the time overrun event relies on the Client/Employer

8. According to your experience, which party holds the highest liability (accountability) for overall time overrun events of a bridge construction project? (please rank 'highest liability' as 1 and 'lowest liability' as 4, according to the priority) *

Mark only one oval per row.

	Employer/Client	Engineer/Consultant	Contractor	Any other party
Rank 1	☐	☐	☐	☐
Rank 2	☐	☐	☐	☐
Rank 3	☐	☐	☐	☐
Rank 4	☐	☐	☐	☐

9. which of these time overruns initiated by Client/Employer (responsible) in bridge construction projects? *

Mark only one oval per row.

	by Client/Employer	Combination of Client & any other parties	Any other party
Possession of site	☐	☐	☐
Land acquisition matters	☐	☐	☐
Utility shifting works	☐	☐	☐
Estimation errors	☐	☐	☐
Unclear scope (Variation Orders)	☐	☐	☐
Delay in payments	☐	☐	☐
Conflict in specifications and other documents	☐	☐	☐
New regulations and change in economic conditions of government	☐	☐	☐
Design changes	☐	☐	☐
Shortage of labour & materials	☐	☐	☐
Poor soil investigations	☐	☐	☐
Delay in approvals	☐	☐	☐
Coordination delays with other agencies	☐	☐	☐
Conflict in quality control or quality assurance processes	☐	☐	☐
Natural disaster	☐	☐	☐
Terrorism, riots...etc.	☐	☐	☐
Pandemic	☐	☐	☐

Lack of coordination with main project parties	☐	☐	☐
Public matters & traffic management	☐	☐	☐
Political influence	☐	☐	☐
Incompetency of Consultant/Engineer	☐	☐	☐
Unforeseen site conditions	☐	☐	☐
Adverse weather	☐	☐	☐
Ineffectiveness of client's representatives	☐	☐	☐

10. Please mention any other time overrun event that you have come across which has the responsibility of it relies on the Client of a project

11. Most of the client-initiated time overrun events can be settled before awarding the Contracts rather than after *

Mark only one oval.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

12. Before awarding the project, lack of project planning by the client is the main cause for the time overrun events accountable to the client in bridge construction projects *

Mark only one oval.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

13. The project procurement process and selection of the Contractor has a direct influence on the origin of the client-based time overrun events *

Mark only one oval.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

14. Time overrun events accountable to the client has the biggest impact concerning all the time overruns for a particular bridge project *

Mark only one oval.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree

Topic Based Opinions

15. Most of the client-accountable time overrun events can be forecasted and estimated before awarding the project *

Mark only one oval.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree
- ☐ Other: _____

16. According to your experience, which percentage of time overrun events accountable to the client can be identified and solved before awarding the project *

Mark only one oval.

- ☐ 0 - 25 %
- ☐ 25 - 50 %
- ☐ 50 - 75 %
- ☐ 75 - 90 %
- ☐ Other: _____

17. Recruiting an experienced staff to the Client in the project planning stage (before awarding the Contract) can mitigate the risk of Client-based time overrun events in a project *

Mark only one oval.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

18. Investing more by the client in assessing the risk of time overrun events and mitigating those in the pre-contract awarding stage (before awarding the project) would be highly beneficial to the Client as well as the project *

Mark only one oval.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

19. In almost all bridge construction projects, the Client/Employer role holds by a government body. In this case, nominating a private firm to represent the Client will be a better solution for the higher number of time overrun events accountable to the client *

Mark only one oval.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

20. Any other suggestions on mitigating the repetitive number of time overrun events accountable to the client

Thank you for dedicating your valuable time to complete this questionnaire. If you have any queries, Please do not hesitate to contact me. (N.W.H. Lakshamana - hansaka8888@gmail.com)

Please click the "Submit" button.

Appendix 02 – Questions for the Interview of Key Experts

Probability and Impact of Time Overrun Events Accountable to the Client in Bridge Construction Projects, Sri Lanka

This is a secondary survey to understand the probability & impact of client-initiated time overruns in bridge construction projects, Sri Lanka.

PROBABILITY - Frequency of the event that can occur in a particular bridge/elevated highway project

IMPACT - Effect of the event concerning TIME factor for the client/Employer of the project

1. Please rank the PROBABILITY of the occurrence of each time overrun event in a bridge / elevated highway project

	High	Medium	Low
Possession of site	☐	☐	☐
Unclear scope (Variation Orders)	☐	☐	☐
Land acquisition matters	☐	☐	☐
Delay in payments	☐	☐	☐
Utility shifting works	☐	☐	☐
Coordination delays with other agencies	☐	☐	☐
Delay in approvals	☐	☐	☐
Public matters & traffic management	☐	☐	☐
Political influence	☐	☐	☐
Poor soil investigations	☐	☐	☐
New regulations and changes in economic conditions of government	☐	☐	☐
Lack of coordination with the main project parties	☐	☐	☐
Estimation errors	☐	☐	☐
Design changes	☐	☐	☐
Terrorism, riots...etc.	☐	☐	☐
Incompetency of Consultant/Engineer	☐	☐	☐
Conflict in specifications and other documents	☐	☐	☐
Ineffectiveness of client's representatives	☐	☐	☐
Adverse weather	☐	☐	☐

2. Please rank the IMPACT of the time overrun events concerning the TIME factor in a bridge / elevated highway project

	High	Medium	Low
Possession of site	☐	☐	☐
Unclear scope (Variation Orders)	☐	☐	☐
Land acquisition matters	☐	☐	☐
Delay in payments	☐	☐	☐
Utility shifting works	☐	☐	☐
Coordination delays with other agencies	☐	☐	☐
Delay in approvals	☐	☐	☐
Public matters & traffic management	☐	☐	☐
Political influence	☐	☐	☐
Poor soil investigations	☐	☐	☐
New regulations and change in economic conditions of government	☐	☐	☐
Lack of coordination with main project parties	☐	☐	☐
Estimation errors	☐	☐	☐
Design changes	☐	☐	☐
Terrorism, riots...etc.	☐	☐	☐
Incompetency of Consultant/Engineer	☐	☐	☐
Conflict in specifications and other documents	☐	☐	☐
Ineffectiveness of client's representatives	☐	☐	☐
Adverse weather	☐	☐	☐

3. The risk of below listed time overrun events can be forecasted and avoided / mitigated by the Client at the planning stage (before commencing the civil work) of a particular project. Please select your view on each event.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Possession of site	☐	☐	☐	☐	☐
Unclear scope (Variation Orders)	☐	☐	☐	☐	☐
Land acquisition matters	☐	☐	☐	☐	☐
Delay in payments	☐	☐	☐	☐	☐
Utility shifting works	☐	☐	☐	☐	☐
Coordination delays with other agencies	☐	☐	☐	☐	☐
Delay in approvals	☐	☐	☐	☐	☐
Public matters & traffic management	☐	☐	☐	☐	☐
Political influence	☐	☐	☐	☐	☐
Poor soil investigations	☐	☐	☐	☐	☐
New regulations and changes in economic conditions of government	☐	☐	☐	☐	☐
Lack of coordination with main project parties	☐	☐	☐	☐	☐
Estimation errors	☐	☐	☐	☐	☐
Design changes	☐	☐	☐	☐	☐
Terrorism, riots...etc.	☐	☐	☐	☐	☐
Incompetency of Consultant/Engineer	☐	☐	☐	☐	☐
Conflict in specifications and other	☐	☐	☐	☐	☐

4. what are the mitigation measures that can be taken for the risk of time overrun events accountable to the client in bridge construction projects?

5. What are the reasons of the repetitive nature of client accountable time overruns in bridge projects?

6. Your email
