Risk Assessment from Stakeholder's Perspectives in Small Scale Construction Projects

Project Report

Submitted by

Rohan Varun Das	110904702
Rijul Rastogi	110904999
Ankit Saraf	110904722
Sumati Banthia	100904179

Under the guidance of

Ms. Sowmya Rao G S
Asst.Professor, Department of Civil Engineering

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CERTIFICATE

This is to certify that the project titled **RISK ASSESSMENT FROM STAKEHOLDER’S PERSPECTIVES IN SMALL SCALE CONSTRUCTION PROJECTS** is a record of the bonafide work done by **ANKIT SARAF** (110904722), **RIJUL RASTOGI** (110904999), **SUMATI BANTHIA** (100904179) and **ROHAN VARUN DAS** (110904702) submitted in partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering (B.E) in Civil Engineering by Manipal Institute of Technology Manipal, Karnataka (A Constituent College of Manipal University), during the academic year 2014 – 2015.

Ms. Sowmya Rao G S
Project Guide

Dr. Mohandas Chadaga
HOD, Dept. of Civil Engineering

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ABSTRACT

Risk management is a scientific tool that targets at identifying sources of risk and uncertainty, determining their impact, and developing suitable and applicable management responses. Managing risks in construction projects has been acknowledged as an imperative management process in order to accomplish the project objectives in terms of time, cost, quality, safety and environmental sustainability.

This report uses a systematic and holistic approach to identify risks and investigate the probability of occurrence and impact levels of these risks. The report aims to identify and analyse the risks related with the development of construction projects from the perspectives of project stakeholders. Questionnaire surveys were used to collect the facts and data. Based on a comprehensive valuation of the possibility of occurrence and their impact levels on the project objectives using Shen's mathematical formula for finding significant risk factor, software such as IBM SPSS Statistical Data Editor and IBM Sample Power 3 for analysing the vast data collected, this report identifies several major risk factors.

In the construction industry, "Tight project schedule" is recognized to influence all project objectives maximally, whereas other factors such as "design variations", "excessive approval procedures in administrative government departments", "high performance/quality expectation", and "unsuitable construction program planning" are deemed to impact only some of the project objectives. These risks are spread through the whole project life cycle and many risks occur at more than one phase, with the construction stage as the most risky phase, followed by the feasibility stage. The report also tries to establish that clients, contractors and government bodies must work cooperatively in order to address potential risks in time.

The research methodology selected for this risk management project comprises a comprehensive literature review, a detailed questionnaire to the construction industry practitioners and a statistical analysis of the survey data using risk significant index.

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CHAPTER 1
INTRODUCTION

This chapter provides an introduction to the said project. The background and motivation have been discussed. An account of the literature review in carrying out the project has been illustrated. This chapter also provides discussion on the main work objective of the project along with the details on the chapter wise organization of this report.

1.1 Background and Motivation

Primary inspiration behind the project is to work in the area of risk management in the construction industry. The purpose of this project is to identify key risks involved in construction projects and how the risk management process is used in the construction industry. According to the Project Management Institute, project risk management is one of the nine most critical parts of project commissioning. This indicates a strong relationship between managing risks and project success. While risk management is described as the most difficult area within construction management, its application is promoted in all projects in order to avoid negative consequences.

The technical background and relevance stems from the need of an efficient risk management process. To understand the concept of risk management and the risk management process, investigating how the sector manages risks and facilitates the use of risk management are important aspects.

The construction industry operates in a very uncertain environment where conditions can change due to the complexity of each project. The aim of each organization is to be successful and risk management process can facilitate it. However it should be duly noted that risk management is not a tool which ensures success but rather a tool which helps to increase the probability of achieving success. Risk management is therefore a proactive rather than a reactive concept.

1.2 Literature Review

The Literature has been divided into two main parts. The first part introduces the concept of risk management and various definitions of the terms used in the process. The second part comprises of the conclusions reached by several notable studies that have been conducted in the past.

Risks faced in the construction industry vary in nature and aspects and all different impacts on a project. However, in spite of this, risk management is not widely used within the construction industry.

- Concept of Risk Management -

Many definitions of risks and risk management have been developed, and each author provides his own perception of what risk means and how to manage it. According to Samson, 2009 - this description depends on the profession, project and type of business. Risk management thus, is a very broad subject and definitions of risk can therefore differ and be difficult to apply in all industries in general.

- Definitions of Risk -

Risk is a term which must be clearly understood to get a grasp of the concepts in the literature covering the Risk Management field. A literature research in this aspect yielded a number of definitions which have been compiled as follows –

- According to Winch, 2002 - Stages where there is a lack of information, but by looking at past experience, it is easier to predict the future. Events where the outcome is known and expected.
- Claden, 2009, states - Risk is the statement of what may arise from that lack of knowledge. Risks are gaps in knowledge which we think constitute a threat to the project.

- Benefits of Risk Management -

The benefits of Risk Management as highlighted in the studies by authors noted above are -

- The main incentives are clear understanding and awareness of potential risks in the project. In other words, risk management contributes to a better view of possible consequences resulting from unmanaged risks and how to avoid them. (Thomas, 2009)

- The risk management also provides a procedure which can reduce possible and sudden surprises. (Cooper et al, 2005)
- A benefit of working with risk management is increased level of control over the whole project and more efficient problem solving processes which can be supported on a more genuine basis. (Perry, 1986)

According to a Winch study in 2002 - Within the RM process approach, three company's approaches can be distinguished as follows -
The first one is the risk-natural firm which does not invest much in risk management but is still aware of the most important risks. The second approach is the risk-averse, where no investments are made in order to reduce the probability of occurrence of risk. The last one is the risk-seeker where the organization is prepared to face all risks and is often called gambler.

- Limits of Risk Management -

- A 2010 Darnall & Preston study relates the level of risk to project complexity. The bigger the project is, the larger the number of potential risks that may be faced.
- Golde & Joyce in a 2002 study state that several factors can stimulate risk occurrence. Those most often mentioned in the literature are financial, environmental, time, design and quality. Other influences on the occurrence of risk are the level of technology used and the organization's risks.

- Risks in Construction Projects –

Due to the nature of the construction sector, Risk Management is a very important process here. It is most widely used in those projects which include high level of uncertainty. Several notable points in this regard are as follows –

- To make sure that the project objectives are met, the portfolio of risks associated with all actors across the project life cycle should be considered. (Cleland and Gareis, 2006)
- To keep track of previously identified threats, will result in early warnings to the project manager if any of the objectives, time, cost or quality, are not being met. (Tummala and Burchett, 1999)
- Changes in design and scope along with time frames for project completion are the most common risks for the construction sector. The further in the process, changes in scope or design are implemented, the more additional resources, time and cost, those changes require. Project completion ahead of time may be as troublesome as delays in a schedule. (Gould and Joyce, 2002).

1.3 Objectives

The main objective is to identify the potential key risks from the perspectives of stakeholders through a comprehensive questionnaire survey in terms of cost, time, quality, safety and environment and a statistical analysis of the survey data.

1.4 Organization of the Project Report (Chapter Wise)

This report is organised in the following manner:
Chapter 1 provides a brief introduction to the project and subsequently discusses the primary motivation and background to the project. Further to that, the chapter enunciates the primary objective of the project.

Chapter 2 provides the detailed background theory to the project. Detailed buck converter operation in continuous conduction mode has been explained along with relevant equations and waveforms followed by a brief discussion on the buck converter power stage small signal modelling.

Chapter 3 discusses the methodology employed in the project. The detailed small signal analysis has been provided. The details of the controller selection and design steps have been enunciated. Also an account of the inductor design has been provided in this chapter.

Chapter 4 discusses the various simulation results and the inferences drawn from them.

Chapter 5 provides an account of the conclusions drawn from the project work and also discusses the future modifications possible in terms of the further extension of the project.

CHAPTER 2

BACKGROUND THEORY

Substantive research has been done in the field of risk management for construction projects, a significant outcome of which is the identification of many risks that may influence the construction project delivery. Chen *et al.* (2004) proposed 15 risks concerned with project cost and divided them into three groups: resources factors, management factors and parent factors. Through a case study on the West Rail Project of Hong Kong, Chen found that “price escalation of material” pertaining to resource factors, “inaccurate cost budget” and “supplier or subcontractors’ default” pertaining to management factors, and “excessive interface on project management” pertaining to parent factors are the most significant risks in this particular project. Summarizing other researchers’ work, Shen (1997) identified eight major risks accounting for project delay and ranked them based on a questionnaire survey with industry practitioners. Shen also proposed risk management actions to cope with these risks and validated their effectiveness through individual interview surveys. Tam *et al*. (2004) conducted a survey to examine the elements of poor construction safety management in China and as a result, identified the main factors affecting safety performance including “poor safetyawareness of top management”, “lack of training”, “poor safety awareness of project managers”, “reluctance to input resources to safety” and “reckless operation”. While the above research studied the diverse risks influencing the project objectives in terms of cost, time and safety, other research examined the risks or risk management in different phases of a project. Uher and Toakley (1999) investigated various structural and cultural factors concerned with the implementation of risk management in the conceptual phase of a project life cycle and found that while most industry practitioners were familiar with risk management, its application in the conceptual phase was relatively low; qualitative rather than quantitative analysis methods were generally used; widespread adoption of risk management was impeded by a low knowledge and skill base, resulting from a lack of commitment to training and professional development. Chapman (2001) translated the risks described within the Central Computer and Telecommunications Agency Publication “Management of Project Risk” into the design risks which included but were not limited to “difficulty in capturing and specifying the user requirements”, “difficulty of estimating the time and resources required to complete the design”, “difficulty of measuring progress during the development of the design”. Chapman also stated that the design team’s in-depth knowledge of the sources of risk can greatly influence the identification of risks in the design phase of a project. Abdou (1996) classified construction risks into three groups, i.e. construction finance, construction time and construction design, and addressed these risks in detail in light of the different contractual relationships existing among the functional entities involved in the design, development and construction of a project.

Risk classification is a significant step in the risk management process, as it attempts toStructure the diverse risks affecting a construction project. In order to manage risks effectively, many approaches have been suggested in the literature for classifying risks. Perry and Hayes (1985) presented a list of factors extracted from several sources which were divided in terms of risks retainable by contractors, consultants and clients. Combining the holistic approach of general systems theory with the discipline of a work breakdown structure as a framework, Chapman (2001) grouped risks into four subsets: environment, industry, client and project. Of the 58 identified risks associated with Sino-Foreign construction joint ventures, Shen (2001) categorized them into six groups in accordance with the nature of the risks, i.e. financial, legal, management, market, policy and political, as well as technical risks. In a word, many ways can be used to classify the risks associated with construction projects and the rationale for choosing a method must service the purpose of the research. In this paper, the research team aims to seek to study the risks from the perspective of project stakeholders, and hence classifies the risks in accordance with their origins concerned with stakeholders.

2.1 ONE-SAMPLE T-TEST

A t-test is any statistical hypothesis test in which the test statistic follows a Student's t distribution if the null hypothesis is supported. The one-sample t-test is used to determine whether a sample comes from a population with a specific mean. This population mean is not always known, but is sometimes hypothesized.

In testing the null hypothesis that the populations mean is equal to a specified value μ_0, one uses the statistic

$$t = \frac{\overline{x} - \mu_0}{s/\sqrt{n}}$$

where $\overline{x}$ is the sample mean, s is the sample standard deviation of the sample and n is the sample size. The degrees of freedom used in this test are $n - 1$. Although the parent population does not need to be normally distributed, the distribution of the population of sample means, $\overline{x}$, is assumed to be normal. By the central limit theorem, if the sampling of the parent population is independent then the sample means will be approximately normal. [(The degree of approximation will depend on how close the parent population is to a normal distribution and the sample size, *n*.)

The one-sample t-test is also used when we want to know whether our sample comes from a particular population but we do not have full population information available to us. For instance, we may want to know if a particular sample of college students is similar to or different from college students in general. The one-sample t-test is used only for tests of the sample mean. Thus, our hypothesis tests whether the average of our sample (M) suggests that our students come from a population with a known mean (m) or whether it comes from a different population.

The statistical hypotheses for one-sample t-tests take one of the following forms, depending on whether your research hypothesis is directional or non-directional.

The name of the one-sample t-test tells us the general research design of studies in which this statistic is selected to test hypotheses. We use the one-sample t-test when we collect data on a single sample drawn from a defined population. In this design, we have one group of subjects, collect data on these subjects and compare our sample statistic (M) to the population parameter (m). The population parameter tells us what to expect if our sample came from that population. If our sample statistic is very different (beyond what we would expect from sampling error), then our statistical test allows us to conclude that our sample came from a different population. Again, in the one-sample t-test, we are comparing the mean (M) calculated on a single set of scores (one sample) to a known population mean (m).

The one-sample t-test compares a sample to a defined population. When we say "defined" population, we are saying that the parameters of the population are known. We typically define a population distribution in terms of central tendency and variability/dispersion. But, for a one-sample t-test, only the population m is known. The one-sample t-test cannot be done if we do not have m . The population s is not required for the one-sample t-test. All t-tests estimate the population standard deviation using sample data (S). Population means are available in the technical manuals of measurement instruments or in research publications. Population information for the attachment scales used in the class dataset is available in the articles on reserve.

2.2 Cronbach’s Alpha

To check the internal consistency, that is, how closely related a set of items are as a group, we ran a Reliability test in SPSS, to find the Cronbach's alpha value is found out.

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability. A "high" value for alpha does not imply that the measure is unidimensional. If, in addition to measuring internal consistency, you wish to provide evidence that the scale in question is unidimensional, additional analyses can be performed. Exploratory factor analysis is one method of checking dimensionality. Technically speaking, Cronbach's alpha is not a statistical test - it is a coefficient of reliability (or consistency). Cronbach's alpha can be written as a function of the number of test items and the average inter-correlation among the items.

CHAPTER 3
METHODOLOGY

The research methodology selected for this risk management project comprised a comprehensive literature review, a questionnaire survey to the construction industry practitioners and a statistical analysis of the survey data using Shen's formula and statistical analysis software IBM SPSS and SPSS Sample Power.

The questionnaire consisted of two sections. Section 1 solicited general information about the respondents. Section 2 carried a total of 37 risks associated with construction projects and asked respondents to review and indicate the likelihood of occurrence of these risks as highly likely, likely or less likely and the level of impact on each project objective that would result in as high, medium or low. These risks were mainly sourced from Chapman (2001) and Wang and Liu (2004) and to the best of the authors' knowledge, were put into five categories –

i. Cost
ii. Time
iii. Quality
iv. Environment
v. Safety

The research team conducted the survey from March to April 2015. Prior to disseminating the questionnaire, a pilot study was conducted for validation with 5 respondents to test whether the questions are intelligible, easy to answer, unambiguous, and reliable etc.

To check the internal consistency, that is, how closely related a set of items are as a group, we ran a Reliability test in SPSS, to find the Cronbach's alpha value of each of the five Project objectives.

Category	Cronbach's alpha
Cost	0.89
Time	0.81
Quality	0.71
Environment	0.77
Safety	0.85

Table 3.1 - Cronbach's alpha values of Categories

A reliability coefficient of 0.70 or higher is considered "acceptable" in most social science research situations and as the alpha coefficient for each of the five categorieswas greater than 0.70 , suggesting that the items have relatively high internal consistency.

Valuable feedbacks were also obtained to improve the quality of the questionnaire. After a small refinement, the questionnaires were distributed to 30 construction practitioners in Manipal and Udupi. After five- week waiting period, 18 feedbacks were received in which 3 feedbacks were identified as invalid due to incomplete or invariable answers.

3.1 Sample Composition

The respondents were all industry practitioners, including public and private developers, project managers, main contractors and subcontractors, consultants and engineers, They had an average of 7 years' work experience in the construction sector, Furthermore, all respondents have received tertiary education. Their positions, long work experience and tertiary educational background infer that the respondents have adequate knowledge of construction projects and the associated risks.

3.2 One-Sample T-Test Using SPSS

A one-sample t-test was run to determine whether the responses to the factors we have taken into account in the Questionnaire Survey was different to normal, defined as the Test value. The Test values of the factors taken into account were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$) and there were no outliers in the data, as assessed by inspection of a boxplot. There were statistically insignificant difference between means ($p >.05$). By default, SPSS uses 95% confidence intervals (labeled as the Confidence Interval Percentage in SPSS). This equates to declaring statistical significance at the $p > .05$ level. The null hypothesis is rejected if the p-value is less than the significance or α level. The α level is the probability of rejecting the null hypothesis given that it is true (type I error) and is most often set at **0.05** (**5%**).

Moving from left-to-right, you are presented with the observed *t*-value ("**t**" column), the degrees of freedom ("**df**"), the statistical significance (*p*-value) ("**Sig. (2-tailed)**") of the one-sample t-test ,and the test value .In all the factors taken into account p>.05. Therefore, it can be concluded that the population means are statistically insignificantly different. When $p > .05$, the difference between the sample-estimated population mean and the comparison population mean would not be statistically significantly different.

T	Indicates the obtained value of the t-statistic (t-value)
(df)	Indicates the degrees of freedom, which is N – 1
Sig.(2-tailed)	Indicates the probability of obtaining the observed t-value if the null hypothesis is correct.

Table 3.2 -T-test Parameters

One Sample T test

	t	(df)	Sig. (2-tailed)	Test Value	95% Confidence Interval of the Difference
TIGHT SCHEDULE	-4.000	4	.060	1.20000	-19.3553
DESIGN VARIATIONS	-4.000	4	.079	1.20000	-19.3553
UNSUITABLE PLANNING	-5.118	4	.080	1.60000	-19.0801
DISPUTE	-5.934	4	.059	1.40000	-19.2801
PRICE INFLATION	-4.000	4	.065	1.20000	-19.3553
INACCURATE ESTIMATE	-5.934	4	.071	1.40000	-19.2801
INADEQUATE SCHEDULING	-5.118	4	.056	1.60000	-19.0801
EXCESSIVE APPROVALS	-5.118	4	.073	1.60000	-19.0801
TIGHT SCHEDULE	-4.000	4	.064	1.20000	-19.3553
DESIGN VARIATIONS	-5.934	4	.089	1.40000	-19.2801
UNSUITABLE PLANNING	-4.000	4	.079	1.20000	-19.3553
INADEQUATE SCHEDULE	-5.118	4	.066	1.60000	-19.0801
BUREAUCRACY	-5.118	4	.062	1.60000	-19.0801
PROJECT VARIATIONS	-4.000	4	.056	1.20000	-19.3553
TIGHT SCHEDULE	-5.118	4	.060	1.60000	-19.0801
INADEQUATE SCHEDULE	-5.118	4	.051	1.60000	-19.0801
INACCURATE ESTIMATE	-5.118	4	.082	1.60000	-19.0801
LOW SUBCONTRACTOR COMPETENCE	-5.934	4	.066	1.40000	-19.2801
HIGH EXPECTATION	-5.934	4	.054	1.40000	-19.2801
DESIGN VARIATIONS	-5.934	4	.087	1.00000	-19.2801
TIGHT SCHEDULE	-1.000	4	.080	1.40000	-18.7553
PROGRAM VARIATIONS	-5.118	4	.075	1.60000	-19.0801
INSUFFICIENT PROFFESIONALS	-4.000	4	.061	1.20000	-19.3553
LESS SITE INFORMATION	-5.934	4	.077	1.40000	-19.2801

Table 3.3 -One Sample T-test Output

Conclusion: No statistically significant difference was found between the Test values. It means that despite the difference encountered, the variables are practically significant.

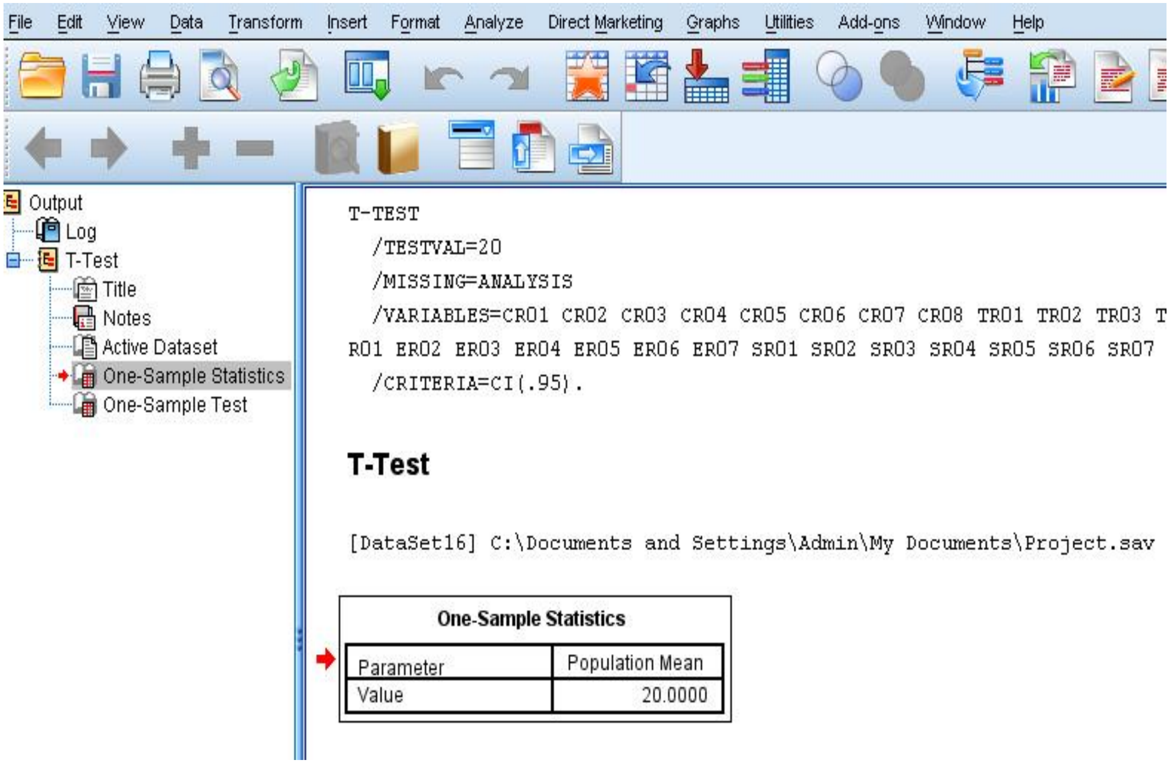

Figure 3.1- T-test Population Mean

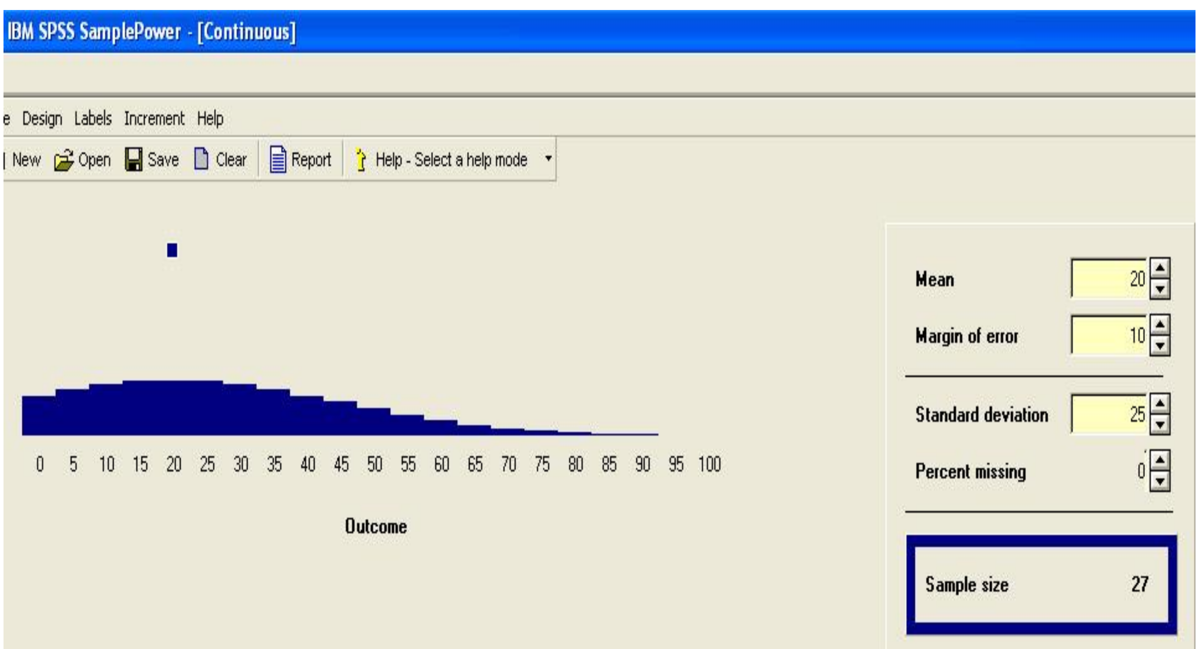

Figure 3.2 – Sample Size

By inputting the value of the Mean Population (i.e.20) which was found out from the aforementioned T-test, in the software SPSS Sample Power 3, the sample size of the survey was found out to be 27. So a Survey of sample size 30 was undertaken for this project.

3.3 Data Analysis Method

The survey feedback includes two groups of data, the likelihood of occurrence of each risk and its level of impact on project objectives in terms of cost, time, quality, environment and safety. The risk significant index developed by Shen et al. (2001) was used in this research. With respect to the impact on a particular project risk factor the significance score for each risk assessed by each respondent can be calculated through Equation (1).

$$r_{ij}^{k} = \alpha_{ij}\beta_{ij}^{k} \qquad (1)$$

Where

- r^k_{ij}=significance score assessed by respondent j for the impact of risk i on project objective k ;
- i=ordinal number of risk, i ε (1, 88)
- k=ordinal number of project objective, k ε (1, 5)
- j = ordinal number of valid feedback to risk i, j ε (1, n)
- n = total number of valid feedbacks to risk i
- α_{ij} = likelihood occurrence of risk i, assessed by respondent j
- β_{ij}^k = level of impact of risk i on project objective k, assessed by respondent j .

The average score for each risk considering its significance on a project objective can be calculated through Equation (2). This average score is called the risk significance index score and will be used to rank among all risks on a particular project objective.

$$R_i^k = \frac{\sum_{j=1}^{n} r_{ij}^k}{n} = \frac{1}{n}\sum_{j=1}^{n} \alpha_{ij}\beta_{ij}^k \qquad (2)$$

where R_i^k = significance index score for risk i on project objective k .

The three-point scales for a (highly likely, likely and less likely) and b (high level of impact, medium level of impact and low level of impact) need to be converted into numerical scales. According to Shen et al. (2001) and Wang and Liu (2004), “high” or “highly” takes a value of 1, “medium” takes a value of 0.5, and “less” or “low” takes a value of 0.1. The matrix presented in the table below shows the calculation of the risk significance index.

a β	High Level Of Impact (1.0)	Medium Level of Impact (0.5)	Low Level of Impact (0.1)
Highly Likely (1.0)	1.00	0.50	0.10
Likely (0.5)	0.50	0.25	0.05
Less Likely (0.1)	0.1	0.05	0.01

Table 3.4 – Risk Significance Index Calculation

The index scores will be used to rank risk factors in the following section. Please note that the method for calculating the significance index score may overlook those risks with a less likelihood of occurrence but a high level of impact on project objectives, which should be taken into account in the risk management practice and however not the focus of this research was.

3.4 Survey Results (Part-1)

After getting a feedback from the first 17 respondents that our Questionnaire is too long and time consuming, this caused a considerable delay in collection of data with respect to our estimated timeline. In order to complete the project on time, we decided to eliminate few factors based on the data extracted from the responses of the first fifteen respondents.

Following are the Frequency tables of few of the factors.

Frequency Tables of Some of the Eliminated Risk Factors

DISPUTE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	4	26.7	26.7	26.7
	Likely	9	60.0	60.0	86.7
	Highly Likely	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

Table 3.5

PRICE INFLATION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	1	6.7	6.7	6.7
	Likely	10	66.7	66.7	73.3
	Highly Likely	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

Table 3.6

EXCESSIVE APPROVALS -

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	4	26.7	26.7	26.7
	Likely	5	33.3	33.3	60.0
	Highly Likely	6	40.0	40.0	100.0
	Total	15	100.0	100.0	

Table 3.7

BUREAUCRACY -

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	1	6.7	6.7	6.7
	Medium	12	80.0	80.0	86.7
	High	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

Table 3.8

LOW SUBCONTRACTOR COMPETENCE -

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	5	33.3	33.3	33.3
	Medium	10	66.7	66.7	100.0
	Total	15	100.0	100.0	

Table 3.9

SKILLED LABOR UNAVAILIBILTY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low	3	20.0	20.0	20.0
	Medium	11	73.3	73.3	93.3
	High	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Table 3.10

List of R_i^k values of the Risk Factors computed from first 15 responses

Risk Factors	R_i^k
Tight Project Schedule – CR01	0.66
Design Variations – CR02	0.563
Unsuitable Planning – CR03	0.56
Occurrence of a Dispute – CR04	0.237
Price Inflation - CR05	0.294
Inaccurate Cost Estimate – CR06	0.49
Inadequate Scheduling – CR07	0.394
Excessive Approvals- CR08	0.192
Tight Project Schedule – TR01	0.66
Design Variations – TR02	0.766
Unsuitable Planning – TR03	0.293
Inadequate Program Scheduling – TR04	0.084
Bureaucracy – TR05	0.200
High Performance Expectations – TR06	0.340
Variation in Project – TR07	0.248
Tight Project Schedule – QR01	0.716
Inadequate Program Scheduling – QR02	0.670
Inaccurate Cost Estimate - QR03	0.236
Low Subcontractor Competence – QR04	0.160
High Performance Expectations – QR05	0.363
Skilled Labor Unavailability – QR06	0.146
Design Variations – QR07	0.188
Tight Project Schedule – ER01	0.097
Variations in Const Programs – ER02	0.630
Insufficient Professionals – ER03	0.028
Less Site Info – ER04	0.426
High Noise Pollution – ER05	0.197
Excessive Approvals – ER06	0.256
Low Subcontractor Competence – ER07	0.205
Tight Project Schedule – SR01	0.373

General Safety Accident Occurrence – SR02	0.546
High Quality Expectations – SR03	0.770
Variations in Const Program – SR04	0.586
Quality Control – SR05	0.280
Low Subcontractor Competence – SR06	0.188
Skilled Labor Unavailability – SR07	0.400
Insufficient Professionals – SR08	0.490

Table 3.11- List of R_i^k values of the Risk Factors computed from first 15 responses

The above mentioned twelve Risk factors were eliminated from the five categories, as they were found to have the lowest R_i^k in their respective categories -

i. Occurrence of dispute
ii. Price Inflation
iii. Excessive Approvals
iv. Inadequate Program Scheduling
v. Bureaucracy
vi. Low Subcontractor Competence
vii. Skilled Labour Unavailability
viii. Tight Project Schedule
ix. Insufficient Professionals
x. Quality Control
xi. Tight Project Schedule
xii. Low Subcontractor Competence

Based on the data extracted from the 15 responses, we computed the Risk Significant Index of all the risk factors taken into account in this Project. After computing the Risk Significant Index , we arranged the risk factors in descending order and eliminated the factors with low Risk Significant Index from each of the five categories, which brought the total number factors to 25 (i.e. 5 factors in each category) from 37, thereby reducing considerable amount of time taken to complete the questionnaire.

A new Questionnaire was formed, after removing the above mentioned Risk factors and was distributed to acquire the remaining number of required responses.

By the last week of May 2015, we had received all of the required 30 responses from various builders, construction firms and individuals. After sorting through the Questionnaires for any missing data, the responses were put in IBM SPSS to extract relevant information from the vast raw data.

CHAPTER-4

RESULT ANALYSIS

All risks observed in the questionnaire can happen to any construction project. The main Purpose of this investigation was not to categorize a list of risks but to determine the key risks that can significantly influence the completion of construction projects. Hence, only the top five ranked ones are chosen as key risks in line with other similar research (Tam et al., 2004). Disregarding the risk category, all risks are ranked in accordance with the index scores measuring their significance on the project objectives i.e. cost, time, quality, environment and safety.

In doing so, two straight forward methods are applicable: (1) ranking as per each risk's accumulative significance score on all five project objectives and (2) ranking as per each risk's significance score on individual project objective. For the former method, risks with significant impact on a particular project objective are likely to be neglected as the significance is usually offset by their lower level of impact on other project objectives.

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4.1 SUMMARY OF FINAL COMPLETED SURVEY

Table 4.1 – Response Summary of top 2 risks from Each Category-1

	TIGHT SCHEDULE - CR01	DESIGN VARIATIONS - CR02	DESIGN VARIATIONS - TR02	TIGHT SCHEDULE - TR01	PROGRAM SHEDULING - QR02
1	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
2	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
3	Highly Likely	Highly Likely	Highly Likely	Likely	Highly Likely
4	Highly Likely	Highly Likely	Highly Likely	Likely	Highly Likely
5	Highly Likely	Highly Likely	Likely	Highly Likely	Highly Likely
6	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
7	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
8	Likely	Likely	Highly Likely	Highly Likely	Likely
9	Highly Likely	Less Likely	Highly Likely	Highly Likely	Likely
10	Highly Likely	Less Likely	Likely	Highly Likely	Likely
11	Less Likely	Likely	Highly Likely	Highly Likely	Likely
12	Likely	Highly Likely	Likely	Highly Likely	Likely
13	Likely	Highly Likely	Likely	Highly Likely	Likely
14	Likely	Likely	Likely	Highly Likely	Highly Likely
15	Highly Likely	Likely	Likely	Highly Likely	Highly Likely
16	Highly Likely	Likely	Likely	Likely	Highly Likely
17	Highly Likely	Highly Likely	Likely	Highly Likely	Likely
18	Highly Likely	Highly Likely	Likely	Highly Likely	Likely
19	Highly Likely	Likely	Likely	Highly Likely	Less Likely
20	Highly Likely	Likely	Less Likely	Likely	Likely
21	Likely	Highly Likely	Likely	Likely	Likely
22	Less Likely	Likely	Highly Likely	Less Likely	Less Likely
23	Likely	Highly Likely	Likely	Less Likely	Likely
24	Highly Likely	Highly Likely	Less Likely	Likely	Likely
25	Likely	Likely	Likely	Highly Likely	Highly Likely
26	Likely	Likely	Likely	Highly Likely	Highly Likely
27	Highly Likely	Highly Likely	Highly Likely	Likely	Likely
28	Likely	Likely	Highly Likely	Less Likely	Likely
29	Likely	Likely	Highly Likely	Likely	Likely
30	Highly Likely	Highly Likely	Likely	Highly Likely	Likely
Total N	30	30	30	30	30

Table 4.2 - Response Summary of top 2 risks from Each Category -2

	TIGHT SCHEDULE - QR01	PROGRAM VARIATIONS - ER01	LESS SITE INFORMATION - ER02	HIGH EXPECTATION - SR02	PROGRAM VARIATIONS - SR03
1	Likely	Highly Likely	Highly Likely	Highly Likely	Likely
2	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
3	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
4	Highly Likely	Highly Likely	Highly Likely	Highly Likely	Highly Likely
5	Highly Likely	Highly Likely	Likely	Highly Likely	Highly Likely
6	Highly Likely	Highly Likely	Likely	Highly Likely	Highly Likely
7	Highly Likely	Highly Likely	Likely	Highly Likely	Likely
8	Highly Likely	Highly Likely	Likely	Highly Likely	Likely
9	Highly Likely	Highly Likely	Likely	Highly Likely	Highly Likely
10	Highly Likely	Less Likely	Likely	Highly Likely	Highly Likely
11	Highly Likely	Less Likely	Likely	Highly Likely	Likely
12	Highly Likely	Highly Likely	Likely	Likely	Highly Likely
13	Highly Likely	Likely	Likely	Likely	Highly Likely
14	Highly Likely	Likely	Likely	Likely	Highly Likely
15	Highly Likely	Likely	Likely	Highly Likely	Likely
16	Likely	Highly Likely	Less Likely	Likely	Likely
17	Likely	Highly Likely	Likely	Highly Likely	Likely
18	Likely	Highly Likely	Less Likely	Highly Likely	Less Likely
19	Likely	Highly Likely	Likely	Less Likely	Highly Likely
20	Likely	Highly Likely	Highly Likely	Less Likely	Highly Likely
21	Likely	Likely	Highly Likely	Less Likely	Highly Likely
22	Likely	Likely	Highly Likely	Highly Likely	Likely
23	Highly Likely	Likely	Highly Likely	Likely	Likely
24	Likely	Less Likely	Likely	Highly Likely	Less Likely
25	Highly Likely	Likely	Likely	Less Likely	Less Likely
26	Less Likely	Likely	Highly Likely	Likely	Likely
27	Highly Likely	Highly Likely	Less Likely	Likely	Likely
28	Highly Likely	Likely	Less Likely	Highly Likely	Highly Likely
29	Highly Likely	Highly Likely	Highly Likely	Likely	Likely
30	Highly Likely	Likely	Likely	Highly Likely	Highly Likely
Total N	30	30	30	30	30

Table 4.3- Statistics of top 2 risks from Each Category-1

		TIGHT SCHEDULE - CR01	DESIGN VARIATIONS - CR02	DESIGN VARIATIONS - TR02	TIGHT SCHEDULE - TR01	PROGRAM SHEDULING - QR02
N	Valid	30	30	30	30	30
	Missing	0	0	0	0	0

Table 4.4 - Statistics of top 2 risks from Each Category-1

		TIGHT SCHEDULE - QR01	PROGRAM VARIATIONS - ER01	LESS SITE INFORMATION - ER02	HIGH EXPECTATION - SR02	PROGRAM VARIATIONS - SR03
N	Valid	30	30	30	30	30
	Missing	0	0	0	0	0

Frequency Tables of top 2 risks from Each Category

Table 4.5 - TIGHT SCHEDULE - CR01

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	2	6.7	6.7	6.7
	Likely	10	33.3	33.3	40.0
	Highly Likely	18	60.0	60.0	100.0
	Total	30	100.0	100.0	

Table 4.6 - **DESIGN VARIATIONS - CR02**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	2	6.7	6.7	6.7
	Likely	12	40.0	40.0	46.7
	Highly Likely	16	53.3	53.3	100.0
	Total	30	100.0	100.0	

Table 4.7 - DESIGN VARIATIONS - TR02

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	2	6.7	6.7	6.7
	Likely	15	50.0	50.0	56.7
	Highly Likely	13	43.3	43.3	100.0
	Total	30	100.0	100.0	

Table 4.8 - TIGHT SCHEDULE - TR01

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	3	10.0	10.0	10.0
	Likely	8	26.7	26.7	36.7
	Highly Likely	19	63.3	63.3	100.0
	Total	30	100.0	100.0	

Table 4.9 - **PROGRAM SHEDULING - QR02**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	2	6.7	6.7	6.7
	Likely	16	53.3	53.3	60.0
	Highly Likely	12	40.0	40.0	100.0
	Total	30	100.0	100.0	

Table 4.10 - TIGHT SCHEDULE - QR01

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	1	3.3	3.3	3.3
	Likely	9	30.0	30.0	33.3
	Highly Likely	20	66.7	66.7	100.0
	Total	30	100.0	100.0	

Table 4.11 - PROGRAM VARIATIONS - ER01

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	3	10.0	10.0	10.0
	Likely	10	33.3	33.3	43.3
	Highly Likely	17	56.7	56.7	100.0
	Total	30	100.0	100.0	

Table 4.12 - LESS SITE INFORMATION - ER02

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	4	13.3	13.3	13.3
	Likely	16	53.3	53.3	66.7
	Highly Likely	10	33.3	33.3	100.0
	Total	30	100.0	100.0	

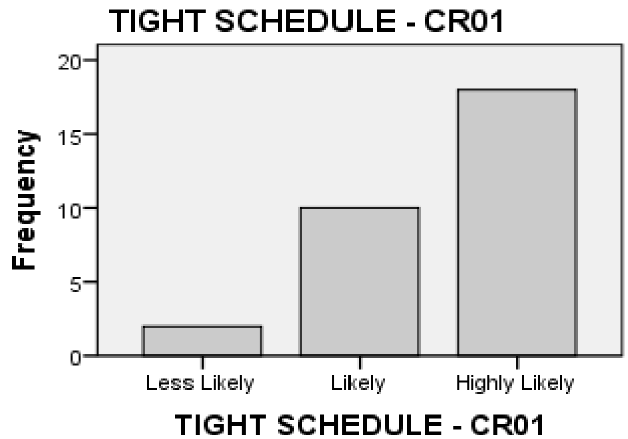
Table 4.13 - HIGH EXPECTATION - SR02

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	4	13.3	13.3	13.3
	Likely	8	26.7	26.7	40.0
	Highly Likely	18	60.0	60.0	100.0
	Total	30	100.0	100.0	

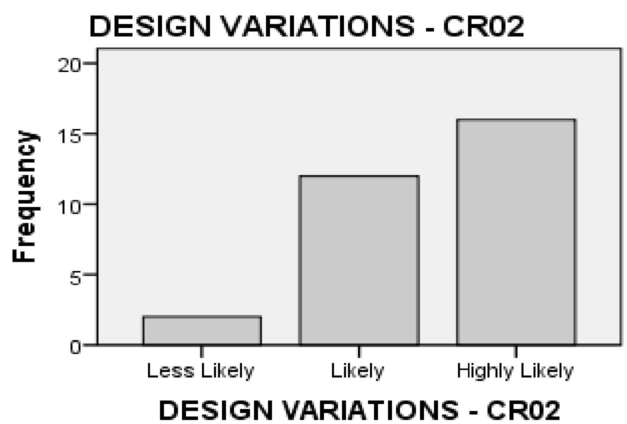
Table 4.14 - PROGRAM VARIATIONS - SR03

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less Likely	3	10.0	10.0	10.0
	Likely	12	40.0	40.0	50.0
	Highly Likely	15	50.0	50.0	100.0
	Total	30	100.0	100.0	

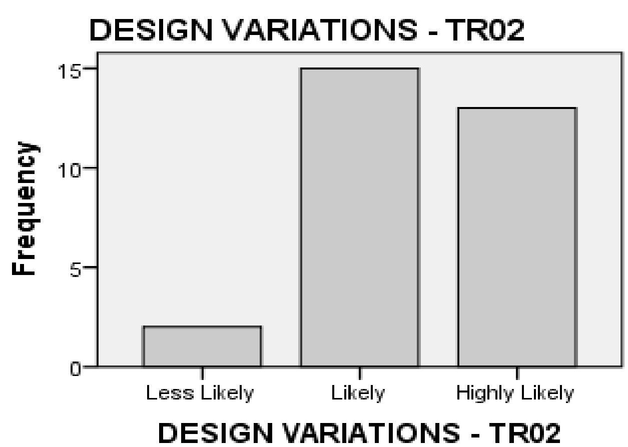
Bar Charts



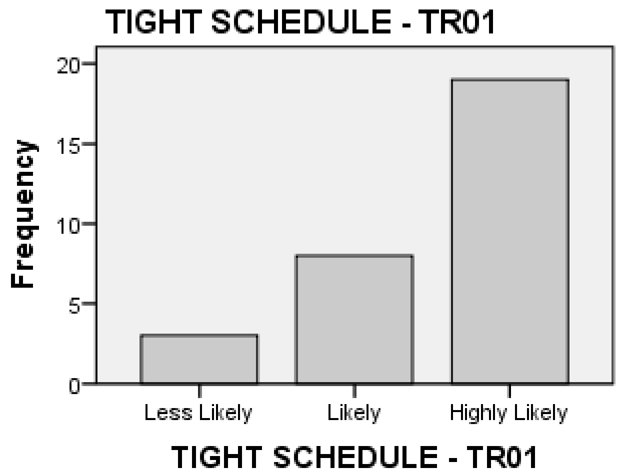
Graph 4.1



Graph 4.2



Graph 4.3



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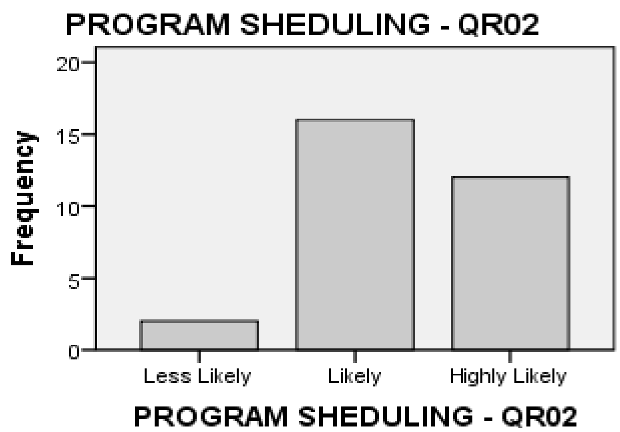

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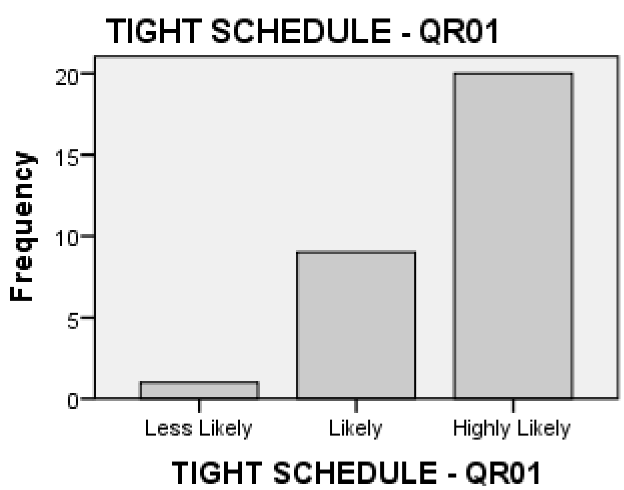

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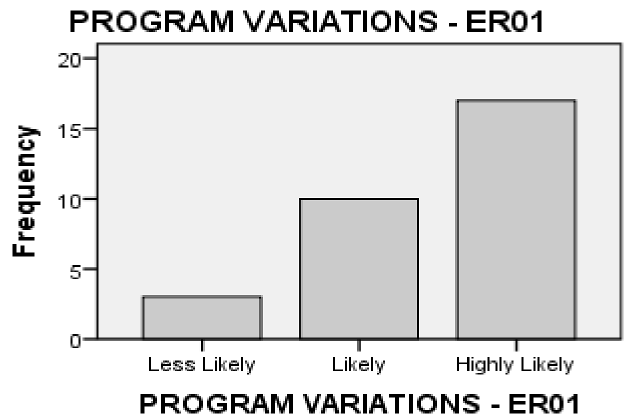

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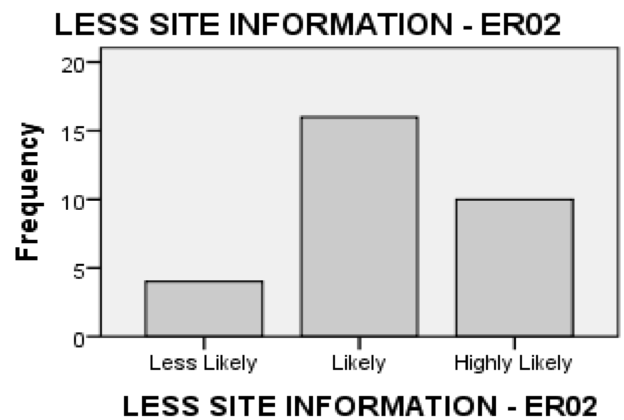
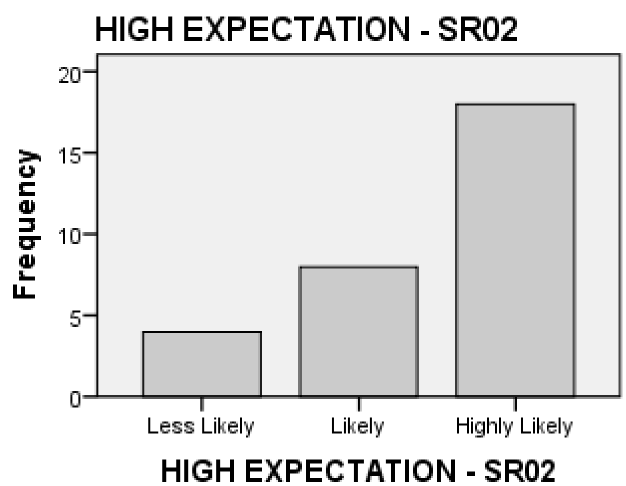


Graph 4.8



Graph 4.9

List of R_i^k values of the Risk Factors of All the Responses

	Risk Factors	R_i^k
1.	Tight Project Schedule – CR01	0.531
2.	Design Variations – TR02	0.526
3.	Inadequate Program Scheduling – QR02	0.475
4.	Design Variations – CR02	0.4715
5.	Tight Project Schedule – TR01	0.4633
6.	Tight Project Schedule – QR01	0.460
7.	High Quality Expectations – SR02	0.450
8.	Variations in Const Programs – ER01	0.425
9.	Variations in Const Program – SR03	0.421
10.	Inaccurate Cost Estimate – CR04	0.387
11.	Insufficient Professionals – SR05	0.385
12.	General Safety Accident Occurrence – SR01	0.373
13.	Unsuitable Planning – CR03	0.3685
14.	Inadequate Scheduling – CR05	0.368
15.	Less Site Info – ER02	0.3595
16.	High Performance Expectations – QR04	0.3465
17.	High Performance Expectations – TR04	0.3335
18.	Skilled Labor Unavailability – SR04	0.300
19.	Low Subcontractor Competence – ER05	0.2495
20.	Excessive Approvals – ER04	0.245
21.	Variation in Project – TR05	0.233
22.	Unsuitable Planning – TR03	0.2045
23.	High Noise Pollution – ER03	0.1865
24.	Inaccurate Cost Estimate - QR03	0.174
25.	Design Variations – QR05	0.131

Table 4.15- List of R_i^k values of the Risk Factors of All the Responses

4.2 Risk Factors: Categorically Sorted and Ranked Based on value of Risk Significant Index (**R_i^k**).

	Cost	**R_i^k**
1.	Tight Project Schedule – CR01	0.531
2.	Design Variations – CR02	0.4715
3.	Inaccurate Cost Estimate – CR04	0.387
4.	Unsuitable Planning – CR03	0.3685
5.	Inadequate Scheduling – CR05	0.368

Table 4.16

	TIME	**R_i^k**
1.	Design Variations – TR02	0.526
2.	Tight Project Schedule – TR01	0.4633
3.	High Performance Expectations – TR04	0.3335
4.	Variation in Project – TR05	0.233
5.	Unsuitable Planning – TR03	0.2045

Table 4.17

	Quality	**R_i^k**
1.	Inadequate Program Scheduling – QR02	0.475
2.	Tight Project Schedule – QR01	0.460
3.	High Performance Expectations – QR04	0.3465
4.	Inaccurate Cost Estimate - QR03	0.174
5.	Design Variations – QR05	0.131

Table 4.18

	ENVIRONMENT	R_i^k
1.	Variations in Const Programs – ER01	0.425
2.	Less Site Info – ER02	0.3595
3.	Low Subcontractor Competence – ER05	0.2495
4.	Excessive Approvals – ER04	0.245
5.	High Noise Pollution – ER03	0.1865

Table 4.19

	SAFETY	R_i^k
1.	High Quality Expectations – SR02	0.450
2.	Variations in Const Program – SR03	0.421
3.	Insufficient Professionals – SR05	0.385
4.	General Safety Accident Occurrence – SR01	0.373
5.	Skilled Labor Unavailability – SR04	0.300

Table 4.20

Our results found that Tight Project Schedule is the source of highest risk in Cost related issues of a construction with a significance index score of 0.531 that is, it causes risk in more than one out of every two projects. Tight Project Schedule is followed by Design Variations with a significance index score of 0.471 which shows that about every second projects have to make changes in their initial design which causes monetary loss to the stakeholders. They are followed by Unsuitable Planning, Inadequate Scheduling and Inaccurate Cost Estimate in the risk related risk category with significance index scores of 0.387, 0.3685 and 0.368 respectively.

In the issue of time related risk to projects, Design Variations pose the highest and most frequent risk with a significance index score of 0.526. Which is understandable since last minute changes in structural designs must cause a huge delay. It is followed up by tight project scheduling by the planning division of the company and naturally causes frequent delays with a significance index score of 0.4633. The last three risk posing factors were , in order , High Performance Expectations (0.3335) , Variations in project (0.233) and Unsuitable Planning (0.2045) .

In Quality related risk factors, the highest risk posed by Inadequate Program Scheduling with a score of 0.475 followed by Tight project schedule which has a significance impact score of 0.46. Factors with least amount of risk were , High Performance Expectations , Inaccurate Cost Estimate, Design Variations with Significance Index Score of 0.3465, 0.174 , 0.131 respectively.

On the account of environment related risk factors, variations in construction programs have a score of 0.425 . less information about the site also causes a lot of environment related risks as its significance index score is 0.3595. last three factors were low sub-contractor competence (0.2495) , Excessive approvals (0.245) and High noise pollution (0.1865)

The last category was safety related risk posed in a project. High Quality Expectations was given the highest significance index score with 0.45. It was followed by Variations in construction programs (0.421), Insufficient supply of highly trained professionals (0.385) and Skilled labor Unviability (0.3).

CHAPTER 5

CONCLUSION

More effective management of risks would be possible if these risks are managed from the perspective of a project life cycle. Accordingly, the foregoing 20 key risks are allocated into different project phases as per their possible time of occurrence. Many risks may arise in more than one phase of a construction project and hence they need to be considered in more than one phase. For example, “tight project schedule” results from clients’ expectation of carrying out the construction project against time as outlined in the feasibility report. Meanwhile, it also happens in the design phase where the designers are urged to work out the drawing and prepare the documentation quickly and in the construction phase where contractors have to reduce program schedules to catch up with the progress. Such an unrealistic schedule can heavily influence the achievement of project objectives in terms of cost, quality, environment and safety. Once accidents happen or conflictions between construction programs arise, the project schedule can be even further delayed.

As much research suggested, addressing project risks earlier rather than later in the project life cycle can minimize the negative consequence brought by the risks (Smith, 2003). Identifying the possible occurrence of risks in each stage and making appropriate actions to cope with the m are significant. On the other hand, as these risks are all project stakeholders orientated, how to effectively get different participants to manage them in the context of a project life cycle is decisive to the project success.

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ANNEXURES

PRELIMINIARY QUESTIONNAIRE SAMPLE

Survey Name : Risks Involved in Construction Industry

Manipal Institute of Technology, Manipal

Dear Sir, thank you for your cooperation and time. We are a group of 3 Undergraduate Civil Engineering students currently completing our degrees in MIT, Manipal. As part of our Final Semester Project, we have undertaken a study into the risks involved in construction industries from the perspectives of all the stakeholders. The team consists of -

- Ankit Saraf - Contact : 08867177499
- Rijul Rastogi - Contact : 08951389925
- Rohan Varun Das - Contact : 09916706533
- Sumati Banthia – Contact : 09916706533

The Questionnaire will take approximately 10 minutes to complete. Your participation in this study is completely voluntary. There are no further commitments from you, as a result of taking part in this activity.

Your views are very important to us and thus, help is greatly appreciated.

If you have any queries at any time regarding this study, please do not hesitate to contact us on our aforementioned contacts.

Personal and Organizational Details

- Respondent's Name -
- Designation -
- Experience -
- Contact -
- Full Name of the Organization/Employer -
- Classification of the organization -

- [ ] Consulting & Designing in Engineering
- [ ] Contracting
- [ ] Quantity Surveying
- [ ] Construction & Project Management
- [ ] Supplier / Manufacturer
- [ ] Developer / Builder
- [ ] Others

Signature & Date

Questionnaire Survey

We would like you to evaluate certain risk categories on their chances of occurrence and their level of impact in a project. The scale for evaluation is as :

- **Column 1 : Factor Applicable**
- **Column 2 : Factor Not Applicable**

Risk Category : Cost Related Impacts and their chances of Occurrence

Risk Category	Chances of Occurrence			Level of Impact		
Cost Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Design Variations						
Unsuitable Planning						
Occurrence of a Dispute						
Price Inflation						
Inaccurate Cost Estimate						
Inadequate Scheduling						
Excessive Approvals						

Risk Category : Time Related Impacts and their chances of Occurrence

Risk Category	Chances of Occurrence			Level of Impact		
Time Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Design Variations						
Unsuitable Planning						
Inadequate Program						
Bureaucracy						
High Performance						
Variation in Project						

Risk Category : Quality Related Impacts and their chances of Occurrence

Risk Category	Chances of Occurrence			Level of Impact		
Quality Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Inadequate Program						
Inaccurate Cost Estimate						
Low Subcontractor						
High Performance						
Skilled Labor Unavailability						
Design Variations						

Risk Category : Environment Related Impacts and their chances of Occurrence

Risk Category	Chances of Occurrence			Level of Impact		
Environment Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Variations in Const Programs						
Insufficient Professionals						
Less Site Info						
High Noise Pollution						
Excessive Approvals						
Low Subcontractor						

Risk Category : Safety Related Impacts and their chances of Occurrence

Risk Category	Chances of Occurrence			Level of Impact		
Safety Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
General Safety Accident						
High Quality Expectations						
Variations in Const Program						
Quality Control						
Low Subcontractor						
Skilled Labor Unavailability						
Insufficient Professionals						

FINAL QUESTIONNAIRE SAMPLE

Survey Name : Risks Involved in Construction Industry

Manipal Institute of Technology, Manipal

Dear Sir, thank you for your cooperation and time. We are a group of 3 Undergraduate Civil Engineering students currently completing our degrees in MIT, Manipal. As part of our Final Semester Project, we have undertaken a study into the risks involved in construction industries from the perspectives of all the stakeholders. The team consists of -

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The Questionnaire will take approximately 10 minutes to complete. Your participation in this study is completely voluntary. There are no further commitments from you, as a result of taking part in this activity.

Your views are very important to us and thus, help is greatly appreciated.

If you have any queries at any time regarding this study, please do not hesitate to contact us on our aforementioned contacts.

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- Designation -
- Experience -
- Contact -
- Full Name of the Organization/Employer -
- Classification of the organization -

- [ ] Consulting & Designing in Engineering
- [ ] Contracting
- [ ] Quantity Surveying
- [ ] Construction & Project Management
- [ ] Supplier / Manufacturer
- [ ] Developer / Builder
- [ ] Others

Signature & Date

Questionnaire Survey

We would like you to evaluate certain risk categories on their chances of occurrence and their level of impact in a project. The scale for evaluation is as :

- **Column 1 : Factor Applicable**
- **Column 2 : Factor Not Applicable**

Risk Category : Cost Related Impacts and their chances of Occurrence

Risk Category	**Chances of Occurrence**			**Level of Impact**		
Cost Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Design Variations						
Unsuitable Planning						
Inaccurate Cost Estimate						
Inadequate Scheduling						

Risk Category : Time Related Impacts and their chances of Occurrence

Risk Category	**Chances of Occurrence**			**Level of Impact**		
Time Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Design Variations						
Inadequate Program						
High Performance						
Variation in Project						

Risk Category : Quality Related Impacts and their chances of Occurrence

Risk Category	**Chances of Occurrence**			**Level of Impact**		
Quality Related	**1**	**2**		**1**	**2**	
Tight Project Schedule						
Inadequate Program						
Inaccurate Cost Estimate						
High Performance						
Design Variations						

Risk Category : Environment Related Impacts and their chances of Occurrence

Risk Category	**Chances of Occurrence**			**Level of Impact**		
Environment Related	**1**	**2**		**1**	**2**	
Variations in Const Programs						
Less Site Info						
High Noise Pollution						
Excessive Approvals						
Low Subcontractor						

Risk Category : Safety Related Impacts and their chances of Occurrence

Risk Category	**Chances of Occurrence**			**Level of Impact**		
Safety Related	**1**	**2**		**1**	**2**	
General Safety Accident						
High Quality Expectations						
Variations in Const Program						
Skilled Labor Unavailability						
Insufficient Professionals						