COST OVERRUNS IN FORING FUNDED HIGHWAY PROJECTS IN SRI LANKA

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08 / 8841 – H

Master of Engineering in Highway & Traffic Engineering

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Thesis / Dissertation submitted in partial fulfillment of the requirements for the degree
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Declaration of the Candidate

I hereby affirm that this dissertation report is an outcome of my own effort for the best of my knowledge and it contains my own work done for the fulfillment of requirement for the higher Degree of Master of Engineering in Highway and Traffic Engineering. It does not include any written material previously submitted for the award of any preliminary degree, higher degree or diploma of a university or any other institution of higher education, or published by any other person or institution except where acknowledgment and references are made in the text.

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February 2011

Declaration of the Supervisor

I certify that the above statement is correct.

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Prof.J.M.S.J.Bandara

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Department of Civil Engineering

February 2011

Dedication

This dissertation report is dedicated to my loving wife & daughter who always backed me up to fulfill my academics.

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Abstract

When an infrastructure development project is planned, an accurate estimation is critical. As a result of failing the fulfillment of expected accuracy, the cost overrun of the projects would result. The cost overrun is defined as a difference between the initial project estimate at the planning stage and the accounted project cost at the time of project completion. However, cost overrun is one of the major negative consequences that may influence to the economy of a developing country, like Sri Lanka. In order to fill the aforesaid financial gap, the necessity of pumping additional funds through the consolidated fund by the GOSL would be arisen.

Out of the significant impacts of which caused by cost overruns in foreign funded projects are delay in completion and curtailment of original scope of work. But both adverse impacts are restricted by the conditions and policies of funding agencies. It is the normal practice that influencing to complete the project up to the agreed scope under the specified standards by the funding agencies. Due to the fact that the highway projects would make greater impacts not only to the development of infrastructure but also to the higher cost overruns, it was decided to limit the analysis only for the highway projects.

The overlooked main factors that cause to turn the project into track of the cost overrun path are;

- Increase quantities
- Price Changes

However, there can have many factors that have supported above mentioned main factors. The objective of this research is to

- To study what is cost overrun?
- To identify factors behind cost overruns in Sri Lankan projects
- To identify main risk factors & risk management

The research would address the gap of knowledge of why highway projects overrun their cost. In addition to that, a method for minimizing cost overruns or identify cost overruns in advance will be proposed.

In this research, twenty numbers of cost overrun highway projects completed within resent years and funded by different agencies were collected and analyzed.

What are the main causes for cost overrun, how is a BoQ item correlate to each other item and what is relationship of cost overruns with project period or delay will be studied.

Key Words: Highway construction, project budgeting, inflation,

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List of Abbreviations

AACE	-	Association for Advancement of Cost Engineering
ADB	-	Asian Development Bank
ASCE	-	American Society of Civil Engineers
BoQ	-	Bill of Quantity
BOOT	-	Build Own Operate Transfer
CE	-	Chief Engineer
CEA	-	Central Environmental authority
CEB	-	Ceylon Electricity Board
CM	-	Construction Management
CPD	-	Continuing Professional Development
CQS	-	Chief Quantity Surveyor
DB	-	Design Build
DBB	-	Design Bid Build
DBOM	-	Design Build Operate Maintain
DBFO	-	Design Build Finance Operate
DD	-	Deputy Director
EDCF	-	Economic Development Cooperation Fund
FIDIC	-	International Federation of Consulting Engineers
GOSL	-	Government of Sri Lanka
ICB	-	International Competitive Bidding
ICTAD	-	Institute of Construction Training and Development
LCB	-	Local Competitive Bidding
MFAP	-	Miscellaneous Foreign Aided Projects
MOHRD	-	Ministry of Highways & Road Development

NHSP	-	National Highways Sector Projects
NRMP	-	National Roads Master Plan
NWS&DB	-	National Water Supply & Drainage Board
PCA	-	Principal Component Analysis
PD	-	Project Director
PMBOK	-	Project Management Book of Knowledge
QS	-	Quantity Surveyor
RCC	-	Reinforced Cement Concrete
RDA	-	Road Development Authority
RDC	-	Recourses Development Consultants
RRM	-	Random Rubble Masonry
SLR	-	Sri Lankan Rupees
SLT	-	Sri Lanka Telecom
STDP	-	Southern Transport Development Project
SWK	-	Scott Wilson & Kirictpatric (Consultancy Firm)
TDCA	–	Transport Data Collection & Analysis

CHAPTER 01
INTRODUCTION

1.1 History & Background

Infrastructure development is one of the prime requirements that urges for a country. Out of the main features of infrastructures that are very much essential for economic development of a country, is highway improvement.

Garry D. Creedy reported that the key weapon in this economic development is infrastructure development. Transport and telecommunication infrastructure plays a central role in nothing less than the creation of what many see as a new world order where people, information, goods, energy and money move about with unprecedented ease. Thus, the past decade has seen a virtual explosion in infrastructure building.

Annexure 3-A & 3-B has revealed that not only in other parts of the country but in Sri Lanka, a significant amount of money spent for infrastructure development. However, it questionable that expected goal is achieved through the investment due to the inability of completion with planned amount of money (Original BoQ), within the due project period. The above Annexure further clarifies it.

But, due to the fact that highway development claims high costs, a developing country cannot afford the investment requirement by their own. In addition to the financial incapacity, the lack of technical capability (knowledge, human & machinery resources) will arise then. As a result of that, the developing country has to borrow funds from funding agencies. However, when the costs are overrun and funds are borrowing from funding agencies, then the question of finding additional funds would arises. If additional funds are provided through a supplementary loan or as a grant then the problem would be considered as partially settled. Otherwise, the additional funds have to be pumped through the owned country after curtailing prescheduled plans. In addition to that, when the foreign currency has been fixed in an ICB projects, the additional money has to be spent for recovering of foreign currency equivalent.

Also Garry D. Creedy had reported the delivery of projects is performed using mainly traditional processes that have evolved from history and the industrial revolution, where specialization of professional organizations was the key trend (Pakkala, 2002). The traditional method consists of feasibility / preliminary design, construction and operation phases. (Fig. 1.1)

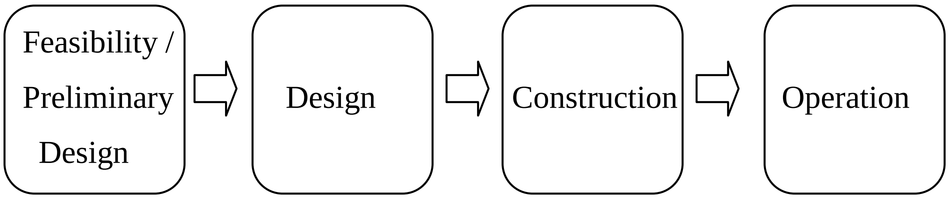

Figure 1.1: Traditional Project Development Phases

The traditional procurement process is inefficient and claims significant time to complete. Further, Garry D. Creedy had reported that although lack of cost control in all of the project development phases can contribute to cost control problems of particular interest is the time the client makes the decision to build (Hester et al., 1991). Accurate budget estimates are critical to the initial decision – to- build process for the construction of capital projects (Ward, 1999). For infrastructure projects, cost estimates are prepared first to have reliable decisions regarding economic feasibility and justification.

Although significant number of activities and the huge amount of money are being spent on infrastructure development, the systematic knowledge about the costs, benefits and risks involved is not in a satisfied level. Existing studies of costs, benefits and uncertainties in transport infrastructure development are few. On the other hand, such studies are too small or uneven single-case studies and they do not represent a sample of infrastructure project, which is common for most cases to allow systematic, statistical analyses. According to the Garry D. Creedy, examples of such studies are Hall (1980), Fouracreet al. (1990), Kain (1990), Pickrell (1990), Walmsley and Pickett (1992), Szyliowicz and Goetz (1995), Skamris and Flyvbjerg (1997), Bruzeliuset al. (1998), Nijkamp and Ubbels (1999) and Richmond (2001). However, accurate estimates are critical to the initial decision – to – build process for the construction of capital projects (Flyvbjerg et al., 2002).

If an accurate estimate is unable to prepare at design stage, the cost overruns of the project must be expected. When an inaccurate original estimate is prepared for a project and is used to compare the actual cost of the project, then there can be a noticeable difference, referred to as a cost change (Flyvbjerg et al., 2002). But highway construction projects are notorious for running over budgets (Hester et al., 1991).

When the highway project overrunning their costs, then expected cost benefit cannot be achieved and hence, projects may fallen into under benefitted category.

1.2 Problem Definition

Although the large number of activities and the enormous sums of money is being spent on infrastructure, a very little systematic knowledge exists about the costs, benefits and risks involved. No researcher has previously given their attention on these aspects in a comprehensive manner. Therefore, this research addresses the factors of cost overrun and suitable solutions for minimizing the same for road projects.

1.3 Objective

The objectives of the research are;

- To undertake the analysis of previous project cost overrun factors and find correlation of them with project parameters.
- To propose realistic allowances for future estimates, leads to accurate client budgets through the identified cost overrun factors.

1.4 Scope Limitation & Assumptions

Even though cost overrun is not exclusive for highway construction projects, this research has been limited only for highway construction projects. On the other hand, all the highway projects are not depend on foreign funds, but funded by domestic treasures. But this study is restricted to foreign funds investments in Sri Lanka.

Cost growth, cost changes and cost overruns are considered as the same meaning for the purpose of this research, and they can be defined as the difference between the final project cost and the cost estimate at the time of the decision – to – build after design for a particular project.

The total project cost estimate for the client includes the estimated costs of all components from the initiation of the project proposal to finalization, In this regards, all the construction costs, definitely paid through the foreign fund are included. But the costs incurred for other items, listed below may pay either through foreign fund or domestic fund, depend on loan conditions; have not been included for cost estimates.

- Procurements of designs & tender documents
- Conducting investigations & surveying for the supporting of designs
- ROW clearance
- Relocation of utility services
- Project supervision & administration
- All the taxes directly paid to the government

1.5 Thesis Organization

The thesis consists of following five chapters.

Chapter 1 : ***Introduction***

Depicts the introduction of the report highlighting the history and background, Problem definition, Objectives, Scope limitations and Thesis organization of the report.

Chapter 2 : ***Literature Review***

Contains the literature review from journals, books and internet search on the cost estimating, cost control processes, risk management and cost overruns.

Chapter 3 : ***Research Methodology***

Methodology of the research and mechanism of data collection are described. Analysis of historical data of completed projects having break down data and no break down data.

Chapter 4 : ***Analysis of Data***

Presents the data analysis based on the described methodology. Analysis of Twenty One numbers of completed projects having break down data and thirteen numbers of completed projects having no break down data.

Chapter 5 : ***Conclusion & Recommendations***

Contains conclusion and recommendation.

CHAPTER 02
LITERATURE REVIEW

2.1 Introduction

Garry D. Creedy has reported that the change in project cost or cost growth occurs as a result of many related factors all of which are associated with some form of risk (Flyvbjerg et al., 2003). This literature review focus on various project delivery mechanisms used in project construction and the influence that they have on minimizing and managing project uncertainty, particularly for client. In order to achieve this target, the project cost estimating and procedures that are used in minimizing client risk for reducing project cost overrun is required. This also is being mainly reviewed.

2.2 Definitions

There are various definitions for some frequently used terms spread throughout this thesis are as follows.

2.2.1 Project

According to the Garry D. Creedy , in 1969, Steiner defined project as;
An organization of people dedicated to a specific purpose or object.

Subsequently, the definition of the same has clarified further and the Project Management Institute (Project Management Institute, 2002:21) defines a project as;
A temporary Endeavour undertaken to create a unique product or service: 'Temporary' meaning that every project has a definite end: 'Unique' meaning that the product or service is different in some distinguishing way from all similar products or services.

The projects involve unique or high risk objectives that have to be completed within a certain period of time, certain amount of money while delivering some expected performance.

2.2.2 Project Management

Project Management Institute (Project Management Institute, 2002:22) defines a project management as;

Application of knowledge, skills, tools and techniques to the project activities in order to meet or exceed stakeholder needs and expectations from a project is known as project management.

Hence, project management involves balancing of competing demands of;

- Scope, time, cost and quality
- Stakeholders with differing needs and expectations
- Identified requirements (needs) and unidentified requirements (expectations)

2.2.3 Project Stakeholders

In project development, the project client is the most significant character who plays a vital role.
The person or an organization investing in the construction of built facilities (Mark and Picken, 2000) *is known as project client.*

Project Management Institute (Project Management Institute, 2000) defines a project stakeholder as;

The individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected to the project execution or successful project completion are project stakeholders.

2.2.4 Project Risk

As per the Dake (1992) reported by Garry D. Creedy, before the several centuries, *Risk was defined as the probability of an event occurring, with a focus on either the losses or gains that the event would represent if it occurs.* The interesting part of the early definitions is they had paid much attention to the benefits or losses. Statman and Tyebjee (1984) had recognized risk as being a high probability of failure.

Jaafari (1990) sees risk as being the *presence of potential or actual constraints that could stand in the way of project performance by causing partial or complete failure during construction and commissioning, or at the time of using the project.*

Garry D. Creedy reported that risk has been defined by Chapman and Ward (1997: 58) as being; *the exposure to the possibility of an economic and financial losses or gains, physical damage or injury, or delay as a consequence of uncertainty.*

Young (1996) sees risk in the project management environment as being *any event that could prevent the project relisting the expectations of the stakeholders as stated in the agreed project brief or agreed definition.*

Garry D. Creedy reported that, Adameitz (2003:43) described various aspects of risk as;
Risk can be viewed as a four letter word. There can be economic boundaries from the addition of extra 'overhead' activities, and political / cultural boundaries from an unwillingness to acknowledge that a risk exists and must be mitigated. To prevent this budget pressure, risk management and mitigation activities need to be factored into the project plans from the very beginning of a project. Construction projects involve numerous unpredictable and complex processes.

2.2.5 Risk Management

Risk management is the process by which client and project managers make decisions based on data collected in risk assessment. According to the Project Management Book of Knowledge – PMBOK (Project Management Institute, 2000), risk management is 'processes concerned with identifying, analyzing and responding to uncertainty throughout the project's lifecycle. It includes maximizing the results of positive events and minimizing the consequences of adverse events.

The Australian / New Zealand Standard 4360:1999 sees risk management as a generic framework for establishing the context, identification, analysis, evaluation, treatment, monitoring and communication of risk.

Royer (2000) sees risk management as:

- Deciding what is an acceptable risk
- How the level of the risk can be brought down to a level that is acceptable
- Monitoring the reduction in risk after exposure control actions has been taken.

Strategies for mitigating risks on projects include (Turner, 1999; OGC, 2002);

- Reducing the uncertainty associated with the project

- Avoid the risk by finding a different way of doing the project
- Abandoning the project
- Reducing the likelihood of the risk occurring or impact on the project
- Transferring the risk to other parties such as contractors or insurance companies
- Accepting the risk and creating a contingency plan

As per Garry D. Creedy, risk management is also dependent on numerous factors such as industry sector, size of the project and the stage of the project life cycle (Baker et al., 1999).

Dey (2001) has identified the following as general benefits that can be achieved from the application of risk management in any type of project;

- Issues of the project are clarified and allowed for right from the start
- Decisions are supported by thorough analysis of available data
- Structure and definition of the project are continually and objectively monitored
- Contingency planning allows controlled and pre-evaluated responses to risks that materialize
- Clearer definitions of the specific risk associated with a project
- Encourages problem solving innovative solutions to problems within a project
- Provides a basis for project organization structure and appropriate responsibility matrices
- Builds up a statistical profile of historical risk for modeling future projects

2.2.6 Nature of Risk

Garry D. Creedy reported that, as per Del Cano and Del la Cruz; 2002, the term of Risk is not consistently applied across construction, project management, engineering, health and safety, environment, business and other industries.

Rutgers and Haley (1997) identified four distinct phases of risk in a project;

- *Development risks* – technical, commercial / financial feasibility
- Project economics, permits / authorization, third party intervention and political changes
- *Construction risks* – schedule, cost, performance, design changes, interest rates & escalation, consequential damage, force majeure/ country risk & currency changes

- Operational risks – market changes, statutory changes, unrest/ strikes, acts of God, third party liability etc.

2.2.7 Risk Control Processes

As we are understood, the essential part of the construction project manager is the control of projects and hence the control of risks. Risk monitoring is required to respond to the events occur over the period of a project. According to 'Del Cano and Del la Cruz; 2002'; risk control can be achieved through the updating of risk management plans with new information, identifying alternatives to unplanned risk events and by mitigating unplanned risks. Most of the risk analysis has centered on analyzing the duration of projects.

2.3 Risk Engineering

Garry D. Creedy reported the risk is defined by Kumamoto and Henley (1996) as thought of in terms of the possibility of suffering harm, typically resulting in negative consequences. The aim of project management is maximize the results of positive events and minimize the consequences of negative events (Project Management Institute, 2000). Thus, in the project management context, risk should be thought of opportunities as well as threats or negative consequences. According to Association for the Advancement of Cost Engineering (AACE, 2000), risk engineering is negative risk having consequences that adversely affect a project cost.

But Cooper et al. (1985) suggests a 'risk engineering' approach as systematic risk evaluation could be performed by subdividing a project into its major elements and analyzing the risk and uncertainty associated with each detail.

2.4 Risk Assessments

Risk assessments can be carried out in two different ways known as Qualitative and Quantitative measures.

As per Del Cano and de la Cruz, 2002; quantitative analysis relies on statistical methods and it is depend on quality of data. As well as each project is unique and the certain uncertainty exists when past projects data is applied to current projects.

Construction simulation, fault tree analysis, fuzzy stochastic applications, risk premium and expected net present value are some of quantitative risk assessment techniques that are used (Garry D. Creedy, 2006).

Some researches have been done on the meaning of probability analysis. Out of these, Schafer (1976) has defined two types of probabilities as;

- Aleatoric probability – relates to a outcome of the uncertain situation
- Epistemic probability – relates to a measure in belief in a proposition

However, in risk assessment, probability theory is used to represent engineering uncertainties. The uncertainty is a concept it refers to events that occur with periodic frequency, such as demands on equipments & resources, as well as unknown conditions, such as poor ground foundations (Mak and Picken, 2000).

On the other hand, probability is a precise concept having a mathematical background with an explicit definition. The mathematical probability theory is used to represent uncertainties, despite the fact that such uncertainties take many forms.

Hertz (1964) derived probability values for different cost elements of an estimate to reduce uncertainty. With this method, it is possible to quantify the range of a cost estimate.

2.5 Project Risk Management

Project construction risk can have physical or capability related aspects (Zack, 1997). Physical risks are events that prevent completing the project or increase the costs and schedule by means of acts of Gods, weather, impracticability or other factors that are beyond the control of project team. Capability related risks interfere with performing the work but management has a choice in minimizing the risk such as poor quality, safety and equipment selection. Project Management Institute (2000) classified risks as:

- External (Uncontrollable)
- Internal (Controllable)

Project size can be a major cause of risk, and also other factors are:

- Complexity of project
- Speed of construction

- Project location
- Degree of project unfamiliarity

Some of most common and potential risk sources in construction industry have been listed out by Edwards (1995), Smith & Bohn (1999) and Kim & Bajaja (2000) as follows.

Table 2.5 : Sources of Common construction project risks

Risk Source	Description of Risk Source
Cost	*Estimate is uncertain because it is based on past and projected costs*
Schedule	*Estimate is uncertain because it is based on past and predicted performance*
Labour	*Labour strength and productivity uncertainties*
Project Management	*Uncertain experience levels, team cohesiveness and composition*
Safety	*Potential for accidents and consequences of injuries or higher costs*
Change Orders	*Potential increased costs, schedule delay and poor technical performance*
Unforeseen conditions	*Undefined underground or hidden site conditions that can cause cost and schedule growth*
Environmental concern	*Regulatory approvals and mitigation of environmental concerns may cause time delay or cost escalation*
Inflation	*Potential for material and labour price increase*
Weather	*Delay causing costs and technical non-performance from adverse weather*
Construction complexity	*Level of difficulty increases the potential for cost and schedule growth*
Fire	*Probability of fire hazard from work operations, vandalism or lighting*
Supplies	*Non-performance from vendors, sub contractors or suppliers that can cause impacts to cost and schedule*
Property loss	*Potential for loss due to flood, fire, theft, sabotage or vandalism*
Design	*Incomplete or lack of design elements that considers construction aspects*
Quality	*Potential for consequence of poor quality and technical non performance*
Political	*Potential loss of support leading to less opportunity to acquire new projects*

Out of these sources of project risks, one of the most common and main source of construction risk is site condition risk. It is included followings and of both has not been properly identified at the time of making decision to build the project.

- Delay of removing physical obstructions (Eg. Utility services)
- Unforeseen or unexpected site /ground conditions

The final repercussion from both cases is delay of work and increased cost.

2.6 Risk Distribution in Project Procurement

A most important aspect of risk either for client or contractor is; 'Who is liable for the particular risk? , Who & how has the motivation to avoid or vitiate the risk? (Curtis et al., 1991). Therefore, the prime function of any contract is to identify, assess and allocate risk (NEDO, 1982).

Wang and Chou (2003) assert that risk management needs to be made more efficient and effective so all parties can understand:

- Their respective responsibilities
- Risk event conditions
- Risk performances
- Risk management capabilities

Generally, client expects that contractors bear or should bear certain part of risk, though some clients considers this should reach to extreme and contractor bound to bear essentially all through some contract condition mechanisms. As per Garry D.Creedy, 2006, a factor that tends to defeat the efficient allocation of risk in construction contracts is that project owners may have more powers at the project formulation stage than the contractors. This power can be derived from a number of sources, such as:

- The competitive bidding process with reasonable time pressure and often involving a large number of bidders
- In – house risk management and legal expertise which greatly exceeds that of the contractor

- A general reluctance by some contractors to price adequately for the risks that they are being required to be accept

Construction contracts are the written agreements signed by contracting parties which bind them and also define relationships and obligations. In any particular contract, the project owner's goals can best be achieved by selecting the contract type that will most effectively motivate the contractor to the desired end and is also dependent on completeness of information for the bidders at tender time and the extent the owner wishes to take specific risk (Zaghloul and Hartman, 2003).

The contract terms define how such risk is distributed between the owner and the contractor. Liabilities and responsibilities of each contracting party are allocated through the condition of contract. Risk allocation in procurement methods is a critical issue in the selection of construction contracts. Different project procurement types offer different compensations to the contractors to bear cost, delivery time and performance of contracts.

2.7 Delivery processes for projects

Delivery methods for capital construction projects are mainly traditional processes that have evolved from history and the industrial revolution, where specialization of professional organizations was the key trend (Pakkala, 2002). As per him, there is some procurement types used in construction industry.

2.7.1 Design –Bid – Build (DBB- Traditional Method)

The Owner / Client procures the service of a design consultant to develop the scope of a project and complete design documents which are then considered as legal documents for use in selecting a contractor who builds in accordance to the specifications developed by the design team. The owner maintains most of the risk. Operation and maintenance after the completion and also responsibility for financial needs are with the owner.

2.7.2 Design – Build (DB)

The Owner / Client select an organization to completed both design and construction under one agreement. The responsibility for financial needs is still with the owner.

2.7.3 Design – Build –Operate -Maintain (DBOM)

Design, construction, maintenance and operation up on an agreed period are to be done under one agreement. The responsibility for operation and maintenance after the completion of contract, unless the operations are continued under a separate contract is with the owner.

2.7.4 Design – Build –Finance - Operate (DBFO)

This is similar to the DBOM method, except contractor is responsible for financing the project. The contractor is assumed the risks of financing until the end of the contract period. The owner is then responsible for operation and maintenance of the asset.

2.7.5 Build – Own – Operate -Transfer (BOOT)

The project delivery method similar to the DBFO, except there is an actual transfer of ownership. The contractor is responsible for the design, construction, maintenance, operation and financing the project. The contractor is assumed the risks of financing until the end of the contract period. Subsequently, the owner is responsible for the operations and maintenance of the asset.

2.7.6 Construction Management (CM- At Free Agency)

This process is similar to the DDB. However, the construction management organization takes on the responsibility for the administration and management, the constructability issues, day-to-day activities and also assumes an advisory role to the client.

2.7.7 Construction Management at Risk Advisor (CM- At Risk)

In this context, owner has one agreement with the construction manager, who then manages the contracts with the design consultants and the general contractor. The owner maintains most of the risks and he is responsible for operation and maintenance, as well as financial aspects.

2.8 Improving Project Delivery Methods for Risk

There are many literatures which have been discussed possible options for improving contracting methods and better risk allocation processes. Some of literatures have studied new ways, such as: partnerships, risk sharing / reward systems and incentive based contracts etc. The current trend of industry-wide acknowledgement is existing procurement practices are inefficient and there are many inequities, and it compromises the outcome.

Zaghloul and Hartmen (2003) suggest a trust relationship through:

- A clear understanding of the risks being borne by each party and who owns or who can manage the risk
- More time and effort in the front end of a project and sufficient expertise to manage or mitigate the risks and administer the contract\
- A negotiation phase prior to the start of the contract, this is required to build a trust relationship between the contracting parties (this negotiation phase is a part of the contract itself.)
- An adequate risk- sharing or risk- reward system should exist to share the benefits if the risk does not occur during the project life cycle.

However, highway administrators and other public organizations seek a better project delivery system. Some authorities are using or evaluating alternative models such as DB, DBOM and BOO. In 2002, Pakkala suggested innovative project delivery methods and main advantages of these delivery methods are:

- Produce projects that have better quality
- Cost saving to the client
- Transfer risk to a organization which can manage the risk better
- Faster project completion

2.9 Factors Influencing Costs

The literature review shows that there is variety of factors influencing the construction costs. Garry D. Creedy has reported that as per Yeo, 1990 and Minato & Ashley, 1998, cost overrun arises preliminary because of four main factors:

- External risk due to
    - Modifications in the scope of a project
    - Changes in the legal, economic and technologic environments
- Technical complexity of the project due to
    - Size

  - Duration
  - Technical difficulty
- Inadequate project management due to
  - The control of internal recourse
  - Poor labour relations
  - Low productivity
- Unrealistic estimates because of the uncertainties involved

The project scope defines the work to be performed in a project and so that the project cost estimation is completely depends on this scope description. Incomplete scope definition leads to a major source of bad estimations (Cowie, 1987). Further, the factor of inadequate scope definition has two implications for cost control:

- It decreases the accuracy of cost estimates
- It creates a potential for changes in scope during the construction stage, which generally results in an increase in cost to both owners and contractors

Hence, the accuracy of a cost estimate is highly dependent on the level of detail available in the project scope definition.

As per Garry D. Creedy, the findings of the task force set up by the Queensland Division of Engineers, Australia (2004) have revealed the following root causes for cost overrun.

- Inadequate project briefs based on unrealistic expectations of time and cost
- Lack of integration along the supply chain linking parties, and between project phases
- Poor understanding and low skills in risk assessment and management
- Inadequate use of modern technology in the design processes and in the compilation of specifications

2.10 Cost Forecasting Models

There are many literatures that reveal forecasted project cost accuracy is very much important to both the client (who can have better cost control over the project) and the contractor (who can have a better chance to bid the job with a reasonable profit margin). Out of literatures, many the researches have been concentrated on the accuracy in the construction cost forecasting. Ashworth and Skitmore (1983) have identified that factors which influencing project cost forecasting accuracy as:

- Availability of design information
- Size of the project
- Market condition
- Number of bidders

The one of the techniques for assessing project costs, at completion is development of cost forecasting models. According to Garry D. Creedy, the development of cost forecasting models is summarized by Raftery and Ng (1993) as:

- First Generation Models: Element cost planning and bidding models
- Second Generation Models: Using regression analysis
- Third Generation Models: Probabilistic estimates, frequently based on Monte Carlo techniques

Oberlender and Trost (2001 & 2003) had identified six main factors affecting estimate accuracy and order of significance as:

- Basic process design
- Team experience and cost information
- Time allowed to prepare the estimate
- Site requirements
- Bidding climates
- Labour climate

In early stages, forecasting future highway construction costs have been achieved basically in three ways.

First Stage: - Unit rates of construction, such as rate per lane kilometer, have been used to estimate construction costs in the short term assessing. However, this method is found to be unreliable, because site conditions such as topography, in-situ soil, land prices, environmental and traffic loads differ from location to location to make average prices inaccurate for individual projects (Hartgen and Talvite, 1995).

Second Stage: - Extrapolation of past trends, or time-series analysis, has been used to forecast future overall construction costs (Hartgen et al., 1997). In these analysis, construction costs are break into overall expressions of construction indices. These types of models are usually only used for short-term forecasting because of their reliance is depend on past conditions and standards are extrapolated into the future.

Third Stage: - In this case, models are established that describe construction costs as a function of factors assumed to be influenced to the construction costs. The relationship between construction costs and these factors is established from past records of construction costs. Typically, these models are used to estimate the cost of individual contracts only.

Charles and Andrew (1990) have identified the factors that influence the construction change over rates causing cost overrun as:

- Size of the project
- Difference between the low bid and the estimate
- Type of construction
- Level of competition
- Quality of the contract documentation
- Interpersonal relations within the project
- Policies of the contractor

It was discovered that a cost overrun rate of 1 to 40% is most probably occurs on larger projects than smaller projects.

2.11 Recovery of cost overruns through contingency

It is difficult to identify cost overrun of a project at early stages but an attempt should be made to at least such risky project items and attach some financial value to the overall project budget. Some of project uncertainties will be eliminated and clarified at the planning stage. They will be carried forward to project tender stage. It is the fact that, most project owners transfer most risks to other parties in different forms. In this regard, the clients of many construction projects add a contingency allowance to the estimated cost for the purpose of avoiding cost overrun arising from unexpected events.

In order to managing risk on a project, contingency can appear in many forms. It may be a time allowance in the program of work for delay due to wet weather etc, a cost allowance in the project cost estimate for residual risks accepted by the project or a contingency process in case an event happens. Cost contingency is included within a budget to represent the total financial commitment for a project client and the quantum of such contingency is of critical importance to the projects (Garry D.Credy, 2006).

There is no standard definition of contingency and different definitions could be found.

According to Patrascu (1988:115),

Contingency is probably the most misunderstood misinterpreted and misapplied word in project execution. Contingency can and does mean different things to different people.

As per Association of the Advancement of Cost Engineers (AACE 2000:28), Wikipedia

An amount of money or time (or other resources) added to the base estimated amount to achieve a specific confidence level, or to allow for changes that experience shows will likely be required.

The Project Management Institute (2000:199) defines contingency as:
The amount of money or time needed above the estimate to reduce the risk of overrun of project objectives to a level acceptable to the organization is known as contingency.

There are two attributes of the project cost contingency as:

- Reserve - Cost contingency is a reserve of money (AACE,2000)
- Risk - The need and amount for contingency reflects the existence of risk in projects (Thompson and Perry, 1992)

As per Project Management Institute, 2000, the contingency can be divided into two categories of risk:

- Known unknowns
- Unknown unknowns

Or it can be categorized for events within the defined project scope into:

- Unforeseen

- Unexpected

Or in other form of:

- Undefined
- Defined

However, Garry D. Creedy reported that there are several weaknesses of using a contingency amount as given below and they have been identified by Thompson and Perry (1992).

- The percentage figure is arbitrarily arrived and not appropriate for the specific project
- There can have double counting of risks because some estimators are tend to include contingencies in their best estimate
- A percentage addition still results in a single figure prediction of estimated cost, implying a degree of certainty that is simply not justified
- The percentage added indicates the potential for detrimental or downside risk; it does not indicate any potential for cost reduction and it may hide poor management of the execution of the project
- Because the percentage allows for all risk in terms of a cost contingency, it tends to direct attention away from time, performance and quality risks
- It does not encourage creativity in estimating practices, allowing it to become routine and general, which can propagate oversights.

HM Treasury (1993) identifies two major categories of contingency, which can be incorporated into construction projects:

- *Design contingency* - This allows for changes during the design process for factors such as; incomplete scope definition, inaccuracy of estimating methods and data (Clark and Lorenzoni,1985)
- *Construction contingency* – This is to accommodate changes during construction process. Under the traditional procurement arrangement, the client engages others to produce the design before selecting construction contractor competitively. The contract permits variations to allow changes and provide mechanism for determine and valuing variations.

2.12 Summary of Literature

The some of the important findings in the existing theoretical and empirical literature on risks associated with the delivery of construction projects and project cost overrun is noted here.

The definitions of some important terms such as project risk, risk management, nature of risks, risk control processes could be founded. What is risk engineering and risk assessment, how to do risk management, what are the risk sources, how to distribute risk in procurement, project delivery methods and improving project delivery methods are also discussed. In addition to that, the literatures for factors influencing costs, cost forecasting methods and recovery of cost overrun through contingency were reviewed.

Most researches have made a considerable effort to investigate the construction aspects of project delivery and impacts on the performance. It could be identified that change of original construction contract has lead not only to the increased cost but also to contract delay of which then affect project delivery. The nature of contract has caused for many cost overruns. However, a small empirical research has determined client risks leading to cost overrun in some highway projects under different project delivery methods.

The cost estimating models have described the construction risks as a function of factors believed to be influenced construction cost. But these models established in this manner can be used to estimate the cost of individual contracts only.

Now the researches are required to assess relationship of project properties with delivery methods which indicates higher tendency for cost overrun. And also researches should focus on the client, not the contractor and projects leading to build minimized cost overruns.

CHAPTER 03
RESEARCH METHODOLOGY

3.1 Introduction

The research methodology is the collection of methods to change or create new beliefs and knowledge (Garry D. Creedy, 2006). The term of methodology is defined in many ways depend on the person who uses it. However, Research Methodology deals with the methods for creating knowledge about the world and interpretation of this knowledge in the nature of world and relation between humans and their knowledge (Reich, 1994). In comply with the literature review summarized in Chapter 2.12; the collected data would be analyzed to achieve the objective.

3.2 Research Strategy

The term of scientific research refers to the systematic, controlled, rigorous, empirical and critical investigation of a hypothetical proposition about a presumed relation in order to find the solution to a problem or discover and interpret new knowledge (Garry D. Creedy, 2006). On the other hand, the engineering and construction management can be further clarified as systematic processes of discovering, acquiring and using new knowledge to solve problems. As per the Garry D. Creedy, the steps followed in an empirical study are;

a) *Observation :* An informed and critical questioning of an existing phenomenon leading to the problem statement and research question.
b) *Hypothesis :* A formal expression of a preconceived factual relationship which provides a tentative explanation or solution to the problem
c) *Experimentation :* The design of the study leading to a systematic and controlled testing of the hypothesis
d) *Induction :* A generalization of the experimental results that leads to a conclusion about the formal statement of the theory

In this regard, the collection of data is done in two different ways;

- Collection of data at a defined point in a time (Cross sectional study)
- Collection of data within a given period of time (Longitudinal study)

In this study, the data have been collected at the points of starting (Contract BoQ) and at the point of completion (Final BoQ) of certain projects within a certain period of time (recent past). Hence, both categories are covered.

3.3 Procedure of Research

In this thesis, the following factors for developing research procedure would be considered.

- Identification of the problem
- Definition of the objectives
- Description of the point of departure
- Methodology to perform investigation

After reviewing the relevant literatures for determining the aim of research, the steps given below will be followed to conduct research.

1. *Step 1 - Establishment of data sources of highway construction Project*
2. *Step 2 - Identification of main cost overrun factors from Collected*
3. *Step 3 - Factor analysis*
4. *Step 4 - Data analysis and Statistical Modeling*

3.3.1 Step 1 – Establishment of Data Sources

It is understood that, the data sample is to be appropriate for the area of research and it is required to be adequate for statistical analysis of cost overrun factors. The data of cost overrun projects are difficult to find out. The reasons for that difficulty are;

- Time consuming to generate (Duration between commencement and finalization of final BoQ at completion.)
- Hiding of data of cost overrun projects by the involved officers and interpretation of different causes for cost overruns, which differ from actual.

The study of this research was focus into the highway construction projects, funded by different foreign agencies. Because Road Development Authority (RDA) is managing 11,760 km of national roads, out of 95,519 km of total road network in Sri Lanka (TDCA Lecture notes, Prof. Amal Kumarage), the analysis would be mainly rely on the data had been generated by RDA. In addition to that, the data could be collected from the provincial councils but without inadequate details will also be used for analysis because they manage 14915 km of rods in Sri Lankan road network.

On the other hand, the following main features influenced to use RDA data for analysis;

- They have been rehabilitated all by the foreign funds
- They consist of rods in different topography
- Highest traffic density
- The different foreign agencies had funded and different divisions of RDA had managed the constructions
- The constructions had been done by different contractors under different types of contracts (ICB, LCB)

The research focused on highway infrastructure projects that contained data on significant project cost overruns. The data have been selected on the basis of data availability of the projects that have known to be cost overrun. In addition to that, all projects found in Sri Lanka are using the delivery mechanism of design – bid- build. When the project costs are selected either at the beginning (program cost – cost at bidding stage) or at the completion, only the construction project cost was selected. In other words, the costs for other items listed below contribute for overall cost has not been considered. They are;

- Design & procurement cost
- Land acquisition cost
- Utility shifting cost
- Construction supervision cost
- Project administration cost
- All the taxes imposed by GOSL from time to time etc.

3.3.2 Step 2 - Identification of Main Cost Overrun Factors from Collected Data

In this stage, the cost overrun factors for each project would be determined. The available data contained individual descriptions of all works items and also the reasons for cost overrun. In this analysis, the data will be analyzed in the view of client's exposure for construction cost overrun and not from the side of contractor. In the literature review, some of considerations could be identified as;

- Contract delivery type
- Pre- qualification of contractors
- Contract payment type and tender evaluation technique
- Contract clauses & provisions in contracts

3.3.3 Step 3 – Factor Analysis

In this stage, the project risk factors contribute for cost overrun will be grouped. When the available literatures are reviewed, there were several methods for extracting the factors from the data. The most common form of factor analysis is Principal Components Analysis (PCA).

3.3.4 Step 4 – Data Analysis & Statistical Modeling

In this final stage, the statistical models which can explain the correlation between the cause and other relationships for cost overrun will be investigated. The term 'model' refers to the dynamic framework that helps to indicate key concepts and propositions of the research phenomenon (Garry D. Creedy, 2006).

The method of quantification and the analysis techniques depend on each other and restricted by the availability of data. Out of theses, Multivariate regression technique is seem to be a most effective tool to manage multiple project variables in the development of a model to determine relationships between projects and risks for cost overrun. It is a scientific guess used in analytical work where the problem of inferring from sets of performance measurements on a number of individuals of objects is constantly faced(Garry D. Creedy, 2006).

Linear statistical models have been used for several reasons;

- They can be easily used
- Visual data identification shows linear trends in initial project cost data using scatter diagrams

The following key factors will be considered when the multivariate regression model is developed (Carver and Nash, 2005).

- Problem formulation
- Adequate, high quality project data
- Selection of appropriate project variables

The multivariate regression took the following form;

$$Y = a_o + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots\ldots\ldots\ldots + b_nX_n + e$$

Source: Lewis- Back, 1993

Where,

Y, is dependent variable (% of project cost overrun)

a_o , is a constant which intersect Y axis

b_n , are partial regression coefficients

e , is error term

X, is independent variable (% of project cost overrun contributing factors)

3.4 Summary

The methodology described the process of investigation and assessing the correlations between project risk factors and cost overruns on highway projects.

The collected data will be analyzed by using the techniques described in methodology in the following chapter 4.

CHAPTER 4
ANALYSIS OF DATA

4.1 Introduction

In this regard, the following steps will be followed to achieve the objective of research. The objectives of research are;

- To undertake the analysis of previous project cost overrun factors and find correlation of them with project parameters
- To propose realistic allowances for future estimates, leads to accurate client budgets through the identified cost overrun factors

Step 1 - Establishment of data sources of highway construction Project
Step 2 - Identification of main cost overrun factors from Collected data
Step 3 - Factor analysis
Step 4 - Data analysis and Statistical Modeling

Out of these, data sources are already established (RDA and Provincial Council) and hence, we will follow next steps.

4.2 Grouping of Collected Data

As discussed in Chapter 3.3.1, the data have been collected from Road Development Authority (RDA) and Provincial Councils. They will be grouped in this chapter. Having considered the fact of difficulty of collecting data due to the hiding of data by responsible officers who mange the projects; the projects names, contract number and source name will not be displayed but a coding system have been introduced.

As we are understood, the project delivery methods adopted in Sri Lanka is;

- Open Tender: The bidding of Bill of Quantities (BoQ) is done among the pre-qualified contractors under the open tender environment. All most all contracts of Sri Lankan highway are fallen into this category.
- Agreed Priced Internal Contracts: This method is normally used at an extension of one project. It is a negotiated internal contract and very rarely used only

when a contractor is established at the vicinity and it gains significant advantages to the client. In addition to that, fund for the extension should be from the same source. Out of the collected data, only the Rehabilitation of Balangoda – Bandarawela road as an extension of Rehabilitation of Ratnapura - Balangoda road under EDCF fund will fall into this category.

Hence, the project delivery method is not a factor for grouping the projects. But according to the source of fund, terrain condition and period of project execution can be considered as the factors for project grouping.

However, the project code has been selected according to the source of fund and therefore, it will not be tabulated here.

As per the geographical terrain condition, projects are grouped as follows;

Table 4.2.1 : Grouping of projects as per terrain conditions

Project Code	*Project Name*	*Flat Terrain*	*Rolling Terrain*	*Mountainous Terrain*
JR-1	PBC Road			x
KR-1	PHK Road			x
KR-2	Kandy- Jaffna Road			x
ER-1	CRWB Road			x
ER-2	CRWB + BH Roads			x
ARR-1	PMN Road			x
ARR-2	PMN Road		x	
ARR-3	PMN Road		x	
ARR-4	PMN Road	x		
ATR-1	Tissa - Kirinda Road	x		
ATR-2	CGHW Road	x		
WR-1	PNR Road			x
WR -2	CK Road			x
WR-3	BH Road			x
WR-4	Bandarawela- Welimada Rd			x
WR-5	GDM Road			x
WR-6	Denagama- Mulatiyana Rd	x		
WR-7	Wellawaya- Siyabalanduwa Rd	x		
WR-8	Siyabalanduwa -Ampara Rd	x		
WR-9	Maradankadawala- Jayanthipura Rd	x		
WR-10	Padeniya – Puttalam Rd	x		

In addition to that, price escalation is directly related with the inflation. It is depend on the economy of the country during a particular period. Hence, weather the period of project execution correlate with the inflation and that contributes with the cost overrun will be studied.

As per the period of project execution, projects can be grouped as follows;

Table 4.2.2 : Grouping of projects as per period of period of execution

Project Code	Year 2000	Year 2001	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010
KR-1					x	x	x	x	x	x	
KR-2						x	x	x	x	x	
ER-1	x	x	x	x							
ER-2						x	x	x	x		
ARR-1			x	x	x	x					
ARR-2			x	x	x						
ARR-3			x	x	x						
ARR-4					x	x	x				
ATR-1								x	x	x	
ATR-2								x	x	x	
WR-1							x	x	x	x	
WR -2							x	x	x	x	
WR-3							x	x	x	x	
WR-4							x	x	x	x	
WR-5							x	x	x	x	x
WR-6							x	x	x	x	
WR-7							x	x	x	x	
WR-8							x	x	x	x	x
WR-9								x	x	x	
WR-10								x	x	x	
JR-1				x	x	x	x				

This is clearly illustrated by the bar chart given in Annexure 2-2.

4.3 Identification of main cost overrun factors

In this regard, the analysis is focus in client's exposure to project cost overrun and not from the side of contractor. When the historical data are analyzed and available literatures are reviewed, it could be observed that following factors have contributed for cost overrun;

- Project acceleration requirements
- Construction difficulty (Due to heavy traffic, water & other environmental difficulties etc)
- Project , scope or design changes
- Institutional delays or influences
- Social , cultural or heritage issues
- Latent conditions (Unexpected site or weather)
- Price fluctuation due to inflation or supply- demand changes
- Material or working quality issues
- Disputes in project team and ultimately failing of contracts

However, most of these are correlated with each other and actual cause for cost overrun had exposed in different version. In order to suit project acceleration requirements, construction difficulty (due to heavy traffic, water & other environmental difficulties) and social, cultural or heritage issues design scope may have to change. Similarly, due to the fact of material or working quality issues disputes in project team can arises.

When our data are analyzed, the following main factors could be identified.

Table 4.3.1 : Main cost overrun factors

Factor	Code
Project / Design scope Change	SC
Price Fluctuation	PF
Errors in designs / Tender Documents	ED
Unexpected site / weather conditions	UC
Institutional Delays	ID
Disputes in Project Team	DT

The contribution of each factor for cost overrun is then considered and an index matrix can be formed as follows. For the forming of matrix, the scaling of zero (0) and one (1) is used. The zero is stands for no contribution for overall cost overrun and one stands for some contribution for overall cost overrun.

Table 4.3.2 : Index Matrix for main cost overrun factors

Project Code	Cost Overrun Factor					
	SC	***PF***	***ED***	***UC***	***ID***	***DT***
JR-1	1	1	0	0	1	0
KR-1	0	1	0	0	1	0
KR-2	1	1	1	1	1	0
ER-1	1	1	1	1	0	0
ER-2	1	1	0	1	0	0
ARR-1	0	1	1	0	0	0
ARR-2	0	1	1	0	0	0
ARR-3	0	1	0	1	0	0
ARR-4	0	1	0	1	0	0
ATR-1	1	1	1	0	0	0
ATR-2	1	1	1	0	0	0
WR-1	1	1	1	0	1	1
WR-2	1	1	1	1	1	1
WR-3	1	1	1	1	1	1
WR-4	1	1	1	1	1	1
WR-5	1	1	1	1	1	1
WR-6	1	1	1	1	1	1
WR-7	1	1	1	1	1	1
WR-8	1	1	1	1	1	1
WR-9	1	1	1	1	1	1
WR-10	1	1	1	1	1	1
Overall %	***80.9***	***100.0***	***76.2***	***66.7***	***61.9***	***47.6***

The ultimate result from above factors is overall cost overrun. The next aim is to identify what are the most significant components for cost overrun and how their contributions are. When the breakdowns of overall cost overrun are analyzed from the table in Annexure 5, it could be identified that followings as the most significant components that contribute for cost overrun.

- Road Structures
- Road Pavement
- Price Escalation

- Extra Works, Variations & Claims
- All other BoQ Items, except above all

In addition to that, when the Annexure 2-1 (Table) and Annexure 2-1(Bar Chart) are analyzed, the Time Factor could be identified as another significant component that contribute for cost overrun.

- Time Overrun

4.4 Factor Analysis

It can be observed that, there can have a relationship between the size of the project and percentage of cost overrun. (Annexture4-C)

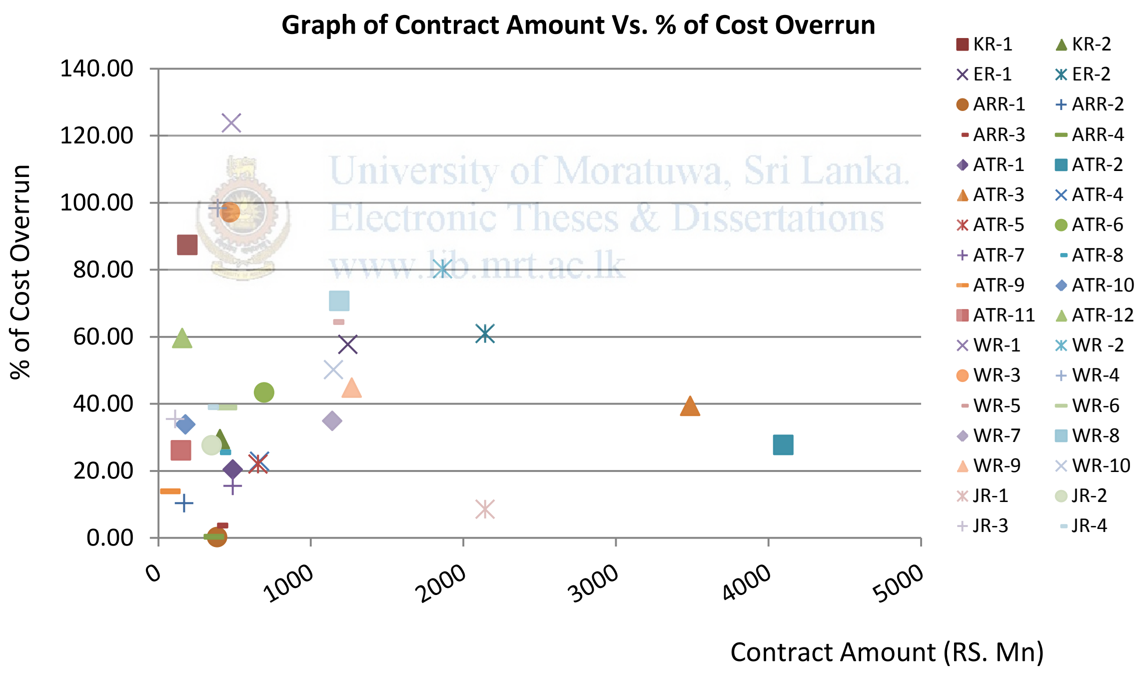

Figure No. 4.4.1 Graph of Contract Amount vs. % of Total Cost Overrun

In addition to that, it can be observed that the cost overrun caused by the price escalation is also independent with the year of project completion (Annexure 4-B). But it can be observed that there can have a relationship with the category of project fund, which is administrated by a unit of the execution agency (Eg. One of a division in RDA).

There can have a delay of completion with Cost Overrun due to price Escalation (Annexure 4-A). Also, a direct relationship between the delay of project completion and contribution to overall cost overrun by the price escalation cannot be observed as per the Annexure 2-1.

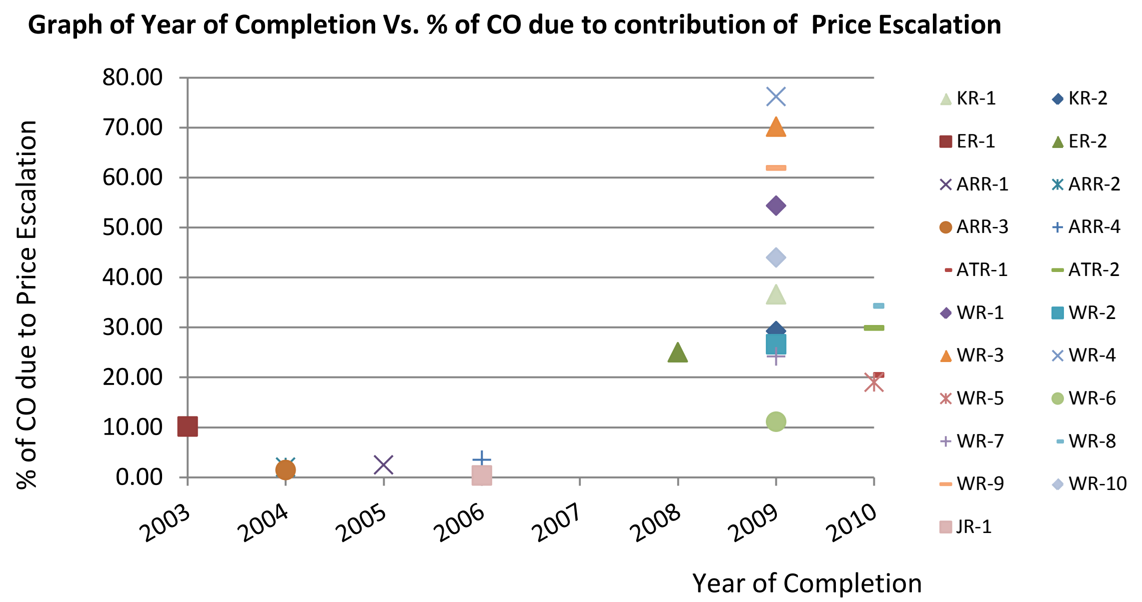

Figure No. 4.4.2 Graph of Year of Completion vs. % of Cost Overrun due to Price Escalation

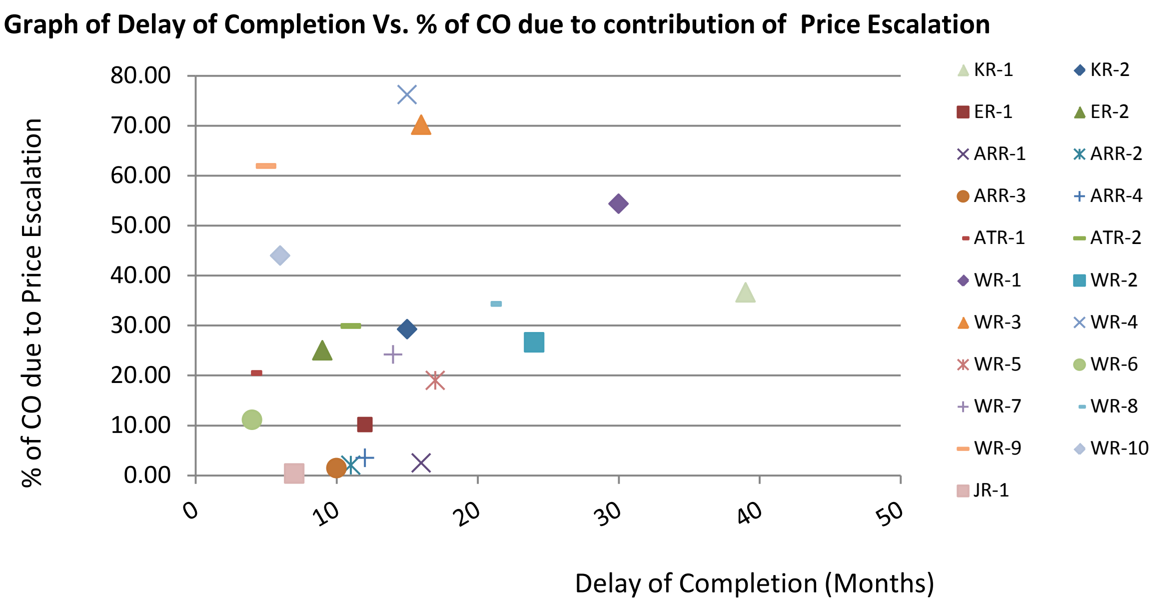

Figure No. 4.4.3 Graph of Delay of Completion vs. % of Cost Overrun due to Price Escalation

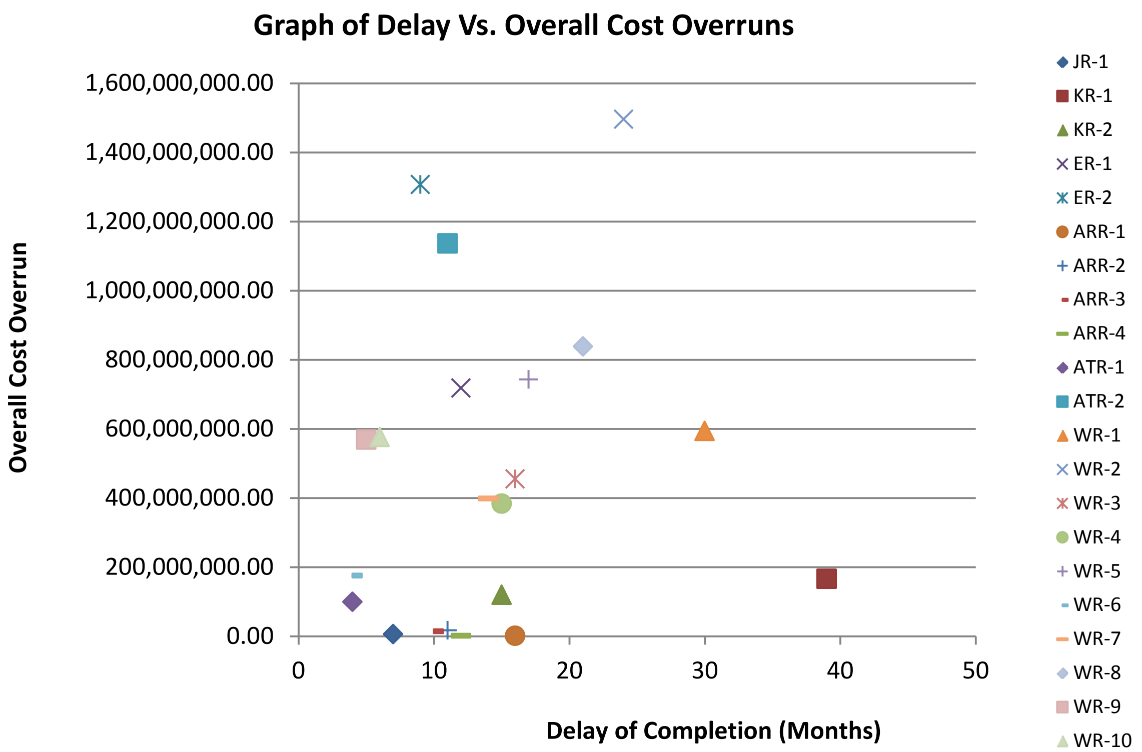

Figure No. 4.4.4 Graph of Delay of Completion vs. % of Overall Cost Overrun

But, it seems that there may have a relationship between delay of completion and overall cost overrun (Annexure 4-D). Therefore, under the next chapter the above relationships will be analyzed and. their correlations will try to be found.

4.5 Data Analysis and Statistical modeling

Due to the wide spectrum of highway projects, there are 3 geological location types, 6 main risk factors, found at Chapter 4.3 that influence the amount of project cost overrun has to be considered for the project analysis. Therefore, each and every factor can be considered as independent variable and cost overrun can be considered as dependent variable. However, our objective is to find relationships of the cost overrun values and selected factors.

4.5.1 Finding of Main Cost Overrun Factors

When the table of "Amount Contribution to Overall Cost Overrun by BOQ items" given in Annexure 5 and table of "Percentage Contribution to Overall Cost Overrun by BOQ items" given in Annexure 6 are observed, mainly the following costs of individual BOQ items have contributed to overall cost overrun.

- Structure
- Road Pavement
- Price Fluctuation
- Extra works, Variations & Claims
- All other BoQ Items, except above all

In addition to that, when the Annexure 2-1 (Table) and Annexure 2-1(Bar Chart) are analyzed, the Time Factor could be identified as another significant component that contribute for cost overrun.

- Time Overrun

4.5.2 Findings of Correlations

4.5.2.1 Overall Cost Overrun with Cost Overruns of Road Pavement, Price, Fluctuation, Extra Works and Delay

When the available data are tabulated as Annexure 7 and analyses done using SPSS software, the result can be obtained as Annexure 14.1.From this, output of Annexure 14.1, the following significant relationships can be observed.

- Level of 0.05
  - Overall Cost Overrun with Road Pavement Cost Overrun
- Level of 0.01
  - Overall Cost Overrun with Price Fluctuation Cost Overrun
  - Overall Cost Overrun with Extra Works, Variations & Claims Cost Overrun
  - Price Fluctuation Cost Overrun with Extra Works, Variations & Claims Cost Overrun
  - No any direct relationship of Delay with any other considered factors

4.5.2.2 Overall Cost Overrun with Original BOQ and Delay

When the available data are tabulated as Annexure 8 and analyses done using SPSS software, the result can be obtained as Annexure 14.2.From this, output of Annexure 14.2, the following significant relationships can be observed.

- Original Grand Total (BOQ) with Overall Cost Overrun (Level of 0.01)

4.5.2.3 Overall Cost Overrun with Contract Period and Delay

When the available data are tabulated as Annexure 9 and analyses done using SPSS software, the result can be obtained as Annexure 14.3.From this, output of Annexure 14.3, the following significant relationships can be observed.

- In this study, the no any significant relationship with any considered factors can be observed.

4.5.2.4 Overall Cost Overrun with Original and Final Rates per unit Construction

When the available data are tabulated as Annexure 10 and analyses done using SPSS software, the result can be obtained as Annexure 14.4.From this, output of Annexure 14.4, the following significant relationships can be observed.

1. Level of 0.01
   - Original Surface Rate per Km per lane with Final Surface Rate per Km per lane, Original Surface Rate per Sq.m, and Final Surface Rate per Sq.m
   - final Surface Rate per Km per lane with Original Surface Rate per Sq.m

However, since any of these factors do not directly relate with overall Cost overrun, these findings do not reflect any value for this study.

4.5.2.5 Overall Cost Overrun with Terrain

When the available data are tabulated as Annexure 11 and analyses done using SPSS software, the result can be obtained as Annexure 14.5.From this, output of Annexure 14.5, no any significant relationships can be observed.

When these data are used and One-way ANOVA of SPSS software was run, the following result can be obtained.

Table 4.5.2.4(a) : Table of Correlations of Overall CO with Terrain

Source	DF	SS	MS	F	P
Terrain	2	6.25610E+17	3.12805E+17	1.77	0.203
Error	15	2.64377E+18	1.76251E+17		
Total	17	3.26938E+18			

S = 419822928 R-Sq = 19.14% R-Sq(adj) = 8.35%

However, this one-way ANOVA results in a low F-value of 1.77 (P-value 0.203) which indicates that the terrain type has no significant impact on the overall cost overrun.

4.5.2.6 % Overall Cost Overrun with % Change (CO) of Individual Items

(a) Preliminary and General

When the available data are tabulated as Annexure 12.1 and analyses done using SPSS software, the result can be obtained as Annexure 14.6(a).From this, output of Annexure 14.6(a), the following significant relationships can be observed.

- Low F-value of 19.798, there is no significant impact to the overall cost overrun by the individual BoQ item of Preliminary & General.

(b) Site Clearing

When the available data are tabulated as Annexure 12.2 and analyses using SPSS software, the result can be obtained as Annexure 14.6(b).From this, output of Annexure 14.6(b), the following significant relationships can be observed.

- Moderate F-value of 143.086, there is an impact to the overall cost overrun by the individual BoQ item of Site Clearing. But it cannot be considered as a significant impact.

(c) Earth Work

When the available data are tabulated as Annexure 12.3 and analyses using SPSS software, the result can be obtained as Annexure 14.6(c).From this, output of Annexure 14.6(c), the following significant relationships can be observed.

- Low F-value of 50.386, there is no any significant impact to the overall cost overrun by the individual BoQ item of Earth Work.

(d) Drainage

When the available data are tabulated as Annexure 12.4 and analyses using SPSS software, the result can be obtained as Annexure 14.6(d).From this, output of Annexure 14.6(d), the following significant relationships can be observed.

- Moderate F-value of 180.852, there is an impact to the overall cost overrun by the individual BoQ item of Drainage. But it cannot be considered as a significant impact.
-

(e) Structures

When the available data are tabulated as Annexure 12.5 and analyses using SPSS software, the result can be obtained as Annexure 14.6(e).From this, output of Annexure 14.6(e), the following significant relationships can be observed.

- High F-value of 331.639, there is an impact to the overall cost overrun by the individual BoQ item of Structure.

(f) Pavement

When the available data are tabulated as Annexure 12.6 and analyses using SPSS software, the result can be obtained as Annexure 14.6(f).From this, output of Annexure 14.6(f), the following significant relationships can be observed.

- High F-value of 311.573, there is an impact to the overall cost overrun by the individual BoQ item of Pavement.

(g) Incidentals

When the available data are tabulated as Annexure 12.7 and analyses using SPSS software, the result can be obtained as Annexure 14.6(g).From this, output of Annexure 14.6(g), the following significant relationships can be observed.

- Low F-value of 69.635, there is no any significant impact to the overall cost overrun by the individual BoQ item of Incidentals.

(h) Day Works

When the available data are tabulated as Annexure 12.8 and analyses using SPSS software, the result can be obtained as Annexure 14.6(h).From this, output of Annexure 14.6(h), the following significant relationships can be observed.

- Low F-value of 9.058, there is no any significant impact to the overall cost overrun by the individual BoQ item of Day Works.

However, due to the fact that there is no allocation for some of following items in the original BOQ, these items have not been considered for this analysis (ie. % Overall CO with % CO of following individual BoQ items)

- Price Fluctuations.

- Extra works, Variations & Claims

But a component is allocated in BoQ as 'Contingency' to cover all of these items.

4.5.2.7 % Overall Cost Overrun with % of Items in Original BOQ (with out Contingency)

When the available data are tabulated as Annexure 13 and analyses done using SPSS software, the result can be obtained as Annexure 14.7.From this, output of Annexure 14.7, the following significant relationships can be observed.

1. Level of 0.05
   - % of CO with Total BOQ (w/o Contingency) with % Earth work
   - % of Site Cleaning with % of Earth work
   - % of Earth work with % of incidentals

2. Level of 0.01
   - % of CO with Total BOQ (w/o Contingency) with % of incidentals
   - % of Road Pavement with % of Structure
   - % of P&G with % of CO with Total BOQ (w/o Contingency)
   - % of P&G with % of Road Pavement

4.5.3 Findings of Relationships through Regression Analysis

4.5.3.1 Overall Cost Overrun with CO of Structures Road Pavement, Price Fluctuation, Extra Works and Delay

When the available data are tabulated as Annexure 7 and analyses done using SPSS software, the following significant relationships can be observed.

The regression equation is

Overall Cost Overrun (CO) = - 94376108 + 0.680 Structures CO
+ 1.62 Road Pavement CO + 0.867 Price Fluctuations CO
+ 0.527 Extra Works, Variations & Claim
+ 4569417 Delay (Months)

Table of 4.5.3.1 -1 Table of Regression Results of Overall CO with Main CO factors

Predictor	Coefficient	SE Coefficient	T	P
Constant	-94376108	55404102	-1.70	0.109
Structures CO	0.6804	0.1437	4.74	0.000
Road Pavement CO	1.6233	0.2414	6.72	0.000
Price Fluctuations CO	0.8670	0.1008	8.60	0.000
Extra Works, Variations & Claim	0.5273	0.1984	2.66	0.018
Delay (Months)	4569417	2984770	1.53	0.147

S = 105941476   R-Sq = 95.8%   R-Sq(adj) = 94.3%

Table of 4.5.3.1 -2 Table of Analyzed Variance of Overall CO with Main CO factors

Source	DF	SS	MS	F	P
Regression	5	3.80178E+18	7.60357E+17	67.75	0.000
Residual Error	15	1.68354E+17	1.12236E+16		
Total	20	3.97014E+18			

Table of 4.5.3.1 -3 Table of Unusual observations of Overall CO with Main CO factors

Observation	Structures CO	Overall CO	Fit	SE Fit	Residual	St Resid
1	61783781	5597750	301423717	43520889	-295825967	-3.06R
11	-145482662	1136779822	1158150583	100612234	-21370761	-0.64 X

- R denotes an observation with a large standardized residual.
- X denotes an observation whose X value gives it large influence.
- The F-value of 67.75(P-value of 0) indicates that the fitted regression equation is significant. The R-sq value of 94.3% provides further indication of this.

However, where the individual estimated parameters are concerned, the constant, extra work and delay are not significant variables in the fitted equation (P-vale higher than 5%). Since observations 1 and 11 were identified as unusual observations, a new regression after removing these observations was run; the new and improved results can be obtained. But having considered the above discussed significant behavior, no further iterations will be done.

In addition to that, the cost overruns in above main factors and delay are not known before the project completion. Hence, this relationship cannot be adopted at initial stages.

4.5.3.2 Overall Cost Overrun with Original Grand Total (BOQ) and Delay

When the available data are tabulated as Annexure 8 and analyses using SPSS software, the following significant relationships can be observed.

The regression equation is

COST OVERRUN = - 82405043 + 0.341 Original Grand Total (BOQ)
+ 14786980 Delay (Months)

Table 4.5.3.2 -1 Table of Regression Results of Overall CO with Original BOQ & Delay

Predictor	Coefficient	SE Coefficient	T	P
Constant	-82405043	174932735	-0.47	0.643
Original Grand Total (BOQ)	0.34091	0.07975	4.27	0.000
Delay (Months)	14786980	8591695	1.72	0.102

S = 327224527 R-Sq = 51.5% R-Sq(adj) = 46.1%

Table 4.5.3.2 -2 Table of Analyzed Variations of Overall CO with Original BOQ & Delay

Source	DF	SS	MS	F	P
Regression	2	2.04277E+18	1.02139E+18	9.54	0.001
Residual Error	18	1.92737E+18	1.07076E+17		
Total	20	3.97014E+18			

Table 4.5.3.2 -3 Table of Unusually Observations of Overall CO with Original BOQ & Delay

Observation	Original BOQ	Overall CO	Fit	SE Fit	Residual	St Resid
1	2142032220	5597750	751346912	121081770	-745749162	-2.45R
2	190337128	166349065	559175250	222205862	-392826185	-1.64 X
11	4097305922	1136779822	1477069830	251332174	-340290008	-1.62 X

- R denotes an observation with a large standardized residual.
- X denotes an observation whose X value gives it large influence.
- The F-value of 9.54(P-value of 0.001) indicates that the fitted regression equation is not significant. The R-sq value of 51.5% provides further indication of this.

4.5.3.3 Overall Cost Overrun with Original Grand Total (BOQ)

When the available data are tabulated as Annexure 8 and analyses using SPSS software, the following significant relationships can be observed.

The regression equation is

OVERALL COST OVERRUN = 1.55E+08 + 0.314 original BOQ

Table 4.5.3.3 -1 Table of Regression Results of Overall CO with Original BOQ

Predictor	Coefficient	SE Coefficient	T	P
Constant	155212094	112835363	1.38	1.38
Original Grand Total (BOQ)	0.31385	0.08212	3.82	0.001

S = 343705556 R-Sq = 43.5% R-Sq(adj) = 40.5%

Table 4.5.3.3 -2 Table of Analyzed Variance of Overall CO with Original BOQ

Source	DF	SS	MS	F	P
Regression	1	1.72560E+18	1.72560E+18	14.61	0.001
Residual Error	19	2.24454E+18	1.18134E+17		
Total	20	3.97014E+18			

Table 4.5.3.3 -3 Table of Unusually Observations of Overall CO with Original BOQ

Observation	Original BOQ	Overall CO	Fit	SE Fit	Residual	St Resid
1	2142032220	5597750	827483919	118387945	-821886169	-2.55R
11	4097305922	1136779822	1441142018	263078634	-304362196	-1.38 X
13	1863947658	1495738104	740207726	101753404	755530378	2.30 R

- R denotes an observation with a large standardized residual.

- X denotes an observation whose X value gives it large influence.
- The F-value of 14.61(P-value of 0.001) indicates that the fitted regression equation is not significant. The R-sq value of 43.5% provides further indication of this.

4.5.3.4 % of Overall Cost Overrun with all Contribution Factors

When the available data are tabulated as Annexure 13 and analyses using SPSS software, the following significant relationships can be observed.

Table 4.5.3. 4-1 Table of Model Summery for % of Overall CO with all Contribution factors

Model Summary

Model	R	R square	Adjusted R Square	Std. Error of the Estimate
1	.801[a]	.642	.449	**********

a. Predictors: (Constant), % of Day Works, % of Earth Works. % Structure, % of Drainage, % of incidentals, % of P&G, % of Site Clearing

From this output, the following observations can be made.

- The R-sq value of (0.642) 64.2% indicates that the fitted regression equation is significant.
- However, out of the entered variables % Road Pavement has been excluded by the program due to the unusual behavior of these data with others.

Table 4.5.3.4 -2 Table of Coefficients for % of Overall CO with all Contribution factors

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
1 (Constant)	46.321	34.373		1.348	.201
% of P&G	-2.329	1.016	-458	-2.293	.039
% of Site Clearing	19.895	20.142	.197	.988	.341
% of Earth Works	-1.259	1.414	-.203	-.891	.389
% of Drainage	-.535	1.746	-.060	-.306	.764
% of Structure	-.563	.517	-.198	-1.089	.296
% of incidentals	8.362	3.229	.504	2.589	.022
% of Day Works	.276	2.142	.021	.114	.911

a . Dependent Variable: % of CO with Total BOQ (W/O contingency)

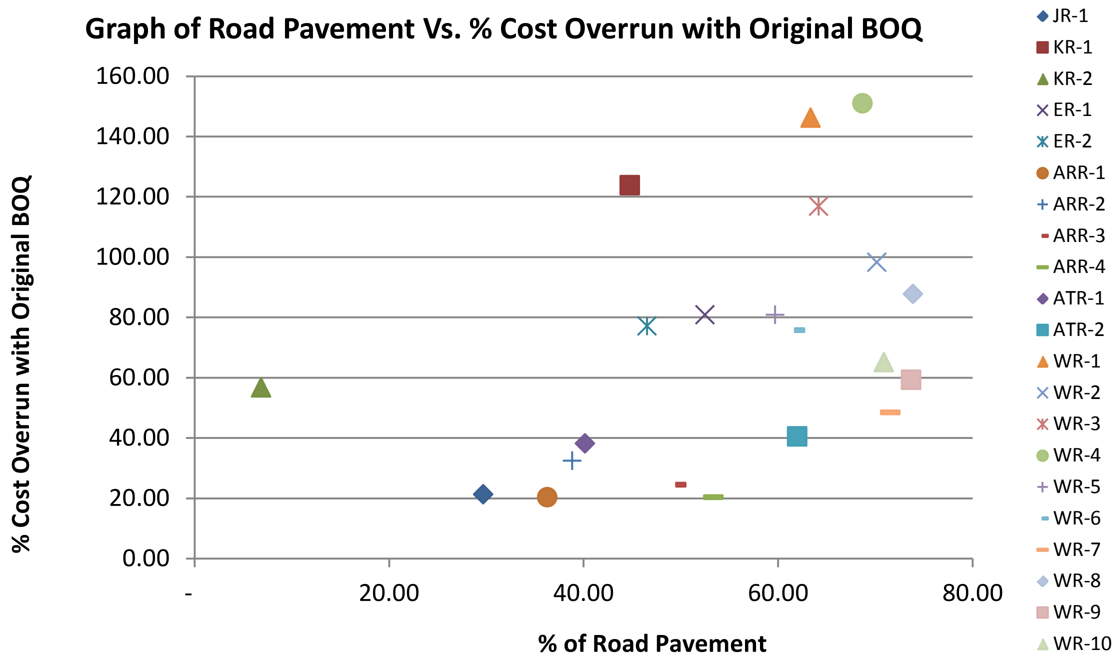

Figure No : 4.5.3.4: Graph of % of Road Pavement VS % of CO with Original BOQ

From the Annexure 13;

$$Y = C + C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6X_6 + C_7X_7 + C_8X_8$$

Where,

Y	-	% of Cost overrun with Total BOQ (without contingency)	
C_1	= -0.458	-	Coefficient for Preliminary & General
C_2	= 0.197	-	Coefficient for Site Clearing
C_3	= -0.203	-	Coefficient for Earth Work
C_4	= -0.060	-	Coefficient for Drainage
C_5	= -0.198	-	Coefficient for Structure
C_6	= 0.00	-	Coefficient for Road Pavement, but it was excluded by the software due to unusual behavior.
C_7	= 0.504	-	Coefficient for Incidentals
C_8	= 0.021	-	Coefficient for Day Works
C	= 46.321	-	Constant

Note: When the percentages are considered, the contingency of Original BOQ would not be taken into account.

X_1 - % of Contribution by Preliminary & General in Original BOQ

X_2 - % of Contribution by Site Clearing in Original BOQ

X_3 - % of Contribution by Earth Work in Original BOQ

X_4 - % of Contribution by Drainage in Original BOQ

X_5 - % of Contribution by Structure in Original BOQ

X_6 - % of Contribution by Road Pavement in Original BOQ, but it was excluded by the software due to unusual behavior.

X_7 - % of Contribution by Incidentals in Original BOQ

X_8 - % of Contribution by Day Works in Original BOQ

CHAPTER 5
DISCUSSION, RECOMMANDATIONS AND CONCLUSION

5.1 Introduction

In this chapter the findings to achieve objectives of the research and areas of further research will be discussed. And also the factors which contribute for cost overruns will be discussed.

5.2 Main Cost Overrun Factors

When the available data having detail breakdowns are analyzed in chapter 4.3, the following findings could be observed in Table 4.3.2 and they can be summarized as;

Table 5.2.1 : Table for influence of factors for cost overrun

Main Cost Overrun Factors	***Overall % of Occurrences***
Project / Design scope Change	*80.9*
Price Fluctuation	*100.0*
Errors in designs / Tender Documents	*76.2*
Unexpected site / weather conditions	*66.7*
Institutional Delays	*61.9*
Disputes in Project Team	*47.6*

The above table reveals us the most influencing factor for cost overrun is, Price Fluctuation. The design and project scope change is fallen into second category. The errors in designs and tender documents can be considered as third place. The unexpected site and weather conditions are fallen into forth place. The institutional delays and disputes in project team claims least contribution for cost overrun. However, it directly contributes for delay in completion.

5.2.1 Price Fluctuation

It is a normal practice that, when the contract agreements are signed for the long term construction contracts, prices are fixed at a specific date as a datum. The risk of price changing, depending on inflation and supply – demand mechanism, is taken over by the client. Then the overall price change of an agreed price is compensated by evaluating the components (labour & material requirements) of the same used to build the above price. In this regard, different countries follow different indices but Sri Lanka uses ICTAD indices.

It could be observed that the socio, economical and political condition of the country or world trend has directly connect with the inflation. During the period of years 2005 to 2007, due to the economic crisis in the world, inflation of the country has significantly increased.

For an example, in the Project Report No. 43234-LK, submitted on 23rd June, 2008 for additional financing (Credit) for the Road Sector Assistance Project (RSSP) has revealed that they had to requested additional credits due the main reason of unprecedented oil price increase in the world market that has led to the escalation of prices in oil-based materials. In particular, the price of bitumen has increased by 433%, from SLRs.19.0 per liter at the award of the contracts to the current price (then) of SLRs.101.35 per liter. In the past annual price increase in bitumen had only been about 15%. The prices of other road construction materials have also skyrocketed due to higher transportation charges. The price of fuel has increased from SLRs.46 per liter at the start of the Project to the current price (then) of SLRs.157 per liter, (ie. 241% increase).

The price escalations on the contracts have directly impacted to the overall cost overrun. The percentage of the increase is attributable to escalation in the price of materials. The estimates for price escalation allow for increases in prices from commencement to end of project derived from a trend analysis of historical data. Since the projections are based on the current fuel prices, the estimates include 10% additional price contingencies to deal with any further price increases. The price escalation is also based on the revised contract periods. As the revised project cost incorporates costs associated with the agreed constructions and additional works, no further physical contingencies have been provided. As a consequence of the above increase in project cost, the government tax amount has also increased.

5.2.2 Subsequent Scope Changes

5.2.2.1 Project Scope

In this regard, change of original scope of work due to some of the design changes, policy decisions and to suit with site condition etc. has to be considered. Some of the parameters that can be changed after the tender stage are given below,

- Change of length, widths , type of drains & cross drainage structures

- Change of surfacing & type of shoulders
- Addition of new structure, feature / road furniture or removal of the same from the tender
- Change of method of construction to suit site conditions as per the instruction of either employer or consultant

ER-1 road rehabilitation project has some of examples which caused for cost overrun can be listed below;

1 Drain type change from R.R. Masonry to R.C.C lining
2. Surface type changed from binder cum wearing single layer to two different layers
3. Changed SBST shoulder to asphalt hard shoulder

5.2.2.2 Design Scope

5.2.2.2.1 Effects of Technical Specification & Safety

There is an example, in the Project Report No. 43234-LK, submitted on 23rd June, 2008 for additional financing (Credit) for the Road Sector Assistance Project (RSSP). It has revealed that they had to requested additional credits due the another main reason of using higher standards for national highways to improve safety environment as stipulated in the National Road Master Plan (NRMP) adopted in December 2007. This new policy of the Ministry of Highways and Road Development (MOHRD) necessitated widening of roads under the RSS project to 6.2 meter national standards with 0.65 meter hard shoulder on the inside of the numerous bends. As a result of the change in width of carriageway, all culverts had to be extended. In addition, embankment trimming necessary for the widening resulted in an increase in the amount of retaining walls. Some additional works are required such as raising some sections due to water logging, gabion retaining walls adjacent to paddy fields, protection of the embankment slopes in wet areas, guard rails for safety reasons, and additional provisions to minimize project affected persons. These additional works are technically justified and would contribute to higher quality and safer highways but ultimate cost overrun.

5.2.2.2.2 Effects of Natural Environment

In order to fulfill conditions agreed in some of the loan agreements such as National Highway Sector Project (NHSP) development fund by ADB, a very high consideration has to be given for natural environment. In this regard, a huge cost has to be spent for environment. If due attention has not be given at tendering stage, an additional cost to be incurred at construction stage, causing cost overrun.

5.2.2.2.3 Effects of Cultural & Social

Similarly, as per the conditions of loan agreements or due to the influence of social and cultural effects, a very high attention needs to be drawn. To satisfy those requirements, such as protection walls to the properties, enhancing living standards by providing developed accesses etc, a very high cost to be incurred. Since these constructions are not generally considered together with road constructions, the costs to be spent for the fulfillment of those requirements are additional costs. Hence, this additional cost contributes for cost overrun.

5.2.2.3 Construction Scope

There are some cases that changed their original construction scope such as change of number of lanes etc, which cause for high variation of project cost. Sothern Transport Development Project (STDP) is a typical example for this. In this project, the number of lanes and method of soft ground treatment had been changed, causing very high cost overrun.

5.2.3 Errors in Designs & Contract Documents

Due to the lack of information for designs at tender stage, negligence at design & tender document preparation or inability to prepare detailed designs caused by the factor of time, financial or capability of resources would result errors in Design & Tender documents. When a project is implemented under the erroneous designs & documents, result is disputes among involving parties and financial / time overrun. Some of the errors in Design & Tender documents are;

- Inability of fitting horizontal & vertical alignment (HA & VA) to the site practically.
- Loop holes in tender document to gain additional benefit to the contractor.
- Failing of design to address actual site conditions. (Eg. Use of computer software for HA & VA design with out pay much attention to the condition of terrain)

Again, ER-1 road rehabilitation project has some of examples for cost overrun caused by,

1. Locations & type of structures has not been identified therein. Result was increased in quantities.

2. According to the tender design, a constant width of land strip had been acquired without considering cut or fill slope. Result was additional structures to manage available space.

5.2.4 Unexpected Site / Weather conditions

Soil or behavior of rock pattern in both embankments and ground cannot be guaranteed even after undergoing field tests in random manner. The same is varying from location to location naturally and due to the activities carried out by the human beings. When the constructions are carried out, the cost requirement for sound construction under the factor of unexpected site conditions, a cost variation would be incurred.

Again, ER-1 road rehabilitation project rich with some of examples for cost overrun caused by,

1. During the excavation of foundation for Bridge No. 115/7 (Ch.114+925) of CRWB road, an underground gem mining tunnel was found. Result was change of spread footing foundation to cylinder sinking foundation.
2. Due to the presence of rock beds in foundation, most of culverts had to be changed from Hume pipe culverts to Box type culverts.

Irrespective of exact period of time and location, a natural disaster should be expected. Even though flood, earth slips, subsidence of grounds etc, may be expected depend on the location and time. But some disasters cannot be thought even as no information is available for such during a long history. The typical example is Tsunami disaster.

Out of the collected data, the road rehabilitation project namely, ER-1 road project had also experienced such disaster. The project duration of the same is from September 2000 to September 2003. But on 23rd May 2003, this project experienced a heavy flood and there was no such a flood during past 50 years. The result was;

- Suspension all activities of the project by a week
- Damages to some structures, drains and road base
- Creating additional activities such as repairing & replacing some structures
- Creating additional activities such as removal of debris brought by flood

All these factors directly contributed to cost overrun the project.

5.2.5 Institutional delays

The activities of some of utility provision agencies such as CEB, NWS&DB, Local government and SLT, the agencies involve with land acquisition such as Ministry of lands, Divisional Secretary, Valuation & Survey Departments have contributed to delay of land acquisition and delay of shifting of services. In addition to that, when the police security for rock blasting, clearance from CEA & other environmental related agencies, could not be obtained on due time, the result is;

- Delay of construction progress and requirement of extension of time to cover up lagging
- Requirement of additional structures to manage within the available space
- Inconvenience to the road users
- Making grounds for a claim by the contractor to the employer
- Unexpected dates to schedule some activities

5.2.6 Disputes in Project Team

When a dispute regarding an instruction of design, financial or method of construction is created among the key members of Employer, Consultant or Contractor then the result is delay of progress. There are many examples experienced in Sri Lanka and out of them, Rehabilitation of Katugastota – Madawala – Bambarella road & Katugastota – Kurunegala – Puttalam road would be significant. The both constructions were originally undertaken by M/s. China Jelling Construction Co. and subsequently, first project was taken over by M/s. Daya Construction Co. & second project was by government owned “Maganeguma”.

In addition to the disputes, such an incident is caused by;

- Low bidding rates of which insufficient to undertake project
- Incapability of implementing constructions due to lack of financial & experience
- Lack of competent staff , machines & equipments

Not only the disputes between connected organizations but the disputes among the employees of one of an organization would create same result.

5.3 Results of Risk analysis

The research could found following rankings for the cost overruns in highway construction projects.

Table 5.3.1 : Table for ranked principal cost overrun risk groups

Risk Group	***Cost Overrun Factor***	***Project Development Phase***		
		Design	***Construction***	***Operation***
Scope Change	*Project / Design scope Change*	*H*	*H*	*L*
Price Escalation	*Price Fluctuation*	*M*	*H*	*L*
Deficit in Documents	*Errors in designs / Tender Documents*	*M*	*H*	*M*
Insufficient site Investigations & unexpected weather	*Unexpected site / weather conditions*	*M*	*H*	*H*
ROW clearance	*Institutional Delays*	*L*	*H*	*L*
Project Management	*Disputes in Project Team*	*M*	*H*	*H*

Where, L, M, H is impacts on potential cost overruns at different project development stages as specified below.

L - Low impact on potential cost overrun
M - Medium impact on potential cost overrun
H - High impact on potential cost overrun

As given in Table 5.2.1 of which observed in Table 4.3.2, (Table for influence of factors for cost overrun) the cost overrun factors can be ranked as follows;

Table 5.3.2 : Table for ranked cost overrun factors

Main Cost Overrun Factors	*Overall % of Occurrences*	*Rank*
Project / Design scope Change	*80.9*	*2*
Price Fluctuation	*100.0*	*1*
Errors in designs / Tender Documents	*76.2*	*3*
Unexpected site / weather conditions	*66.7*	*4*
Institutional Delays	*61.9*	*5*
Disputes in Project Team	*47.6*	*6*

The description of main cost overrun factors, observed in Table 4.3.2 and how these risks impact to the main cost overrun can be summarized as below;

Table 5.3.3 : Table for main cost overrun factors and their impacts

Rank	*Main Cost Overrun Factors*	*Description of Risk Impact*
1	*Price Fluctuation*	*Potential for labour or material price increase, due to inflation or imbalance supply & demand*
2	*Project / Design scope Change*	*Incomplete or missing design elements, policy changes*
3	*Errors in designs / Tender Documents*	*Incomplete or missing design elements, negligence or inexperience*
4	*Unexpected site / weather conditions*	*Incomplete or missing design elements, natural but unexpected weather pattern*
5	*Institutional Delays*	*Time delay, various approvals, low priority or price changes & disputes*
6	*Disputes in Project Team*	*Disputes of quality, inexperience, personnel emotions*

5.4 Results of Statistical Modeling

When the available data are analyzed through "SPSS" Software, the following general observations could be obtained.

- In all the regressions the constant is not significant. However, in regression analysis the constant is of secondary importance.
- The R^2 value has continuously improved when unusual observations were removed.

- However, since there were unusual observations in all these regressions, further attempts to remove observations (outliners) were abandoned due to removal of outliners causes the sample size used for fitting the regression to reduce.
- A smaller sample size reduces the reliability of the fitted regression equations.

In this study, the following significant correlations can be observed.

➢ Level of 0.05

- Amount of Overall Cost Overrun with Road Pavement Cost Overrun
- % of CO with Total BOQ (w/o Contingency) with % Earth work
- % of Site Cleaning with % of Earth work
- % of Earth work with % of incidentals

➢ Level of 0.01

- Amount of Overall Cost Overrun with Price Fluctuation Cost Overrun
- Amount of Overall Cost Overrun with Extra Works, Variations & Claims Cost Overrun
- Price Fluctuation Cost Overrun with Extra Works, Variations & Claims Cost Overrun
- Original Grand Total (BOQ) with Overall Cost Overrun
- % of CO with Total BOQ (w/o Contingency) with % of incidentals
- % of Road Pavement with % of Structure
- % of P&G with % of CO with Total BOQ (w/o Contingency)
- % of P&G with % of Road Pavement
- Original Surface Rate per Km per lane with Final Surface Rate per Km per lane, Original Surface Rate per Sq.m, Final Surface Rate per Sq.m
- Final Surface Rate per Km per lane with Original Surface Rate per Sq.m

However, since any of these unit construction factors do not directly relate with overall Cost overrun, these findings do not reflect any value for this study.

- No any direct relationship of Delay with any other considered factors (Overall CO, Road Pavement CO, Price Fluctuations CO, Extra works, Variations & Claims)

- No any direct relationship of Delay with Contract Period and Cost Overrun

➢ However, when one-way ANOVA is run, the results are as follows,

- Low F-value of 1.77 (P-value 0.203) indicates that the terrain type has no significant impact on the overall cost overrun.
- Low F-value of 19.798, indicate that there is no significant impact to the overall cost overrun by the individual item of Preliminary & General.
- Moderate F-value of 143.086; indicate that there is an impact to the overall cost overrun by the individual item of Site Clearing. But it cannot be considered as a significant impact.
- Low F-value of 50.386 proves that there is no any significant impact to the overall cost overrun by the individual item of Earth Work.
- Moderate F-value of 180.852, shows that there is an impact to the overall cost overrun by the individual item of Drainage. But it cannot be considered as a significant impact.
- High F-value of 331.639 indicates that there is an impact to the overall cost overrun by the individual item of Structure.

- High F-value of 311.573 proves that there is an impact to the overall cost overrun by the individual item of Pavement.
- Low F-value of 69.635 shows that there is no any significant impact to the overall cost overrun by the individual item of Incidentals.
- Low F-value of 9.058, indicate that there is no any significant impact to the overall cost overrun by the individual item of Day Works.

➢ Regression equation results are as follows,

- The F-value of 67.75(P-value of 0) indicates that the fitted regression equation is significant. The R-sq value of 94.3% provides further indication of this. The fitted equation is;

Overall Cost Overrun (CO) = - 94376108 + 0.680 Structures CO + 1.62 Road Pavement CO + 0.867 Price Fluctuations CO + 0.527 Extra Works, Variations & Claim + 4569417 Delay (Months)

- The F-value of 9.54(P-value of 0.001) indicates that the fitted regression equation is not significant. The R-sq value of 51.5% provides further indication of this. The fitted equation is;

Overall Cost Overrun (CO) = - 82405043 + 0.341 Original Grand Total (BOQ)
+ 14786980 Delay (Months)

- The F-value of 14.61(P-value of 0.001) indicates that the fitted regression equation is not significant. The R-sq value of 43.5% provides further indication of this. The fitted equation is;

Overall Cost Overrun (CO) = 1.55E+08 + 0.314 original BOQ

- The R-sq value of (0.642) 64.2% indicates that the fitted regression equation is significant. The fitted equation is;

$Y = 46.321 - 0.458X_1 + 0.197X_2 - 0.203X_3 - 0.060X_4 - 0.198X_5 + 0.504X_7 + 0.021X_8$

Where,

Y - % of Cost Overrun with Total BoQ (w/o contingency)
X_1 - % of Contribution by Preliminary & General in Original BOQ
X_2 - % of Contribution by Site Clearing in Original BOQ
X_3 - % of Contribution by Earth Work in Original BOQ
X_4 - % of Contribution by Drainage in Original BOQ
X_5 - % of Contribution by Structure in Original BOQ
X_7 - % of Contribution by Incidentals in Original BOQ
X_8 - % of Contribution by Day Works in Original BOQ

- However, out of the entered variables % Road Pavement has been excluded by the program due to the unusual behavior of these data with others.

5.5 Discussions

The change in project cost, or cost growth, occurs due to many factors, some of which are related to each other, and all are associated with some form of risk. This analysis of cost over-run risk factors was carried out on 34 highway construction projects (21 projects having detailed breakdowns and 13 projects without detailed breakdowns) between 2000 and 2010 whose initial estimated project cost was more than SLR100.0 Mn and whose final cost exceeded the original estimate by greater than 10%. The highway projects were analyzed by means of a systematic review of each project and the cost overrun reasons documented for each project. A list of 9 cost overrun factors was obtained and subsequently, they were reduced to 6 most significant cost overrun factors.

Every human activity involves risk and therefore success or failure of any activity depends on how we deal with it. The construction industry has more tendencies for risk and uncertainty than most other industries. However, these risks are not always dealt with properly by the industry.

Saman Kelegama and Deshal de Mel reported that, according to Mills (2001), the productivity, performance, quality and cost of the project are affected by the risk. Edward and Bowen (1998) identified risk management as an important tool to cope with construction risks and to overcome above problems of a project. Dey (2002) also shows that there are many examples of non-achievement of time, cost and quality of projects due to the absence of risk management techniques in project management. Therefore, the success parameters of a construction project, namely, the timely completion, staying within the specified budget, and achieving requisite performance would depend upon the capability of each party in risk management. Baker et al. (1999a) argued that risk management is also useful in maximizing profits. The construction industry however has been very slow in moving towards understanding the benefits of risk management (Flanagan and Norman, 1993; Raftery, 1994; and Ward et al., 1999).

The Road Development Authority (RDA) of Sri Lanka, due to the ever-increasing traffic volume, is planning for the future development of a national highway network. Road projects however often confront many uncertainties due to factors such as the lack of resource availability, the physical, economic and political environments, statutory regulations, etc. According to Wang and Chou (2003), such risks have a significant effect on the outcome of a road construction process.

Proper risk allocation in construction contracts will reduce the impacts of adverse conditions, and increase efficiency and effectiveness in management (Barnes, 1983; Abrahamson, 1984; Thompson and Perry, 1992; McCallum, 2000; Rahman and Kumaraswamy, 2002). Risk allocation upon risk handling of road projects in Sri Lanka has not been satisfactorily established because of different interpretations of risk allocation between owners and contractors. This research highlights the significance of understanding proper risk allocation between contractual parties in Sri Lankan road projects by changing percentage of contingency component. It aims at assisting Sri Lankan road contractors and employers to

a) Identify the risk sources inherent in road projects,
b) Understand their risk responsibilities,
c) Improve their risk handling strategies so that they would optimize the scarce resources
d) Enhance the socio-economic value of Sri Lankan road projects.

Only the important elements of this procedure are discussed in terms of their relevance to the stipulated objectives of this research.

However, it could not find a direct and strong relationship from this analysis due to the discussed variables. But having considered the pattern of cost overrun of the identified cost overrun factors, some significant remedial measure can be taken.

When the cost overrun factor of structure cost is considered, it depends on with terrain condition. While the flat terrains claims less cost variation, rolling or hilly terrains high variation. But it depends with the attributes of the administration officials. Hence, this relationship cannot be defined.

Similarly, when the cost overrun factor of pavement cost is considered, the hidden relationship can be identified. That is high variation of pavement cost in ICB (International Competitive Bidding). This is significant in the category of locally experienced international contractors. In this regard, the contractor bids lower values to most of BoQ items, other than pavement construction materials and wins the contract. Subsequently, he makes his maximum effort to prove technically the pavement design is as inadequate or erroneous through a recognized professional body. Then, the pavement design is amended, resulting high cost variation. But it cannot be logically proved because the involving parties had approached the problem systematically.

5.6 Conclusions and Recommendations

It is important to identify the factors affecting the increase in cost during the implementation. The project budget then becomes a more realistic representation to the client to afford it. It is a fact that, some of the project uncertainties can be eliminated or clarified as the planning of the project matures, however some uncertainties will be carried forward to project tender stage.

As per Garry D.Credy, (2006), some of project uncertainties will be eliminated and clarified at the planning stage. They will be carried forward to project tender stage. But some uncertainties cannot be identified at planning stage. In this regard, the clients of many construction projects add a contingency allowance to the estimated cost for the purpose of avoiding cost overrun arising from unexpected events. The contingency can appear in many forms. It may be a time allowance in the program of work for delay due to wet weather etc, a cost allowance in the project cost estimate for residual risks accepted by the project or a contingency process in case an event happens.

Cost contingency is included within a budget to represent the total financial commitment for a project client and the quantum of such contingency is of critical importance to the projects. It is a normal practice that, maintaining 10% contingency for total cost overrun factors. But this thesis has proved that, it is incorrect and different allowances should be maintained. In this regards, the under mentioned relationship defined at Chapter 4.5.3.4 is recommended to be adopted.

$$\mathbf{Y = 46.321 - 0.458X_1 + 0.197X_2 - 0.203X_3 - 0.060X_4 - 0.198X_5 + 0.504X_7 + 0.021X_8}$$

Where,

Y	-	% of Cost Overrun with Total BoQ (w/o contingency)
X_1	-	% of Contribution by Preliminary & General in Original BOQ
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X_4	-	% of Contribution by Drainage in Original BOQ
X_5	-	% of Contribution by Structure in Original BOQ
X_7	-	% of Contribution by Incidentals in Original BOQ
X_8	-	% of Contribution by Day Works in Original BOQ

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LIST OF ANNEXTURES