MODERN APPROACH TO MINIMIZE RISK IN CONSTRUCTION INDUSTRY

Submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ENGINEERING

in

CIVIL ENGINEERING

(With specialization in Construction Engineering and Management)

by

Trupti Rahul Kadam

(Registration Number: Anjuman-23**)**

Under the guidance of

Dr. R. B. Magar

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2017

A Dissertation Report on

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CERTIFICATE

This is to certify that the project entitled **"Modern approach to minimize risk in construction industry"** is a bonafide work of **Ms. Trupti Rahul Kadam (Anjuman-23)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Master of Engineering" in "Civil Engineering (With Specialization in Construction Engineering and Management)"

Dr. R. B. Magar	**Dr. Abdul Razak Honnutagi**
(Guide and Head of Department)	(Director, AIKTC)

APPROVAL SHEET

This dissertation report entitled "Modern approach to minimize risk in construction industry" by Ms. Trupti Rahul Kadam is approved for the degree of "Civil Engineering with Specialization in Construction Engineering and Management"

Examiners

1. …………………………

2. …………………………

Supervisors:

1. …………………………

2. …………………………

Date:

Place: Panvel

DECLARATION

I declare that this written submission represents my ideas in our own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

Construction risk has great influence on project objectives of cost, time and quality. Some of the risks associated with the construction process are predictable or easily identifiable, others may be totally unseen. Construction is a highly risk-prone industry due to dynamic and complex nature of construction projects. Construction industry is exposed to the various risks including technical and business. Thus, an effective analysis and management of construction related to risks remain a big challenge to the Construction industry practitioners. The current tools and techniques adopted in the construction industry are evaluated in this project and provides the comparison of twenty-two companies. A thorough literature review was initially conducted to identify the risk factors that affect the performance of construction industry as a whole. The survey questionnaire is designed to examine the pattern of risks in construction industry which include ranking of Risk factors by all respondents. Later, with the help of ranking provided by each respondent important index and risk score are calculated. And with the help of the results obtained, risk factors are determined. Therefore, Analysis shows that there are top 20 risk factors affecting the companies in construction industry. These factors are considered an important field of study for improvement and stabilization of the construction

Keywords: Risk Management, Important index, Risk Score, Risk Analysis

CONTENTS

LIST OF FIGURES

ANJUMAN - I - ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL
ENGINEERING & TECHNOLOGY ARCHITECTURE ★ PHARMACY
AKTC
NAVI MUMBAI - INDIA

LIST OF TABLES

ANJUMAN - I - ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL
ENGINEERING & TECHNOLOGY ARCHITECTURE PHARMACY
AKTC
NAVI MUMBAI - INDIA

ABBREVIATION NOTATION AND NOMENCLATURE

CRMS	Construction Risk Management System
RM	Risk Management
RBS	Risk Breakdown Structure
CPM	Critical Path Method
PERT	Project Evaluation and Review Technique
SWOT	Strength, Weakness, Opportunities and Threats
P.I	Probability Index
I.I	Impact Index
PRM	Project Risk Management
JV	Joint Ventures
KBES	Knowledge Based Expert System
ANOVA	Analysis of Variance
NPV	Net Present Value
OFX	Open Financial Exchange
SPI	Schedule Performance Index
PMBOK	Project Management Body of Knowledge

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Chapter 1

Introduction

1.1 General

Generally, risk is a choice in an environment rather than a fate. BS 6079 (British Standard Institution 1996) defines risk as 'It is the uncertainty inherent in plans and possibility of something happening that can affect the prospects of achieving, business or project goals'. The word ''risk'' was known in the English language in the 17th century. It is believed that the word was originally a sailor's term that came from the Spanish and meant ''to run into danger or to go against a rock.'' The money spent to fund shipments overseas was the first example of risk business in the early days of travel. Each and every activity we do involve risk, only the amount of risk varies. Construction projects are characterized as very complex projects, where uncertainty comes from various sources. (Gould and Joyce, 2002)

Construction projects gather big number of stakeholders, which makes it difficult to study a network as a whole. But at the same time, these projects offer an ideal environment for network and risk management research. Additionally, construction projects are frequently used in management research, and several different tools and techniques have already been developed and especially for the off-shore projects. However, there is a gap between risk management techniques and their practical application by construction contractors. Risks differ between projects due to the fact that every project is unique, especially in the construction industry. However, there are still many practitioners that have not realized the importance of including risk management in the process of delivering the project Even though there is an awareness of risks and their consequences, some organizations do not approach them with established RM methods. (Smith et al., 2006).

1.2 Risk Management

Risk management may be defined as a process to control the level of risk and to mitigate its effects. It is a systematic approach for identifying, evaluating and responding to risks encountered in a project (Nummedal et al., 1996). There are four distinct ways of responding to risks in a construction project, which are: i) Risk elimination (e.g. by placing a very high bid), ii) Risk transfer (e.g. hiring subcontractors), iii) Risk retention (e.g. via insurance) and iv) Risk reduction (e.g. training staff about risk perception and its management). Details about these methods can be found in the references (Kelly, 1996; Thompson and Perry, 1992; Carter and Doherty, 1974). Consequences of uncertainty and its exposure in a project, is risk. In a project context, it is the chance of something happening that will have an impact upon objectives. It includes the possibility of loss or gain, or variation from a desired or planned outcome, as a consequence of the uncertainty associated with following a particular course of action. Risk thus has two elements: the likelihood or probability of something happening, and the consequences or impacts if it does. Managing risk is an integral part of good management, and fundamental to achieving good business and project outcomes and the effective procurement of goods and services. Risk management provides a structured way of assessing and dealing with future uncertainty. Project risk management includes the processes concerned with identifying, analyzing, and responding to project risk. It includes maximizing the results of positive events and minimizing the consequences of adverse events.

One concept which is widely used within the field of RM is called the risk management process (RMP) and consists of four main steps: identification, assessment, taking action and monitoring the risks (Cooper et al., 2005). In each of these steps, there are a number of methods and techniques which facilitate handling the risks. Many industries have become more proactive and aware of using analyses in projects. Likewise, RM has become a timely issue widely discussed across industries. However, with regard to the construction industry, risk management is not commonly used (Klemetti, 2006). More construction companies are starting to become aware of the RMP, but are still not using models and techniques aimed for managing risks. This contradicts the fact that the industry is trying to be more cost and time efficient as well as have more control over projects. Risk is associated to any project regardless the industry and thus RM should be of interest to any project manager.

1.3 Scope of the Work

In view of the fore mentioned problem as specified from the literature review, following scope is outlined for the present study. The scope of this project is to reveal why the construction projects, and generally, all projects, fail due to inadequate risk management and what are the best practices for the recovery. And also discusses the risk factors affecting the construction. It studies the importance of the risk factors based on their probability that event will occur and seriousness if event occurs.

1.4 Motivation

This project discusses the risk factors affecting the construction. It studies the importance of the risk factors based on their probability (that event will occur) and (seriousness if event occurs). This study has created a list of risk and it's in impact on the construction industry using survey. The work is carried out to find the risk factors in construction industry according to each company's point of view, by ranking each risk factor and comparing risk score of each risk factor given by respondents. These factors are considered to be an important field of study for the future advancement and stabilization of the construction industry and study needs to be done in detail. Therefore, this study should assist management in identifying activities where there is a risk of injury or loss and hence provide a basis for management decisions on the application of resources.

1.5 Objective

The aim of this study is to find the risk factors in construction industry. More specifically, the present investigation had the following objectives:

1. To identify and analyze associated risks in the construction industry.
2. To simplify and analyze the important risk factors affecting the construction industry according to each company's point of view, using a questionnaire survey.
3. To find out the most suitable way of managing the risks to ensure that the project is completed on time and within budget, reduced conflicts and improved profitability

1.6 Organization of dissertation

This dissertation is organized into six chapters. A brief description of each chapter is given below:

Chapter 1 gives an introduction to the present study of risk management. The importance of the present study is described. It also includes purpose of study, scope of the work, and objective of this study.

Chapter 2 gives detailed review of literature on different risk management techniques, risk factor, critical success factors.

Chapter 3 provides detailed concepts of risk, risk management, risk analysis techniques, risk definitions, construction risk management systems, and risk breakdown structure.

Chapter 4 presents the overall methodology followed in this work, methods used in this study, tools and techniques adopted in this study, questionnaire development and design.

Chapter 5 presents the results and discussion of different risk factors, methods used to rank the risk factors, importance index and risk score.

Chapter 6 describes the summary and conclusion of risk factors affecting various aspects of construction industry, risk analysis techniques

Chapter 2

Literature Review

2.1 General

There have been several studies on the Risk Analysis Techniques. An extensive review of project risk assessment and management was conducted during the initial phase of the research effort. Previous research suggests that construction activity is particularly subject to more risks than other business activities because of its complexity; a construction project usually requires a multitude of people with different skills and interests and the coordination of a wide range of disparate, yet interrelated, activities. Such complexity is further compounded by the unique features of a project and many other external uncertainties. And also, in general, there is an absence of literature that has focused on the practices, results or development of risk assessment and management techniques for Indian construction projects the review of literature includes books, journal articles, magazines articles, and internet articles on Risk Management and risk analysis techniques in Construction in order to support efficiently the present document.

2.2 Past Research Work on Risk Analysis and Management

Abrahamson (1984) states that ‘a party should bear a construction risk where it is in his control’. The term ‘‘in his control’’ is difficult to be precisely interpreted as the ‘‘control’’ by a contracting party on a real situation could be ‘partial’. The application of those principles to final decision making thus heavily relies on the qualitative judgment and experiential knowledge of construction experts. The problem of this kind of decision making process is its implicitness. Too often it is difficult to be analyzed and retrieved by others.

Calvert (1986) identified other factors to include seasonal effects on construction works, variability in preliminary expenses, contract extensions of time for inclement weather and valuation of variations

Kenly and Wilson (1986) took the ideographic approach to cash flow forecasting by maintaining that value curves are generally unique and should be modelled separately. They insisted that a curve should be fitted for each project as opposed to the nomothetic models, which aggregate groups of projects in order to develop a single standard curve to produce typical value curves.

Lowe (1987) argued that the factors responsible for variation in project cash flow could be grouped under five main headings of contractual, programming, pricing, valuation and economic factors.

Kaka and Price (1993) developed a model for cash flow forecasting identified other risk factors affecting cash flow profiles to include estimating error, tendering strategies, cost and duration variances. The identified risk factors have been reported to affect cash flow profiles as well as significantly impacting on the modelling of cash flow. However, the perception of the contractors to the likelihood of the risk factors occurring in different project types and of varying scope and duration is yet to be investigated. This then is the focus of this study and it is a first step in a programmed of research that intends to develop a cash flow forecasting model that incorporates risk and uncertainty using the knowledge-based expert system.

Wahid (1994) studied the delay problems in construction projects in Egypt. He found that the major causes of delay in construction projects in Egypt are poor contract management and unrealistic scheduling, Lack of finance and payment for completed work, design modification during construction, shortage of certain materials, subcontractors and material supplier's problems.

Harris and McCaffer (1995) identified the factors that affect capital lock-up which ultimately affect project cash flow profile to include the margin (profit margin or contribution), retention, claims, tender unbalancing, delay in receiving payments from clients and delay in paying labours, plant hirers, materials suppliers and subcontractors.

Kangari (1995) discussed the attitude of large U.S construction firms toward risk and determined how the contractors conduct construction risk management through a survey of the top 100 contractors. The study showed that in the recent year’s contractors are more willing to assume risks that accompany contractual and legal problem in the form of risk sharing with the owner. The survey also found that contactors assume the risk associated with actual quantities toward the practice of defensive engineering is determined.

Uff (1995) described risk allocation, the definition and division of responsibility associated with a possible future loss or gain, seeks to assign responsibility for a variety of hypothetical circumstances should a project not proceed. Usually, a tender document of a construction project is prepared by the contracting party, i.e. the owner, who initiates the project.

Akintoye and MacLeod (1997) studied the construction industry's perception of risk associated with its activities and the extent to which the industry uses risk analysis and management techniques with the help of a questionnaire survey of general contractors and project managers. The authors concluded that risk management is essential to construction activities in minimizing losses and enhancing profitability. Construction risk is generally perceived as events that influence project objectives of cost, time and quality. Risk analysis and management in construction depend mainly on intuition, judgement and experience. Formal risk analysis and management techniques are rarely used due to a lack of knowledge and to doubts on the suitability of these techniques for construction industry activities.

Shen (1997) identified eight major risks accounting for project delay and ranked them based on a questionnaire survey with industry practitioners. He also proposed risk management actions to cope with these risks and validated their effectiveness through individual interview surveys.

Bing et al (1999) identified the risk factors associated with international construction joint ventures (JVs) from and ‘‘integrated’’ perspective. The risk factors were grouped into three main groups: (1) Internal; (2) Project- specific; and (3) External. The study examined the most effective mitigating measures adopted by construction professionals in managing these risks for their construction projects in East Asia. Based on an international survey of contractors, it was found that the most critical risk factors exist in the financial aspects of JVs, government policies, economic conditions, and project relationship. When entering a foreign construction market in the form of a JV, a foreign construction company could reduce its risks if it would carefully select its local partner, ensure that a good JV agreement is drafted, choose the right staff and subcontractors, establish good project relationships, and secure a fair construction contract with its client.

Kaka and Boussabaine (1999) however maintained that ideographic models are only useful for analytical purposes. As such, they argued that forecasting requires the use of standard curves developed out of a group of projects similar to the one to be executed (nomothetic models). They therefore have developed cash flow models based on standard cost / value flow curves using logit transformation to fit the data.

Mcguire (1999) studied the risk factors involved in construction during and after the construction about the resource allocation, procurement, inventory control. And to minimize the time, cost and increase in quality of construction by analyzing the risk during planning itself.

Mulholl and Christian (1999) suggested that a description of systematic way to consider and quantify uncertainty in construction schedules. Construction projects are initiated in complex and dynamic environments resulting in circumstances of high uncertainty and risk, which are demanding time constrains

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.

Hastak and Shaked (2000) in their study classified all risks specific to whole construction scenario into three broad levels, i.e. country, market and project levels. Macroeconomic stability is partly linked to the stance of fiscal and monetary policy, and to a country's vulnerability to economic shocks. Construction market level risks, for a foreign firm, include technological advantage over local competitors, availability of construction resources, complexity of regulatory processes, and attitude of local and foreign governments towards the construction industry while project level risks are specific to construction sites and include logistic constraints, improper design, site safety, improper quality control and environmental protection, etc.

Odeyinka and Lowe (2000) studied knowledge-based expert system (KBES) modelling of construction cash flow to incorporate risk and uncertainties, identified and assessed the risk factors responsible for the variation in construction cash flow profiles. The study was conducted through a questionnaire survey administered on contracting organizations. Analyses were carried out using mean response and univariate analysis of variance (ANOVA). Results showed that the major risk factors involved in cash flow forecasting relate to changes in the design or specifications, contract conditions pertaining to cash in flow, interim valuations and certificates and construction programming issues such as inclement weather. Results also indicated that cash flow forecasting modelling that incorporates risk would need to consider categorization along the groupings of firm size, procurement methods and construction duration.

Within the limitations of the data, results showed that the major risk factors affecting cash flow forecasting are: architect's instructions, provision for interim certificate, receiving interim certificates, agreeing interim valuation on site, retention, delay in agreeing variations/dayworks, delay in settling claims, inclement weather, etc, and problems with the foundation. Results from the analyses based on various groupings indicated that a successful modelling of cash flow that incorporates risks and uncertainties may need to consider the modelling along the categorization of firm size, procurement options and construction duration. A definite conclusion could not be reached however regarding construction project type grouping.

Aleshin (2001) studied the problem of risk management of international and joint venture projects with foreign co-operation in Russia. The author identified classified and assessed risks inherent to joint venture projects in Russia and practical recommendation for risk management.

Jaafari (2001) believes that risks my result from external factors (commercial and competitive pressure, social and political factors, ethics, norms and shifting requirements of the clients). Regarding the above-mentioned factors interest in risk assessment is growing. With an increasingly complex and rapidly changing business environment, owners and their contractors are being challenged to manage risk while maintaining control and improving performance

Shen et al (2001) based on their survey, established a risk significance index to show the relative significance among the risks associated with the joint ventures in the Chinese construction procurement practice. Real cases were examined to show the risk environment faced by joint ventures.

Kapila and Hendrickson (2001) they identified the financial risk factors associated with international construction ventures from an integrated perspective. They examined the most effective mitigation measures adopted by construction professionals in managing these risks for their construction projects and suggests other means of risk aversion

Tah and Carr (2001) states that project success is dependent on the proper implementation of RM hence a plan for managing the risks effectively is required to ensure risks are measured, understood, reported, communicated and allocated within a standardize framework. The essential processes (techniques and models), resources (human, time and financial) and responsibilities must be identified.

Can et.al (2002) presented a generic project risk management process that has been particularized for construction projects from the point of view of the owner and the consultant who may be assisting the owner. First, the authors explain a complete or generic project risk management process to be undertaken by organizations with the highest level of risk management maturity in the largest and most complex construction projects. After that, factors influencing possible simplifications of the generic process are identified, and simplifications are proposed for some cases. Then the application to a real project is summarized. As a final validation, a Delphi analysis has been developed to assess the project risk management methodology explained here, and the results are presented.

These are examined in the light of transaction cost economics and relational contracting (RC) principles. It is found that RC may well be a useful route towards reduced transaction costs, while also fostering co-operative relationships and better teamwork that in turn facilitate joint risk management. The usefulness of the latter is reinforced by relevant observations from a recent Hong Kong-based survey, followed by a case study in Mainland China.

Rahman and Kumaraswamy (2002) identified 41 risks in construction projects. Risk management is thus an important tool to cope with such substantial risks in construction industry according to (Edwards, 1998) by the following steps: a) Assessing and ascertaining project viability. b) Analyzing and controlling the risks in order to minimize loss. c) Alleviating risks by proper planning. d) Avoiding dissatisfactory projects and thus enhancing profit margins.

Nasir et al (2003) developed a method to assist in the determination of the lower and upper activity duration values for schedule risk analysis by program evaluation and review technique analysis or Monte Carlo simulation. Probabilities for various combinations of parents for each risk variable were obtained through an expert interview survey and incorporated into the model. Finally, sensitivity analysis was performed. The model was tested using 17 case studies.

Sudong and Robert (2003) used Monte Carlo simulation, to evaluate the mean net present value (NPV), variance and NPV-at-risk of different concession period structures. They analyzed the influence of project characteristics on concession period design to evaluate the feasibility of the design. They concluded that a well-designed concession period structure can create a 'win–win' solution for both project promoter and the host government.

Uher (2003) described risk management as "a systematic way of looking at areas of risk and consciously determining how each should be treated. It is a management tool that aims at identifying sources of risk and uncertainty, determining their impact, and developing appropriate management responses"

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.

Cho and Seo (2004) presented a risk assessment methodology for underground construction projects. A formalized procedure and associated tools were developed to assess and manage the risks involved in underground construction. The suggested risk assessment procedure is composed of four steps of identifying, analyzing, evaluating, and managing the risks inherent in construction projects. The main tool of the proposed risk assessment methodology is the risk analysis software. Other tools developed in this study include the survey sheets for collecting risk-related information and the detail check sheets for risk identification and analysis. They finally discussed a detailed case study of the developed risk assessment methodology performed for a subway construction project in Korea.

Lyons and Skitmore (2004) conducted a survey of senior management involved in the Queensland engineering construction industry, concerning the usage of risk management techniques. Their survey results are compared with four earlier surveys conducted around the world which indicates that: the use of risk management is moderate to high, with very little differences between the types, sizes and risk tolerance of the organizations, and experience and risk tolerance of the individual respondents; risk management usage in the execution and planning stages of the project life cycle is higher than in the conceptual or termination phases; risk identification and risk assessment are the most often used risk management elements ahead of risk response and risk documentation; brainstorming is the most common risk identification technique used; qualitative methods of risk assessment are used most frequently; risk reduction is the most frequently used risk response method, with the use of contingencies and contractual transfer preferred over insurance; and project teams are the most frequent group used for risk analysis, ahead of in-house specialists and consultants

Bing et.al (2005) conducted a questionnaire survey to explore preferences in risk allocation in United Kingdom. Analysis of the response data shows that some risks should still be retained within the public sector or shared with the private sector. These are mainly macro and micro level risks. The majority of risks in PPP/PFI projects, especially those in the macro level risk group, should be allocated to the private sector.

Abousief (2005) studied the main risk factors affecting the construction of power plant in Egypt and he found that the most significant risks relevant to construction of a power plant in Egypt are: Inflation, the exchange rate, Material cost variation, Inaccurate specifications, Availability of foreign currency, Dispute resolution procedure, Change order procedure

El-Diraby and Gill (2006) developed taxonomy for relevant concepts in the domain of privatized-infrastructure finance. The taxonomy is an attempt to create information interoperability between the construction and financial industries. The taxonomy models the concepts of a privatized-infrastructure finance into six main domains: processes, products, projects, actors, resources and technical topics (technical details and basic concepts). The taxonomy was designed to be consistent with Open Financial Exchange (OFX). It was developed through the analysis of 10 case studies and involvement in project development and interaction with industry experts.

Menches and Hanna (2006) proposed an index to quantify project performance, although the paper did not intend to examine factors affecting project performance. However, few attempts were made to quantify quality other than subjective rankings by experts. The authors believed that the major difficulty in quantifying construction quality is the availability of data. When data was not available, scholars tended to either bypass Quantifying quality or collect opinions on quality via questionnaire surveys.

Wenzhe et al. (2007) studied the empirical Chinese industry survey on the importance of project risks, application of risk management techniques, status of the risk management system, and the barriers to risk management, which were perceived by the main project participants. The study reveals that: Most project risks are commonly of concern to project participants; the industry has shifted from risk transfer to risk reduction

Johnson (2008) implied more convenient and less convenient risks progressive and negative outcomes respectively. However, the CI faces fewer random risks, but these may have adverse consequences for a time, for example, increase cost, time overruns and low-quality work. The factors leading to such an outcome include planning, design and construction intricacy as well as the presence of countless interest groups and material resources.

Hambly et.al (2009) studied risk analyze technique by the fatality accident rate method. The realism states how the government is taking the necessary steps to repair and rework process related to the time, cost and politics.

Pesama and Eriksson (2009) proposed an empirical alternative procurement model and empirically test an alternative procurement model based on cooperative procurement procedures, which facilitates cooperation between clients and contractors in construction projects. The traditional competitive type of procurement in the construction industry involves inviting numerous bidders to prepare lump sum contract proposals based on detailed design documents prepared ex ante by the client and their consultants.

Solieman (2009) studied the main risk factors affecting the contractors working in the construction of On-shore Oil & Gas Projects in Egypt, these risk factors are summarized as follows: increase of material price, loss due to inflation, project financing (Debt,) (delayed payment on contract), delay in materials delivery, project duration (project duration is too short for the required activities, delays due long period for tender evaluation and purchase order cycle, vendor bid greater than estimate, shortage of approved For construction drawings, low productivity of equipment's, cost overrun due to planning estimation

Dada (2010) argued that there four distinct ways of responding to risks in a construction project namely: risk avoidance, reduction, transfer and risk retention, Eybpoosh et al. (2011) demonstrated the causal relationship between the risk factor using SEM technique. They concluded that the SEM helps decision makers for risk identification and to develop alternative mitigation strategies at the earlier stage of the project. In addition, risk precautions and control measures are suggested on the basis of the risk assessment results and are applied to risk management in deep foundation pit construction.

Hong-bo and Zhang (2011) stated that risk assessment and risk management for deep foundation pit engineering are essential for quality and safety in civil engineering owing to the needs of urban construction projects. However, uncertainty and fuzziness continue to challenge studies of the probability and consequences of risks in this area. Therefore, a fuzzy comprehensive evaluation method based on Bayesian networks is proposed to assess the risks of deep foundation pit construction. This methodology has five main parts: modelling of BNs, determination of occurrence probabilities of risk events, assessment of consequences, calculations of risk value and membership degree of risk rating, and definitions of risk acceptance criteria.

The probability of every risk event is calculated by using deductive BN techniques. Then the consequence of each event is calculated by using fuzzy analysis (i.e., statistical consequence distributions and weight coefficients of risk events are determined through the database).

Tabish and Jha (2011) revealed that following factors are of generic nature and would be required to be present to ensure success against two-three performance criteria such as: owners need to be understood and defined, valuable decision from top management, availability of resources, top management's support, and regular monitoring by top management, while there are some specific factors which are required to be present to ensure success against a certain criterion such as: understanding of scope by project manager and contractor, regular monitoring and feedback by owner, no social and political interference, clearly articulated scope of work, quality control and quality assurance activities, and adequate communication.

Yusof et al. (2012) studied that project success is a vague concept. There is no exception in construction project success. In fact, the project success concept in the context of construction industry may be even more complicated as it involves plenty of stakeholders, possesses higher inherent risk and vulnerable to various external factors such as political and economic. It is difficult to precisely define success of a construction project as some of the criteria are successfully met, while others are not

Baloi (2012) discussed the importance of managing construction engineering risk factors. It has been concluded that the nature of risks under consideration is determinant in the selection of modeling and analysis techniques. As it has been shown, not all uncertainty is random in nature. Three groups of risk factors inherent in construction engineering projects have been presented and explained. It is understood that the nature of the risk factors is diverse and thus their handling requires appropriate tools and techniques. Suggestions on the most appropriate tools associated with the techniques are also presented. The strength and weakness of each technique is highlighted and discussed.

Buertey (2012) found that the majority of professionals who participated in a survey related to RM in the construction industry had no knowledge regarding RM theories and techniques not planned RM activities, there was no formal RM structure in place and intuition and experience were used for risk decision making.

Thaheem et al (2012) reviewed various quantitative risk analysis techniques. It tries to build an overall understanding of various existing quantitative techniques for construction projects. It initially used results of survey to find out the trends of construction industry, globally, in terms of utilization of quantitative risk analysis and relevant techniques. Finally, it reports some critical findings from the survey and literature review, and their logical and scientific deduction by stressing both researchers and practitioners, towards the need for simplifying the existing quantitative techniques. It also tries to find out research gaps. In conclusion, it proposes areas of future research in quantitative techniques for construction project risk management by improving existing techniques or making new ones.

Goh et al (2013) identified 19 risk factors in the life cycle of the project under four heads such as Planning stage, Design stage, Procurement stage, construction stage, Handling over stage. They discussed the use of work shop with an integrated approach which includes brain storming, checklist, probability impact matrices, subjective judgment, and risk register. Finally, they suggested that the risk management workshop will be useful for risk identification and analysis, as a means of managing risks.

Hwang et al (2013) carried out survey in 2001 in which it has been found that projects had inadequate RM implementation: “lack of time”, “lack of budget”, “low profit margin”, and “not economical” were the most common barriers to RM implementation. However, RM was perceived to be important for project success and it was found that it had a positive impact on the key parameters.

Patel et al. (2013) present significant impact on construction projects in terms of its primary objectives. The Construction projects which are complex in nature, uncertainty and risks in the same can develop from different sources. The record of the construction industry is not acceptable in terms of coping up with risks in projects. This study proposes to apply the risk management technique which includes well - documented procedures for the one stop solution all types of hazards most likely to occur during any construction project Life cycle.

Babu (2014) studied project success and the critical success factors ~CSFs! are considered to be a means to improve the effectiveness of project. The results indicated that the average delay because of closures leading to materials shortage was the most important performance factor, as it has the first rank among all factors from the perspectives of owners, consultants, and contractors. This agreement between all target groups is traced to the difficult political situation.

The most important factors agreed by the owners, consultants, and contractors as the main factors affecting the success of construction projects were: escalation of material prices, availability of resources as planned through project duration, average delay because of closures leading to materials shortage, availability of personnel with a high experience and qualifications, quality of equipment and raw materials in project, and leadership skills for project managers.

Jain and Pathak (2014) identified the various variables affecting the factors. Variables within each group are interrelated and interrelated. A variable in one group can influence a variable in the others, and vice versa. To study how these factors affect project success separately and collectively, it is hypothesized that ‘‘Project success is a function of project related factors, project procedures, project management actions, human-related factors and external environment and they are interrelated and interrelated. It is further hypothesized that the project will be executed more successfully if the project complexity is low; if the project is of shorter duration; the overall managerial actions are effective; if the project is funded by a private and experienced client; if the client is competent on preparing project brief and making decision; if the project team leaders are competent and experienced and if the project is executed in a stable environment with developed technology together with an appropriate organization structure.

This paper focuses on the critical success factors and not on the measurement of project success, i.e., the key performance indicators. Further study should be directed to identify the key performance indicators, so that the causal relationships between Critical Success Factors and Key Performance Indicators can be identified. The causal relationships, once identified, will be a useful piece of information to implement a project successfully. It can help in selecting project team mem

Jayasudha et.al (2014) studied management in identifying activities where there is a risk of time and financial aspects and hence provide a basis for management to take objective decisions on the reduction of risk to an agreed level. These findings are very important for implementing further effective measures to ensure the right direction of future development.

Renuka et. al (2014) discussed the critical risk factors and its assessment techniques through comparative study of various international construction projects. About 50 relevant articles published over the last 25 years have been reviewed. The review resulted that a simple analytical tool will be developed for each project task to assess the risk easily and quickly, which will encourage the practitioners to do the risk analysis in their project.

This review concluded that the earlier risk identification in the project and assessment during the bidding stage of the construction project will lead to the better estimation of the escalation on cost and time overrun. Such risk assessments help to include in the budget and scheduling for the successful completion of the project. This paper recommends that the risks factors affecting the life cycle of the construction projects needs to be identified. Then a frame work is to be design for quantifying the risk factors considering the uncertainties.

Shunmugam and Rwelamila (2014) carried out study on evaluation of the status of RM in construction projects in South Africa. To achieve this, the following objectives were pursued: To identify the extent of use of RM in the SA construction industry and to assess what the current practices and barriers were of RM implementation. A survey questionnaire was the primary tool that was used to collect data from large contracting and consulting companies. The findings were similar to previous studies. Although RM is recognized as a knowledge base, RM practitioners mainly rely on subjective methods (such as judgement based on experience) rather than more sophisticated methods (such as mathematical techniques) to make decisions that affect the key project parameters.

The main barriers to formal RM implementation were found to be ignorant attitudes, time and cost constraints and inadequate skills available to implement the processes appropriately. The study also makes recommendations to improve RM implementation for future endeavors. These included RM training / mentoring; implementation of a formal RM process within organizations and inculcating a change in attitude and perception. Whilst these suggestions are all useful, it was also observed that they cannot be implemented exclusively hence a systematic RM improvement process in the organization which seeks to steadily overcome barriers to the implementation of RM is also discussed.

Sugumaran and Lavanya (2014) defined the critical factors that lead to project success. Following are the top Critical success factors; Decision making effectiveness, Project Manager's experience, Contractor's cash flow, Contractor experience, Timely decision by owner/ owner's representative, Site management, Supervision, Planning effort, Prior project management experience, Client's ability to make decision

Swarna and Venkatakrishnaiah (2014) studied the effectiveness of risk preventive. The findings of this work show a lack of an iterative approach to risk management, which is a weakness in current practices. The result of this study recommended that there is an essential need for more standardization which addresses issues of clarity, fairness, roles and responsibilities, allocation of risks, dispute resolution and payment. More efforts should be made to properly apply risk management in the construction industry.

Based on the findings, a number of recommendations facilitating more effective risk management have been developed for the industry practitioners. The main objective was to gain understanding of risk factors that could be for the building projects in various firms. In this study, identifying the risk factors faced by construction industry is based on collecting information about construction risks, their consequences and corrective actions that may be done to prevent or mitigate the risk effects.

Dziadosz et al. (2015) described that significant variation of results is noticeable, basing on preliminary analyzes conducted on 30 contracts. It is closely related to the presence of numerous random factors during a construction project implementation. Time risk can be an example – this type of risk has occurred in almost all contracts. However, the size of this risk was small (0.3%). That is why it is so important to categorize the factors into groups according to the likelihood of risk occurrence, and the amount of damage. Regression analysis indicated a relationship, albeit only at the level of approx. 30% - between the structure type and the time of implementation. It seems that the wider the time horizon, the better the organization and the more effective risk management is, because the size of real risk was in the range of [4%, 6%].

Fahimnia et.al. (2015) presents a review of quantitative and analytical models (i.e mathematical, optimization and simulation modelling efforts) for managing supply chain risks and points to generative research areas that have provided the field with foundational knowledge, concepts, theories, tools, and techniques.

Reddy (2015) Concluded as per the project factors, risk management is strongly linked with the production phase. Majority of the risk processes are executed during this phase and the most active group being the contractors, have great influence on the risk management process. The owners and contractors pay little effort and time to assess and strategically plan for known, unknown or probable risks. If we don't have a proactive risk management process then problems that take place in a project could increase the delays and costs. Better project performance can be achieved by identifying, allocating and managing risks at the front end of the project planning process. Project risk assessment planning is a process which helps the participants to address the risks before they turn into bigger problems.

Sathishkumar, et al. (2015) identified the risks that are affected in various construction projects and calculating the risks severity to personal and the property. The general methodology of this study relies largely on the survey questionnaire which was collected from various sources. In this study questionnaire has been sent to three hundred and twelve companies. The data were analyzed by Descriptive Statistics and ANOVA.

Shankar and Balasubramanian (2015) determines the key factors of risk in construction industry. A total of 38 factors influencing risks in construction are analyzed through pilot survey which include experts of academic (Professors), governmental sectors and construction industry were interviewed, and 22 evaluation criteria were obtained as the key factor by interviewed experts. This approach provides a more effective, accurate and organized decision support tool.

Lmoussaoui and Jamouli (2016) proposed a new approach called "Three-dimensional Risk Identification" based on the three parameters: Risk typology, project phases, and stakeholders in order to draw up an exhaustive list of risks that may occur in different phases of a construction project. It presents also a new approach based on Multiple Criteria Decision-Making Methods for the prioritization of risks using the concept of weighted criticality. Its practical use has been tested on a real electrification project to identify the most critical risks. A comparison with a method based on the classic notion of criticality identified gaps in the ranking that may guide the decision team to lower priority processing actions or, conversely, to neglect the most critical risks.

Mhetre et al. (2016) studied risk is perceived as a negative term, even though in theory It can have two dimensions. Professionals in the construction industries are using techniques described in the literature concerning RM, but are not aware of it. Risks are being managed every day in the industry, but not in such a structured way as the literature describes. As also other researchers confirmed, the knowledge of RM and RMP is close to zero, even though the concept of risk management is becoming more popular in the construction sector. Risk management is a technique that should be applied within an industry to achieve the goals of the industry. Hence, it is necessary to spread awareness and create interest amongst people to use risk management techniques in the industries.

Mishra (2016) discusses the critical risk factors and its evaluation techniques by conducting a comparative study of various international and national construction projects. About 50 articles published over the last 15 years were reviewed. The finding was that a simple analytical tool will be developed for each project task to evaluate the risk quickly and effectively to do the risk analysis in the project. By study it was concluded that by the virtue of earlier risk identification during the bidding stage of the construction project will lead to precise estimation of the escalation on cost and time overrun. This will help in rescheduling the construction projects by incorporating the things in the budget for the successful completion.

The findings from study shows the various critical risks factors to be managed accordingly in order to achieve a successful result of construction project. An information map was also prepared which represents the sources of critical risk factors and its effect on project success. The study recommends to identify the risk factors of construction projects. Accordingly, a suitable outline should be formed to quantify the risk factors on the basis of uncertainties.

Santos (2016) studied correlation of delay and the schedule performance index (SPI) to evaluate the risk of a construction project completed with time overruns. The hypothesis that the SPI of projects with a delay is distinct from those projects without a delay is assumed. A database with 19 elements was used to test this hypothesis and to calculate limit values to the SPI. Therefore, the risk of delay will be small when the observed SPI is greater than the superior limit and large when the SPI is below the inferior limit. The simplicity involved in the calculation of these values showed an advantage in comparison with other methods of risk evaluation. Another strong point observed is that any company can determine the value of risk by considering its own history and support decisions like doing corrective actions.

Alam and Nim (2017) studied risk management by using probability (likelihoods) and impact method. By applying a simple method, it is possible to identify the potential of risks factors in a simple way. Moreover, it gives possibility to detect which of the identified risks has the largest impact on time, cost and quality. So those risks can be rejected or mitigated by taking a suitable action. The research showed that the most common action was risk mitigation.

Moreover, it was proven that the results from probability and impact method may vary among projects due to the fact that each project and its scope are unique. In today's situation, the risk management has paramount importance as it can bring down risk associated with construction to the great level. If used effectively on time, cost and quality it can yield a brilliant result.

Park et al. (2017) studied main factors that must be considered for developing a risk management system for CM firms were selected by defining and evaluating the risks that can occur during field operation management at CM firms. Centered on these main factors, an effective field operation risk management system was proposed by presenting a functional block diagram. This system was evaluated by experts on five categories using a Liker 5-point-scale. The categories evaluated were practical applicability, adequacy of the response measures, degree of completion of the system, adequacy of the system architecture and ease of use.

However, the CRMS proposed herein offers clear accountability by allowing early response to risks, verification of the person in charge of risk management, clear risk response processes, and rapid response to legal disputes by managing risk records. For these reasons, it is expected to improve risk management effectiveness in CM firms. It was concluded that it was necessary to develop standard operating systems and implement risk management systems in order to manage risks effectively.

Pawar and Pagey (2017) studied risk elements associated with construction projects influence the time, cost and quality performance of the project. Risk management therefore becomes a continuing activity in project development, from inception and throughout the life of the project. Although risk management techniques have been used in other industries for a long time, the construction industry has approached risk management in terms of individual intuition, judgment and experience gained from previous contracts. One major drawback of risk analysis techniques is that the more powerful and sophisticated the technique, the more data and time is required. Construction industry activity is constrained by time because construction production is mostly employed just-in-time for the client's production requirement.

Singh et al., (2017) identified and evaluated current risks and uncertainties in the construction industry through extensive literature survey and aims to make a basis for future studies for development of a risk management framework to be adopted by prospective investors, developers and contractors.

2.3 Summary

As a conclusion from the literature review, it has been found that problems in risk management were derived from a narrow perspective. Amir Abousief (2005) studied the main risk factors affecting the construction of power plant in Egypt and he found that the most significant risks relevant to construction of a power plant in Egypt are: inflation, the exchange rate, material cost variation, inaccurate specifications, availability of foreign currency, dispute resolution procedure, change order procedure. All researches and studies illustrate the increasing importance of the probability of risk and its impact

Chapter 3

Concept of Risk Analysis and Management

3.1 Risk concepts

Risk is a multi-faceted concept. In the context of construction industry, it could be the likelihood of the occurrence of a definite event/factor or combination of events/factors which occur during the whole process of construction to the detriment of the project a lack of predictability about structure outcome or consequences in a decision or planning situation, the uncertainty associated with estimates of outcomes – there is a chance that results could be better than expected as well as worse than expected etc. In addition to the different definitions of risk, there are various ways for categorizing risk for different purposes too. Some categorize risks in construction projects broadly in to external risks and internal risks while others classify risk in more detailed categories of political risk, financial risk, market risk, intellectual property risk, social risk, safety risk, etc. (Lifson and Shaifer 1982)

Risk is inherent and difficult to deal with, and this requires a proper management framework both of theoretical and practical meanings. Risk management is a form a land orderly process of systematically identifying, analyzing, and responding to risks throughout the life-cycle of a project to obtain the optimum degree of risk elimination, mitigation and/or control.

Significant improvement to construction project management performance may be achieved from adopting the process of risk management. The types of exposure to risk that an organization is faced with are wide-ranging and vary from one organization to another. These exposures could be the risk of business failure, the risk of project financial losses, the occurrences of major construction accidents, default of business associates and dispute and organization risks. It is desirable to understand and identify the risks as early as possible, so that suitable strategy can be implemented to retain particular risks or to transfer them to minimize any likely negative aspect they may have. (Hillebrandt 1974)

3.2 Risk in Construction

Construction risk is generally perceived as events that influence project objectives of cost, time and quality (Akintoye and Macleod 1997). The construction industry has had a poor reputation for coping with risks, many projects failing to meet deadlines and cost targets. Clients, contractors, the public and others have suffered as a result (Thompson and Perry 1992). The construction industry is subject to more risk and uncertainty than many other industries. The process of taking a project from initial investment appraisal to completion and into use is complex, generally bespoke, and entails time-consuming design and production processes. It requires a multitude of people with different skills and interests and the co-ordination of a wide range of disparate, yet interrelated activities. Such complexity moreover, is compounded by many external, uncontrollable factors (Flanagan and Norman 1993).

The construction industry has many unknowns and things rarely go according to plan. We need to be more aware of WHIF "What Happens If" analysis. People should be encouraged to have brainstorms of destructive thinking, where wild idea can be thrown up about the things which might go wrong, even though there is no precedent. The ideas need to be collected into a risk management system where analysis can be undertaken (Flanagan and Norman 1993). Risks in construction have been classified in different ways (see for example, Edwards and Bowen's (1998) comprehensive review of risk literature (1960-1997) in construction). However, they significantly have the same meaning in that authors generally agree that some risks can be controlled whereas others cannot. Murdoch and Hughes (2008: 81) classified risks affecting construction projects under physical works, delay and disputes, direction and supervision, damage and injury to persons and property, external factors, payment, and law and arbitration.

Erikson (1979) classified risks in construction as contractual risk (caused by lack of clarity, absence of communication between parties, problems of timeliness in contract administration) and construction risk (inherent in the work itself). In developing a fuzzy model for contractor's risk assessment at the tender stage, Tah et al. (1993) categorized project risks into external and internal risks (see below). This is similar to the classification in the finance literature where portfolio theory and capital-market theory divides risk into systematic risk (external – overall market risk including unanticipated increases in inflation or interest rates, labor shortages, and economic downturn or recession) and unsystematic risk (internal – independent of any economic, political, or social factors which affect the market in a systematic way, including the risks mentioned by Park.

3.3 Project Risk Management

Risk management is defined as a procedure to control the level of risk and to mitigate its effects. Risk management is not a discrete activity, but a basic fundamental of the project management. In the global sense, risk management is the process that, when carried out, ensures that all that can be done will be done to achieve the objectives of the project within the constraints of the project (Toakley 1989).

The risk management process begins with the initial identification of the relevant and potential risks associated with the construction project. It is of considerable importance since the process of risk analysis and response management may only be performed on identified potential risks. Risk analysis and evaluation is the intermediate process between risk identification and management. It incorporates uncertainty in a quantitative and qualitative manner to evaluate the potential impact of risk. The evaluation should generally concentrate on risks with high probabilities, high financial consequences or combinations thereof which yield a substantial financial impact. Once the risks of a project have been identified and analyzed, an appropriate method of treating risk must be adopted. Within a framework of risk management, contractors also should decide how to handle or treat each risk and formulate suitable risk treatment strategies or mitigation measures. These mitigation measures are generally based on the nature and potential consequences of the risk. The main objective is to remove as much as possible the potential impact and to increase the level of control of risk. More the control of one mitigation measure on one risk, the more effective the measure is. The process of risk management does not aim to remove completely all risks from a project. Its objective is to develop an organized framework to assist decision makers to manage the risks, especially the critical ones, effectively and efficiently.

The Project Management Institute (2004: 237-268) covers project risk management (PRM). The objectives of PRM are to increase the probability and impact of positive events, and to decrease the probability and impact of events adverse to the project. The risk identification process, which usually leads to the qualitative risk analysis process, is an iterative process of determining which risks might affect the project and documents and their characteristics. The PMBOK guide also outlines inputs, tools, and techniques that may be used to identify and quantify risks. According to the guide, PRM includes the processes concerned with conducting: Risk Management Planning (deciding how to approach, plan and execute the risk management activities of the project); Risk Identification (determining which risks might affect the project and documenting their characteristics); Risk Analysis (see below); Risk Response Planning (developing options and actions to enhance opportunities, and to reduce threats to project objectives); and Risk Monitoring and Control (tracking identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the project life cycle). The primary outputs from a risk identification exercise may be entered into a risk register, which typically contains: a list of identified risks; list of potential responses; root causes of risk; and updated risk categories.

3.4 Construction Risk Management System

This model presented by Al-bahar (1988), provides an effective systematic framework for quantitatively identifying, evaluating, and responding to risks in construction projects. According to CRMS, it is suggested that risk management must be seen as managing responses rather than responding to risk events after they happen. Hence, the theme of risk management approach is to act instead of react to project risks. Many contractors think of risk management as insurance management where the main objective is to find the optimal economic insurance coverage for the insurable risks but actually it is a scientific systematic approach of managing risks faced by contractor, and it deal with both insurable as well as uninsurable risks and the choice of the appropriate technique or techniques for treating those risks.

These four processes are arranged in a logical and sequential order that progress clockwise. By following this model, the contractor is assured of a systematic way of managing risks. The linkage between the four processes provides a closed feedback loop to update the information in the system and to capture the interaction between these processes.

Fig 3.1 shows the functions of the CRMS model, the proposed CRMS model consists of the following four processes:

1. Risk identification
2. Risk analysis and evaluation

3. Response management
4. System administration

Fig 3.1 The four functions of the CRMS Model (Al-Bahar 1988)

3.5 Risk Breakdown Structure (RBS)

RBS as "A source-oriented grouping of project risks that organizes and defines the total risk exposure of the project, Where the RBS can be used as a prompt list to ensure complete coverage during the risk identification phase. This is accomplished by using the RBS to structure which ever risk identification method is being used. For example, a risk identification workshop or brainstorm might work through the risk identification checklist can also be developed based on the RBS, by taking each of the lowest RBS levels and identifying a number of generic risks in each area based on previous experience. The most obvious demonstration of the value of structuring within project management is the Work Breakdown Structure (WBS), which is recognized as a major tool for the project manager because it provides a means to structure the work to be manageable and definable packages to provide a basis for project planning, communication, reporting, and accountability. In the same way, risk data can be organized and structured to provide a standard presentation of project risks that facilitates understanding, communication and management These have produced hierarchical structures under various names to describe sources of risk, or risk categories or types, though these are usually focused on a particular project type or application area. (Hillson 2002)

In another paper Tumala and Burchett (1999) used: high level of work breakdown structure to properly identify cost centers, to be able to categorize them. He identified 7 types of risk, viz; Financial, political, environmental design, site construction, physical and act of god) they used certain checklist figures to collect required information.

3.6 Major Processes of Project Risk Management

Risk management involves four processes, namely

1. Risk Identification: Determining which risks are likely to affect the project and documenting the characteristics of each.
2. Risk Quantifications: Evaluating risks and risk interactions to assess the range of possible project outcomes.
3. Risk Response Development: Defining enhancement steps for opportunities and responses to threats.
4. Risk Response Control: Responding to changes in risk over the course of the project.

3.6.1 Risk Identification:

Risk identification consists of determining which risks are likely to affect the project and documenting the characteristics of each. Risk identification is not a onetime event; it should be performed on a regular basis throughout the project. Risk identification should address both internal and external risks. Internal risks are factors that the project team can control or influence, such as staff assignments and cost estimates. External risks are things beyond the control or influence of the project team, such as market shifts or government action. In the project context, however, risk identification is also concerned with opportunities (positive outcomes) as well as threats (negative outcomes). (Garg 2005)

3.6.1.1 Tools and techniques for risk identification

Risk can be identified by the following methods: (Garg 2005)

a. Brainstorming.
b. Workshops
c. Interviews
d. Questionnaire survey
e. Feedback from similar projects
f. Use of specialists
g. Previous experience

3.6.2 Risk quantification

Risk quantification involves evaluating risks and risk interactions to assess the range of possible project outcomes. It is primarily concerned with determining which risk events warrant response. It is complicated by a number of factors including, but not limited to Opportunities and threats can interact in unanticipated ways (e.g., schedule delays may force consideration of a new strategy that reduces overall project duration). A single risk event can cause multiple effects, as when late delivery of a key component produces cost overruns, schedule delays, penalty payments, and a lower-quality product. Opportunities for one stakeholder (reduced cost) may be threats to another (reduced profits). The mathematical techniques used can create a false impression of precision and reliability. (Murdoch and Hughes 2008)

3.6.2.1 Tools and techniques for risk quantification

Expected Monetary Value: Expected monetary value, as a tool for risk quantification, is the product of two numbers: Risk event probability-an estimate of the probability that a given risk event will occur, Risk event value-an estimate of the gain or loss that will be incurred if the risk event does occur. Distort the result by equating a small loss with a high probability to a large loss with a small probability.

The expected monetary value is generally used as input to further analysis (e.g., in a decision tree) since risk events can occur individually or in groups, in parallel or in sequence.

Statistical sums: Statistical sums can be used to calculate a range of total project costs from the cost estimates for individual work items. (Calculating a range of probable project completion dates from the activity duration estimates requires simulation). The range of total project costs can be used to quantify the relative risk of alternative project budgets or proposal prices.

Simulation: Simulation uses a representation or model of a system to analyze the behavior or performance of the system. The most common form of simulation on a project is schedule simulation using the project network as the model of the project. Most schedule simulations are based on some form of Monte Carlo analysis. This technique, adapted from general management, “performs” the project many times to provide a statistical distribution of the calculated results. The results of a schedule simulation may be used to quantify the risk of various schedule alternatives, different project strategies, different paths through the network, or individual activities.

Schedule simulation should be used on any large or complex project since traditional mathematical analysis techniques such as the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) do not account for path convergence and thus tend to underestimate project durations. Monte Carlo analysis and other forms of simulation can also be used to assess the range of possible cost outcomes.

Decision tree: A decision tree is a diagram that depicts key interactions among decisions and associated chance events as they are understood by the decision maker. The branches of the tree represent either decisions or chance events are examples of a decision tree.

Expert Judgment: Expert judgment can often be applied in lieu of or in addition to the mathematical techniques. For example, risk events could be described as having a high, medium, or low probability of occurrence and a severe, moderate, or limited impact.

3.6.3 Risk Response Development

Risk response development involves defining enhancement steps for opportunities and responses to threats. Responses to threats generally fall into one of three categories: Avoidance: eliminating a specific threat, usually by eliminating the cause. The project management team can never eliminate all risk, but specific risk events can often be eliminated. Mitigation: reducing the expected monetary value of a risk event by reducing the probability of occurrence (e.g., using proven technology to lessen the probability that the product of the project will not work), reducing the risk event value (e.g., buying insurance), or both. Acceptance: accepting the consequences. Acceptance can be active (e.g., by developing a contingency plan to execute should the risk event occur) or passive (e.g., by accepting a lower profit if some activities overrun). (Flanagan and Norman 1993).

3.6.3.1 Tools and techniques for risk response development

Procurement: Procurement, acquiring goods or services from outside the immediate project organization, is often an appropriate response to some types of risk. For example, risks associated with using a particular technology may be mitigated by contracting with an organization that has experience with that technology.

Procurement often involves exchanging one risk for another. For example, mitigating cost risk with a fixed price contract may create schedule risk if the seller is unable to perform. In similar fashion, trying to transfer all technical risk to the seller may result in an unacceptably high cost proposal.

Contingency Planning: Contingency planning involves defining action steps to be taken if an identified risk event should occur

Alternative strategies. Risk events can often be prevented or avoided by changing the planned approach. For example, additional design work may decrease the number of changes which must be handled during the implementation or construction phase. Many application areas have substantial body of literature on the potential value of various alternative strategies.

Insurance: Insurance or an insurance-like arrangement such as bonding is often available to deal with some categories of risk. The type of coverage available and the cost of coverage vary by application area.

3.6.4 Risk Response Control

Risk response control involves executing the risk management plan in order to respond to risk events over the course of the project. When changes occur, the basic cycle of identify, quantify, and respond is repeated. It is important to understand that even the most thorough and comprehensive analysis cannot identify all risks and probabilities correctly; control and iteration are required.

Flanagan and Norman (1993) allocate the response to the risk to four basic forms, as shown in Fig. 3.2 Proper allocation of risk must consider the ability to absorb the risk

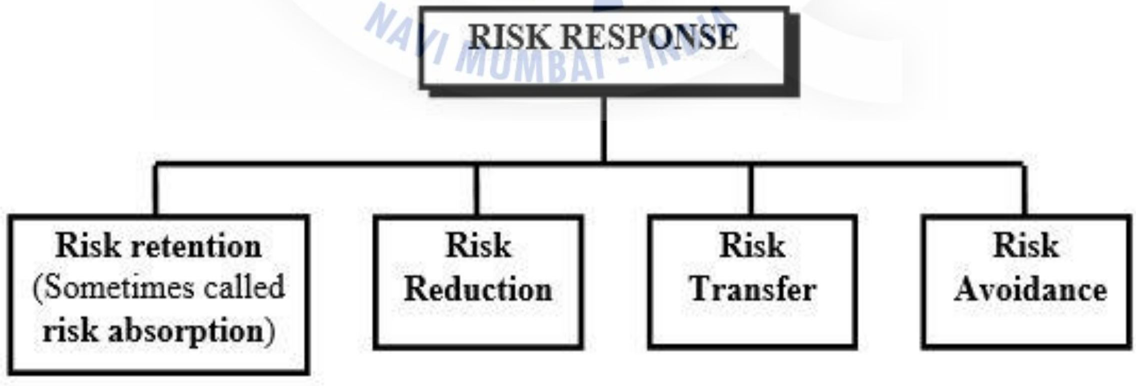

Fig 3.2 Risk Response by Flanagan and Norman (1993)

3.6.4.1 Risk Retention

This is the method of handling risks by the company who controls them. The risks, foreseen or unforeseen, are controlled and financed by the company or contractor that is fulfilling the terms of the contract. There are two retention methods (Carter and Doherty, 1974), active and passive. Active retention (sometimes referred to as self-insurance) is a deliberate management strategy after a conscious evaluation of the possible losses and costs of alternative ways of handling risks. Passive retention (sometimes called non-insurance), however, occurs through neglect, ignorance or absence of decision, e.g. a risk has not been identified and handling the consequences of that risk must be borne by the contractor performing the work

3.6.4.2 Risk Reduction

It may be argued that reducing risks is a part of risk retention, because the risk has to be retained before pursuing actions to reduce the effects of a foreseen risk. Alternatively, risk reduction may be an action within the overall risk management, and it is because of the possible wider use of risk reduction that it has been categorized separately. The actual reduction of risks within these categories is confined to the improvements of a company's physical, procedural, educational, and training devices (Flanagan and Norman, 1993).

The physical devices can be improved by continually maintaining and updating the devices which help prevent loss. The effect of improving procedural devices can be significant. Simple, low cost measures like housekeeping, maintenance, first aid procedures and security can lead to better morale, improved labor relations and increased productivity, as well as their more obvious benefits. Education and training within every department of a business are important, especially in reducing the harmful effects of risks within the working environment. Loss prevention consumes capital resources, and with better education and training devices the effect may be minimized, freeing capital for more productive investments

3.6.4.3 Risk Transfer

Many large projects purchase insurance for a variety of risks, ranging from theft to fire. By doing this, they have effectively transferred risk to the insurance company in that, if a disaster should occur, the insurance company will pay for it. While purchasing insurance is the most direct method of transferring risk, there are others. For example, hiring inexpert to do the work can also transfer risk. A fixed price contract states that the work will be done for an amount specified before the work begins. Fixed schedules may also be added to such a contract, with penalties for overruns. With fixed-price contracts, project managers know exactly what the cost of this part of a project will be. They have effectively transferred the cost and schedule risks from the project to the subcontracting firm; any overruns will be the responsibility of the subcontractor. The only downside to this scenario is that the subcontractor, knowing it will be held to the original bid, will probably make the bid higher to make up for the risk it is assuming. Another type of contract for service is called a reimbursable, or cost-plus, contract. Reimbursable contracts pay subcontractors based on the labor, equipment, and materials they use on a project. The risk of cost and schedule overruns is borne completely by the project on these contracts. The project is not able to transfer risk with this kind of contract, but when the work to be performed is poorly defined, or the type of service is open-ended, reimbursable contract is the only type a subcontractor will sign. Clearly, transferring risk to another party has advantages, but it also introduces new risks.

3.6.4.4 Risk Avoidance

Involves changing the project plan to prevent a potentially detrimental risk condition or event from happening might involve. Reduce/Change Scope or Change way of meeting the requirements

3.6.4.5 Tools and techniques for risk response control

Workarounds: Workarounds are unplanned responses to negative risk events. Workarounds are unplanned only in the sense that the response was not defined in advance of the risk event occurring.

Additional risk response development. If the risk event was not anticipated, or the effect is greater than expected, the planned response may not be adequate, and it will be necessary to repeat the response development process and perhaps the risk quantification process as well.

3.7 Risk rating

A measure of risk importance, usually using a combination of probability and impact. May be expressed semi-quantitatively or quantitatively

3.8 Risk Elimination

Risk elimination is sometimes referred to as risk avoidance. A contractor not placing a bid or the owner not proceeding with project funding are two examples of eliminating the risks totally. There are a number of ways through which risks can be avoided, e.g. tendering a very high bid; placing conditions on the bid; pre-contract negotiations as to which party takes certain risks; and not binding on the high risk portion of the contract (Carter and Doherty, 1974).

3.9 Mitigation

A proactive risk response to a threat. Reduce probability or if not possible, reduce the impact of a potential risk event to an acceptable level.

May involve implementing a new course of action in an effort to reduce the problem or changing the current conditions so that the probability of the risk occurring is reduced.

3.10 Monitoring & Controlling Risks

Monitoring & Controlling Risks is the process of responding to identified and unforeseen risk. It involves tracking identified risk, identifying new risks, implementing risk response plans, and monitoring their effectiveness.

3.11 Qualitative risk analysis

Qualitative Risk Analysis covers the methods for prioritizing identified risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact. The tools and techniques for qualitative risk analysis include:

a. risk probability and impact assessment
b. probability and impact matrix
c. risk data quality assessment
d. risk categorization;
e. Risk urgency assessment.

3.12 Quantitative risk analysis

PMBOK5th (2013) had identify quantitative risks as the process of numerically analyzing the effect of identified risks on overall projects objectives. The process is used mostly to evaluate the aggregate effect of all risks affecting the project. When the risks drive the quantitative analysis, the process may be used to assign a numerical priority rating to those risks individually.

3.13 External Risks

External risks are those that are prevalent in the external environment of projects, such as those due to inflation, currency exchange rate fluctuations, technology change, major client induced changes, politics, and major accidents or disasters. They are relatively non-controllable and so there is the need to continually scan and forecast these risks and in the context of a company's strategy (Tah et al., 1993).

3.14 Internal Risks

According to Tah et al. (1993), internal risks are relatively more controllable and vary between projects. They include the level of resources available, experience in the type of work, the location, and the conditions of contract. Some of these risks are local to individual work packages or categories within a project, whilst others are global to an individual project and cannot be associated with any particular work package. The local risks cover uncertainties due to labor (availability, quality, and productivity), plant (availability, suitability, and productivity), material (availability, suitability, supply, wastage) and subcontractor (availability, quality, productivity, and failure) resources and the site (ground conditions, accessibility, type of work, complexity of work). They are considered for each work package in the case of bill of quantities. Global risks are often allocated to the project as a whole because of their very nature. They cover risks relating to the performance (management experience, availability of partners, relationship with client, workload commitment), contract (contract type, contractual liabilities, amendments to standard form), location (head office, project) and financial (cash flow, funding, economic conditions) aspects of the project.

3.15 Risk Analysis

The risk analysis and evaluation process is the vital link between systematic identification of risks and rational management of the significant ones. It forms the foundations for decision-making between different management strategies. Since the significance, and therefore impact, of any risk is constantly changing, it must be analyzed and evaluated regularly as information changes (Al-Bahar, 1988).

Risk analysis and evaluation defined by Al-Bahar (1988) is "A process which incorporates uncertainty in a quantitative manner, using probability theory, to evaluate the potential impact of risk". The evaluation should generally concentrate on risks with high probabilities, high financial consequences or combination thereof which yield a substantial financial impact.

Flanagan and Norman (1993), proposed that "the main purpose of a risk management system is to assist business to take the right risk". In accordance, the essence of risk analysis is that it attempts to capture all feasible options and analyze the various outcomes of any decision.

Fig 3.3 developed by Al-Bahar (1988) is a schematic presentation of the various components of the process. There are three steps involved in the process which are:

- Data collection
- Modeling uncertainty
- Evaluation of potential impact of risk

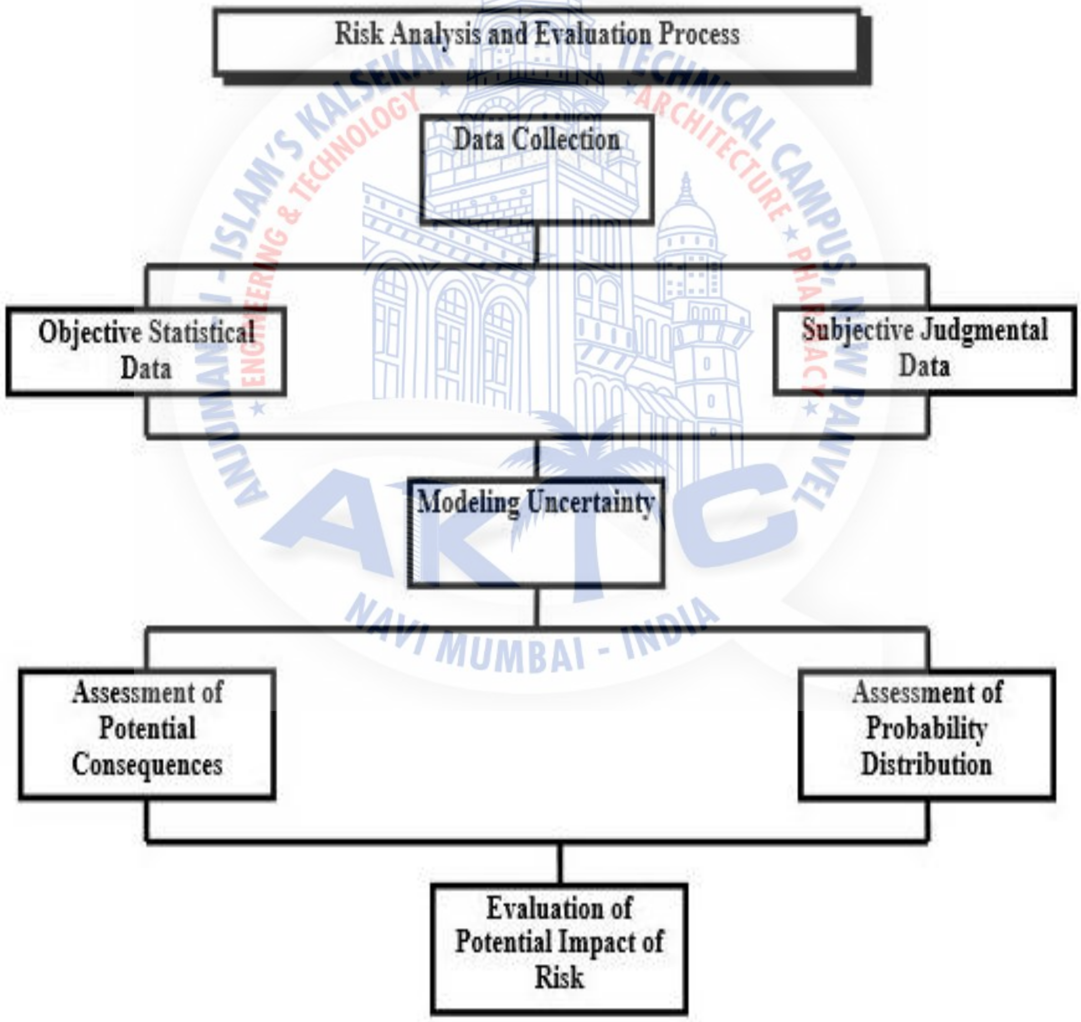

Fig 3.3 Schematic presentation of the various Components of the Risk Analysis process (Al-Bahar (1988)

3.16 Advantages of Risk Management

Following are the advantages of risk management:

a. Less uncertainty.
b. Achievement of objectives.
c. Shareholders' reliability.
d. Reduction of capital cost.
e. Creation of value

3.17 Limitations of Risk Management

If risks are improperly assessed and prioritized, time can be wasted in dealing with risk of losses that are not likely to occur. Spending too much time assessing and managing unlikely risks can divert resources that could be used more profitably. Unlikely events do occur, but if the risk is unlikely enough to occur, it may be better to simply retain the risk, and deal with the result if the loss does in fact occur

Chapter 4

Methodology

4.1 General

This Research is a field survey study through a structured questionnaire which directed to construction projects. The survey identifies the probabilities of occurrence and degree of impact of risks which might face these companies during the construction of this kind of projects, and ranking these risks based on their importance

This chapter presents a detailed description of the research methodology used in this dissertation.

4.2 Risk Definitions

Uncertain event or condition that, if it occurs, has an effect (impact) on any of the project objectives (Time, Cost, Quality, Scope), Impact could be positive (opportunity) or negative (threat) (PMBOK Guide P436)

The Random House College Dictionary defines risk as ‘‘exposure to the chance of injury or loss’ (Hertz and Thomas 1983).

Webster's dictionary defines risk as ''the possibility of loss, injury, disadvantage, or destruction.'' The Health and Safety Commission defines risk as ''the likelihood that harm will occur'' Health and Safety Commission 1995

4.3 General Types of Risks

Risks can be viewed as business, technical, or operational. A technical risk is the inability to build the product that will satisfy requirements. An operational risk is the inability of the customer to work with core team members. Risks are either acceptable or unacceptable. An acceptable risk is one that negatively affects a task on the non-critical path. Risks are either short or long term. A short-term risk has an immediate impact, such as changing the requirements for a deliverable. A long-term risk has an impact sometime in the distant future, such as releasing a product without adequate testing. Risks are viewed as either manageable or unmanageable.

A manageable risk is one you can live with, such as a minor requirement change. An unmanageable risk is impossible to accommodate, such as a huge turnover of core team members. (See Fig 4.1)

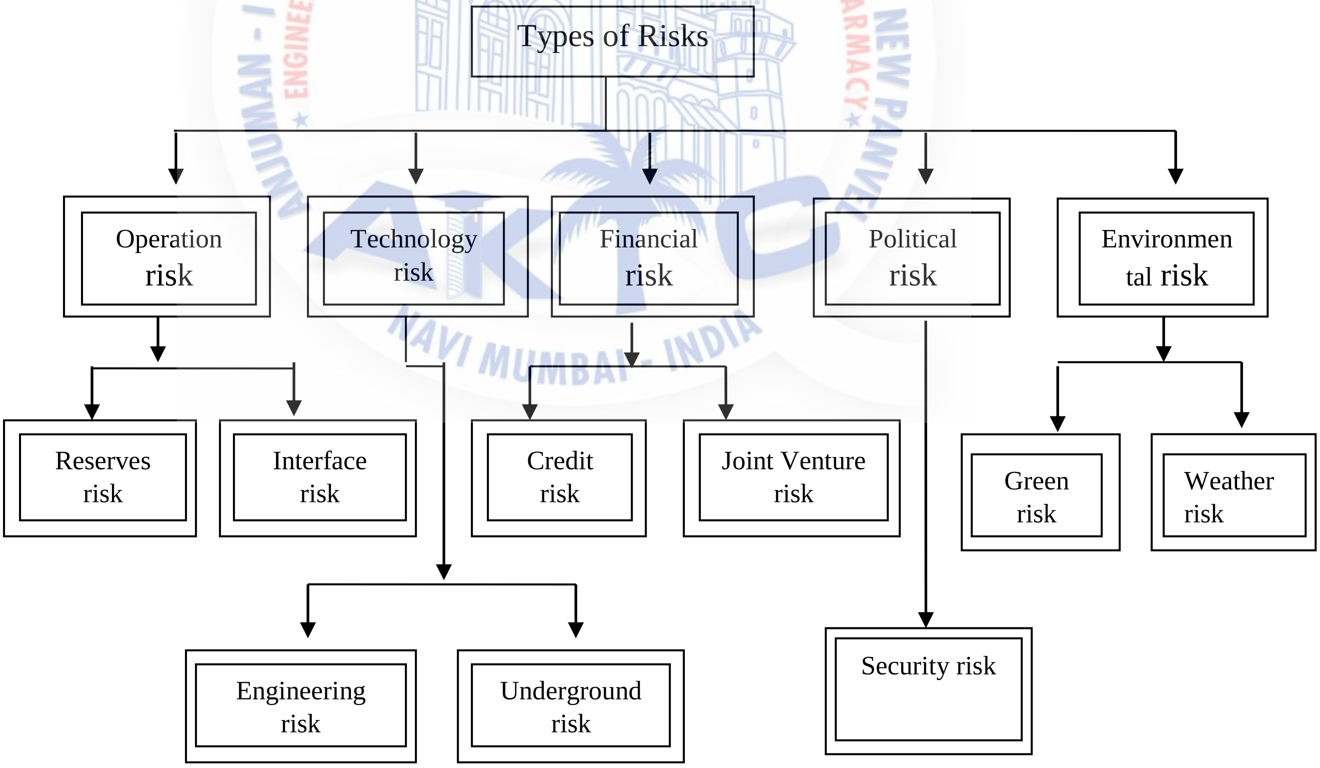

Fig 4.1 Types of Risk

4.4 Characteristics of construction risk

In the practice of construction risk management, Perry and Hays (1985) stated characteristics of construction risk as:

Risk and uncertainties are associated with specific events or activities that can be individually identified. A risk event implies that there is a range of outcomes of each event and each outcome has a probability of occurrence. Some risks offer only the prospect of adverse consequence (loss) a bankruptcy, war, sea or flood damage, these may be low or high probability but of high impact. Many common construction risks offer the prospect of either loss or gain as productivity of labor and plant; these are typically of high probability and may be of low or high impact. Subjective judgment is usually required to calculate the probability of occurrence of specific outcomes of risk event.

Mulholland and Christian (1999) stated that one reason for failure in construction projects has been caused by the selection of the contracting format that did not fit the risk characteristics of the project. For example, the use of lump-sum contract on a fast track project can lead to many contract disputes and diversion of management s attention from the critical field work issues. Poor management practices also create problems the effectiveness of the project management function significantly influences whether the planning project schedule duration will be achieved successfully.

4.5 Risk Assessment

Risk assessment is the process of identifying and evaluating areas of risk in anther words it is process to determine the importance and potential impact of the risk which is conducted by the use of historical data and past experience and mostly by means of educated guess. Another definition of the risk assessment is a technique that aims to identify and estimate risks to personnel and property impacted upon by a project. This approach goes beyond the application of a compliance system such as that of the Occupational Safety and Health Act. It is to consider both individual and generic risks in work activities. Many studies concerned with the assessment of risk in construction due to the complex characteristics of major industrial and construction projects have created the need for improving management support techniques, and tools. Many companies have recognized that need and are drawing from their past experience when developing project organizations, where managers need to know how much risk is involved in an activity to decide how to go about it.

Project teams generally are too preoccupied with solving current problems involved with getting work done and therefore have insufficient time to think about, much less carry out, a formal risk assessment program (Oglesby et al. 1989). Although it is important to assess risk, a precise estimate of risk may not be required. It would be extremely time consuming in practice, and usually a lack of data makes it impossible. What is needed is a reliable tool that measures the extent of the potential risk. Perhaps a model that determines the value of risk would help contractors identify the high risk of major construction activities and would enable them to allocate safety precautions in a more efficient manner. The problem arise since most of the results are given in terms of probability of high, medium, and low chances of occurrence and no accurate results .the assessment of the impact was accompanied by fewer recommendations, and suggested that assessment should be qualitative and the process should be iterative .in anther research , Chapman and Ward (1997) suggest that assessment could be carried out by an incremental method for both the occurrence and impact of risk: by identifying the maximum and minimum impacts and identifying incremental steps to reach a decision on the impact, then same steps are used for the probability assignment.

4.6 Risk Identification

Many managers believe that the principal benefits of risk management come from the identification rather than analysis stage. For them, great benefit comes from the discipline of thinking through the project, understanding the potential risks, and considering possible responses. Rigorous, analytical analysis is often reserved for the larger, more complex projects (Hayes 1987).

Under the supervision of any analyst, the following steps should be implemented:

a. Knowledge acquisition.
b. Selection of representatives.
c. Presentation of the idea to the team.
d. Measurement criteria.
e. Understanding probability.
f. Culture conditions.
g. Identification.

4.7 Risk Identification Tools and Techniques

The tools used to identify risks and the used techniques are:

Documentation reviews: Documentation reviews involve comprehensively reviewing the project documents and assumptions from the project overview and detailed scope perspective in order to identify areas of inconsistency or lack of clarity. Missing information and inconsistencies are indicators of a hidden risk.

Information gathering techniques: Information gathering techniques are used to develop lists of risks and risk characteristics. Each technique is helpful for collecting a particular kind of information. The five techniques are:

a. **Brainstorming:** Brainstorm is employed as a general data-gathering and creativity technique which identifies risks, ideas, or solutions to issues. Brainstorming uses a group of team members or subject-matter experts spring boarding off each other's' ideas, to generate new ideas.

b. **Delphi technique:** The Delphi technique gains information from experts, anonymously, about the likelihood of future events (risks) occurring. The technique eliminates bias and prevents any one expert from having undue influence on the others.

c. **Interviewing**: Interviewing in a face-to-face meeting comprised of project participants, stakeholders, subject-matter experts, and individuals who may have participated in similar, past projects is a technique for gaining first-hand information about and benefit of others' experience and knowledge.

d. **Root cause identification**: Root because identification is a technique for identifying essential causes of risk. Using data from an actual risk event, the technique enables you to find out what happened and how it happened, and understand why it happened, so that you can devise responses to prevent recurrences

e. **Strengths, weaknesses, opportunities, and threats (SWOT) analysis**: A SWOT analysis examines the project from the perspective of each project's strengths, weaknesses, opportunities, and threats to increase the breadth of the risks considered by risk management.

Checklist analysis: Checklists list all identified or potential risks in one place. Checklists are commonly developed from historical information or lessons learned. The Risk Breakdown Structure (RBS) can also be used as a checklist. Just keep in mind that checklists are never comprehensive, so using another technique is still necessary.

Assumptions analysis: All projects are initially planned on a set of assumptions and what if scenarios. These assumptions are documented in the Project Scope Document. During Risk Identification, assumptions are analyzed to determine the amount of inaccuracy, inconsistency, or incompleteness associated with them.

Diagramming techniques: Diagramming techniques, such as system flow charts, cause and-effect diagrams, and influence diagrams are used to uncover risks that aren't readily apparent in verbal descriptions.

a. **Cause and effect diagrams**: Cause and effect diagrams or fishbone diagrams are used for identifying causes of risk.

b. **System or process flow charts**: Flow charts illustrate how elements and processes interrelate.

c. **Influence diagrams**: Influence diagrams depict causal influences, time ordering of events and other relationships between input variables and output variables.

The tools and techniques used for the Risk Identification process are designed to help the project manager gather information, analyze it, and identify risks to and opportunities for the project's objectives, scope, cost, and budget. The information gathered is entered on the Risk Register, which is the primary output of Risk Identification.

Risk Register: The Risk Register containing the results of the Qualitative Risk Analysis, Quantitative Risk Analysis, and Risk Response Planning. The Risk Register illustrates all identified risks, including description, category, and cause, probability of occurring, impact on objectives, proposed responses, owners, and current status. While the risk register will become the comprehensive output, Risk Identification process results in four entries in the Risk Register:

a. Lists of identified risks: Identified Risks with their root causes and risk assumptions are listed.

b. List of potential responses: Potential responses identified here will serve as inputs to the Risk Response Planning process.

c. Root causes of risk: Root causes of risk are fundamental conditions which cause the identified risk.

4.8 Study Approach

The study approach includes the steps as shown in Fig 4.2 which can summarize in the following points:

1. Perform a comprehensive review of literature relative relating to the topic of thesis study, in addition to interviews and discussion with some experienced project managers, consultants and engineers for collecting data concerned with identifying the risk factors.

2. Formulate data collected to develop and design a comprehensive questionnaire that covers the required data, the sources of risks and their probability of occurrence and their impact.

3. Conduct a field survey for construction companies

4. Perform Quantitative risk analysis tool for data by using applicable analysis techniques.

5. Ranking the risk factors according to the importance based on the response of all companies / Expected Companies working in this field in and also ranking these risk factor according to every company's point of view.

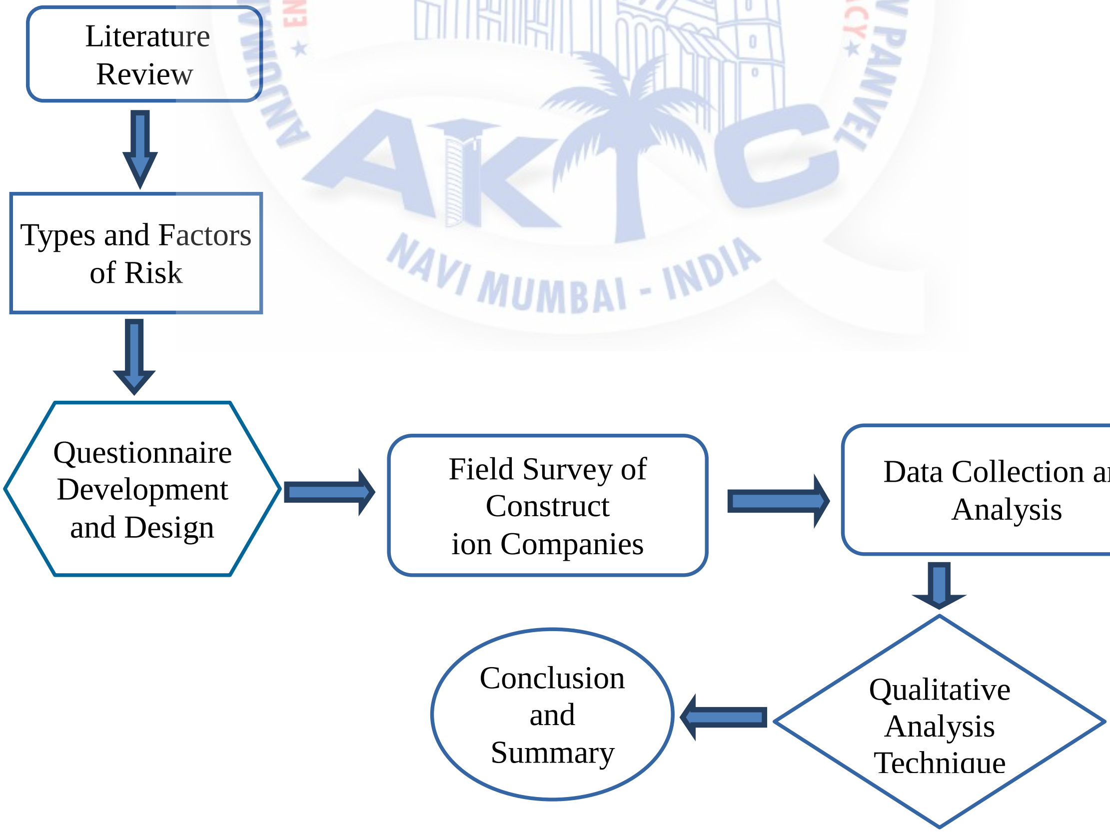

Fig4.2 Study Approach Diagram

4.9 Risk Response Actions

Risk response actions involves defining enhancement steps for opportunities and responses to threats. Responses to threats generally fall into one of three categories: Avoidance: eliminating a specific threat, usually by eliminating the cause. The project management team can never eliminate all risk, but specific risk events can often be eliminated. Mitigation: reducing the expected monetary value of a risk event by reducing the probability of occurrence (e.g., using proven technology to lessen the probability that the product of the project will not work), reducing the risk event value (e.g., buying insurance), or both. Acceptance: accepting the consequences. Acceptance can be active (e.g., by developing a contingency plan to execute should the risk event occur) or passive (e.g., by accepting a lower profit if some activities overrun). (See Table 4.1)

Table 4.1 Risk Response action

High risk problems	**Risk response actions**
A1. The scope of the project is poorly defined:	Focus on firming up scope in the planning process, document all scope assumptions when providing estimates of work, cost or duration, clearly define what is out of scope for project, do not begin project until scope id clear
a. May spend time and cost on areas out of scope	
b. Difficult to write project definition and work plan	
A2. The business requirements of the project are complex:	Get access to the sponsor and to senior management to provide overall guidance, provide training to express business requirements, ensure that the final business requirements are approved in writing.
a. Difficult to document the requirement properly	
b. Difficult to understand what the expectation of the project is	
B. Budget of the project was not established with any proven tool or by any experienced person:	Re-estimate the project using proven tools and experienced personnel, Revise the scope to fir within the funding available, don’t start the project until a better budget can be established
a. Budget will most likely not accurate.	
b. Budget will not be structured in manner to facilitate tracking and control	
C. Long estimated project duration:	Identify clear milestones to check that the project is on schedule, rotate team members into different roles to keep up the interest live, strive to get ahead of schedule as early as possible
a. Harder to manage the schedule	
b. Chances that project will lose organizational commitment	

c. Chances that business requirements will change	
D1. Project management experience is light:	Provide management training, designate a more senior person to coach and mentor the project manager, utilize strong team leads and team members to bring additional experience to bear.
a. May take longer to define the project and build work plan	
b. May make mistakes in judgment causing rework and project delays	
c. More difficulty in organizing and managing a complex project	
D2. Project management process are unfamiliar:	Provide training to the project manager and project team on sound project management processes and procedures, Break the project into smaller pieces that can be managed with less-rigorous project management
a. Project may get out of control as the internal processes become more complex and harder to manage	
b. Chance that the project may be in trouble before it is recognized	

4.10 Questionnaire Development and Design

Questionnaires are extremely critical components of the research process because they identify which information is important and the participants about the discussed problem. The design of the questionnaire requires very careful consideration. One should aim at formulating the question such that no misinterpretation is possible. To do this, the following points should be taken into consideration in designing the questionnaire:

a. Proper introduction of the questionnaire explaining the purpose of the study and emphasizing the confidentiality of responses.
b. Question must give the information required.
c. Question must be concise and clear
d. Question must be presented in the best sequence possible, preferably from simplest to most complex.

The questionnaire survey was sent via email to a sample of managers (mainly in Mumbai) involved in risk management. The questionnaire contained some questions grouped into separate sections: i) background information about the company; ii) identification of critical risks and their impact by ranking; iii) company strategies to handle identified risks; and iv) awareness about the availability of current risk analysis and response techniques and suggestions made accordingly. (Refer Appendix1). Based on all the gathered information, quantitative analysis was performed. The response rate for completed questionnaires is shown in Table 4.2.

Table 4.2 Response Breakdown

Place	Mumbai Sub-urban
No. of participating companies	50
No.of companies rejected due to improper answering	5
No. of companies responded	22
Response rate %	48%

4.11 The Methods used to Rank the Risk Factors

Important index method is used to rank the risk factors in this project. It is used to assess the relative significance among risk factors and then ranking these risks. It is depended on probability index and impact index the probability index (P.I) and impact index (I.I) of each factor will be calculated by the Eq.1. (Ghafly 1995)

$$\mathbf{P.I} = [\sum (P_S * XPs) / (Pmax)] * 100 \qquad \text{Eq. 1}$$

$$\mathbf{I.I} = [\sum (I_S * XI_S) / (Imax)] * 100 \qquad \text{Eq. 2}$$

Where,

P.I = Probability Index

I.I =Impact Index

IMP.IND = Important Index

P_S = Probability scale

I_S = Impact scale

POC_S = Significance assigned to option (s) on the Probability of occurrence scales.

DOI_S = Significance assigned to option (s) on the degree of impact scales.

XPs = number of respondent who selected option (s) for probability of occurrence

XI_S = number of responded who selected option (s) for degree of impact

N = Total number of respondents

P_{max} = The probability of occurrence scales (maximum)

D_{max} = The Impact of occurrence scales (maximum)

Then the importance index (IMP.IND.) will be calculated by the following formula:

$$\mathbf{IMP.IND.\ \% = (P.I * I.I.) * 100} \qquad \text{Eq. 3}$$

Chapter 5

Results and Discussions

5.1 Summary

This chapter presents and discusses the results of the collected data. Also, analysis has been achieved. In order to rank the risk factors affecting the companies working in construction industry, importance index and average risk score method were used. The comparisons of risk factors between the different companies are tabulated.

5.2 Qualitative Risk Analysis

Qualitative risk analysis is the process of evaluating the impact and likelihood of identified risk. Risks are prioritized according to their potential effect on project objectives by this process. The two dimensions of risk are applied to specific risk event. Analysis of risks using probability and impact helps identify those risks that should be managed aggressively Assessing risk probabilities may be difficult because expert judgments are used, often without benefit of historical data. These scales for probability of occurrence and degree of impact were used the questionnaire. The probability of occurrence and degree of impact of the risk factors were measured by the scores given to each factor by the respondents, statistical techniques were used to analyze and interpret the collected data concerning the probability and impact scores of the risk factors. Both of these scales are 5 levels scales ranging between 1 to 5 is shown in below Table 5.1.

Table 5.1. Probability and Impact Scale

Sr. no.	Option	Probability Scale	Impact Scale
1	Very High	5	5
2	High	4	4
3	Moderate	3	3
4	Low	2	2
5	Very Low	1	1

5.3 Survey Result

The questionnaire provided respondents with a set of risk factors, for which they were to assign probability of occurrence and degree of impact. The following sections present and discuss the results concerning the probability of occurrence and degree of impact, then describes the importance of risk factors and sources of these Risk factors based on their probability and degree of impact index. Fig 5.1. shows, that the majority of companies (over 90%) depend on judgment/experience to mitigate risks involved in construction. The computer-based techniques are not really used and in most of the companies (around 81%) are even not aware of these techniques

It was concluded from the results of questionnaire survey, that the top three risk analysis techniques; expert system, probability analysis, direct judgment were utilized by most of the companies (around 80%), which are summarized in Fig5.1

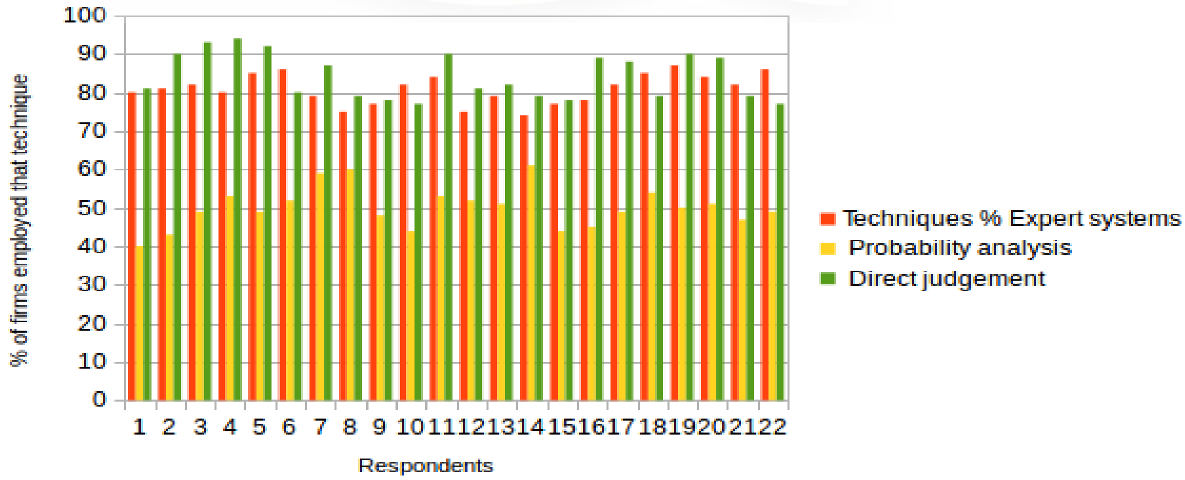

Fig 5.1. Response from Selected companies about Different Risk Analysis Techniques

5.3.1 Probability of Occurrence and Impact of Risk Factors

The probability of occurrence and degree of impact of the risk factors were measured by the scores given to each factor by the respondents as described in section (5.2), techniques were used to analyze and the collected data concerning the probability and impact scores of the risk factors. Both of these scales are 5 levels scales ranging between 1 to 5.

Table 5.2, shows the ranking given by each respondent for corresponding probability of occurrence and degree of impact which can be used to find out an Important Index.

Table 5.2. Probability of occurrence and Degree of Impact

Sr. No	Option	Respondents (Probability of occurrence)	Respondents (Degree of Impact)
1	Very High	0	11
2	High	8	8
3	Moderate	14	3
4	Low	0	0
5	Very Low	0	0
	Total	**22**	**22**

5.4 Risk Score

In this study, the Risk Score shows the Important Risk Factor, the risk score has been calculated using ranking given by respondents and the Risk Score in this study is ranging from 1 to 25, this is divided into three levels as follows: (a) 1 to 5 is Low (b) 6 to 12 is Medium (c) 15 to 25 is Extreme or High. (Refer Appendix 2)

5.5 Importance index and Risk score

Risk Score shows the Important Risk Factor, as shown in below Table 5.3, the risk score has been calculated using ranking given by respondents. The Risk Score in this study is ranging from 1 to 25, this is divided into three levels as follows: (a) Low (b) Medium (c) Extreme or High. (Refer Appendix 3).

Table 5.3. Risk Score

Sr.No.	Risk factors	Risk score																					
	Respondent	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
	A. Financial Risk																						
1	Loss due to fluctuation of inflation rate	20	12	16	9	15	20	15	12	16	9	15	16	12	20	9	15	20	15	12	16	15	15
2	Bankruptcy of project partner	15	16	15	12	25	12	16	15	25	12	16	12	16	15	16	25	12	16	15	25	12	25
	B. Legal risk																						
1	Lack of knowledge	8	9	16	6	10	9	6	8	10	8	6	9	8	16	6	10	9	10	8	10	8	6
2	Uncertainty and unfairness of court justice	9	12	12	4	9	12	9	4	15	12	9	12	9	12	4	9	12	9	9	15	12	9
	C. Management of risk																						
1	No past experience in similar project	4	9	6	4	9	9	6	8	4	9	6	6	9	6	4	9	9	9	8	4	9	6
2	Team work	1	2	4	1	2	2	4	1	2	1	4	2	1	4	1	2	2	4	1	2	1	4
3	Project delay	15	20	9	16	15	9	16	15	20	16	20	16	20	9	16	15	15	16	15	20	16	20
4	Time constraint	9	12	12	9	12	12	9	15	9	12	12	12	9	12	9	12	12	9	15	9	12	12
5	Poor relation and disputes with partner	16	8	16	16	8	8	16	15	16	8	16	16	8	16	16	8	8	16	15	16	8	16
6	Improper project planning and budgeting	20	16	20	12	16	16	20	20	16	15	20	20	16	20	12	16	16	20	20	16	15	20
	D. Market risk																						
1	Increase of labour cost	8	6	8	9	16	9	6	16	8	9	8	8	6	8	9	16	9	6	16	8	9	8
2	Increase of material price	20	15	20	15	25	20	15	25	20	15	25	20	15	20	15	25	20	15	25	20	15	25
3	Competition from other companies	25	20	16	25	20	16	20	25	16	20	25	25	20	16	25	20	16	20	25	16	20	25
	E. Policy and Political Risk																						
1	Cost increase due to changes of govt policies	16	20	15	12	20	16	15	20	12	20	20	16	20	15	12	20	16	15	20	12	20	20
2	Loss due to corruption	25	16	20	25	20	25	20	16	25	20	16	25	16	20	25	20	25	20	16	25	20	16
	F. Technical risk																						
1	Site accidents	16	12	16	20	16	20	16	12	16	12	20	16	12	16	20	16	20	16	12	16	12	20
2	Design changes	9	12	9	16	8	9	8	16	9	12	9	9	12	9	16	8	9	8	16	9	12	9
3	Equipment failure	16	15	12	9	15	15	12	16	9	15	16	16	15	12	9	15	15	12	16	9	15	16
4	Errors in design drawings	6	9	8	6	8	6	8	9	8	6	8	6	9	8	6	8	6	8	9	8	6	8
5	Industrial disputes	8	10	4	8	10	8	10	6	8	9	10	8	10	4	8	10	8	10	6	8	9	10
	G. Environmental risk																						
1	Impact on project dut to climatic conditions	20	16	15	20	25	20	16	25	20	16	25	15	16	15	20	25	20	16	25	20	25	16

From the result displayed in below chart Fig5.2, we can say that, Importance index of risk factor more than 25% and above means that the risk level is extreme and needs to be sorted out and resolved first.

And those risk factors are Loss due to fluctuation of inflation rate, Bankruptcy of project partner, Project delay, Poor relation and disputes with partner, Improper project planning and budgeting, Increase of material price, Competition from other companies, Cost increase due to changes of govt policies, Loss due to corruption, Site accidents, Equipment failure, Impact on project due to climatic conditions.

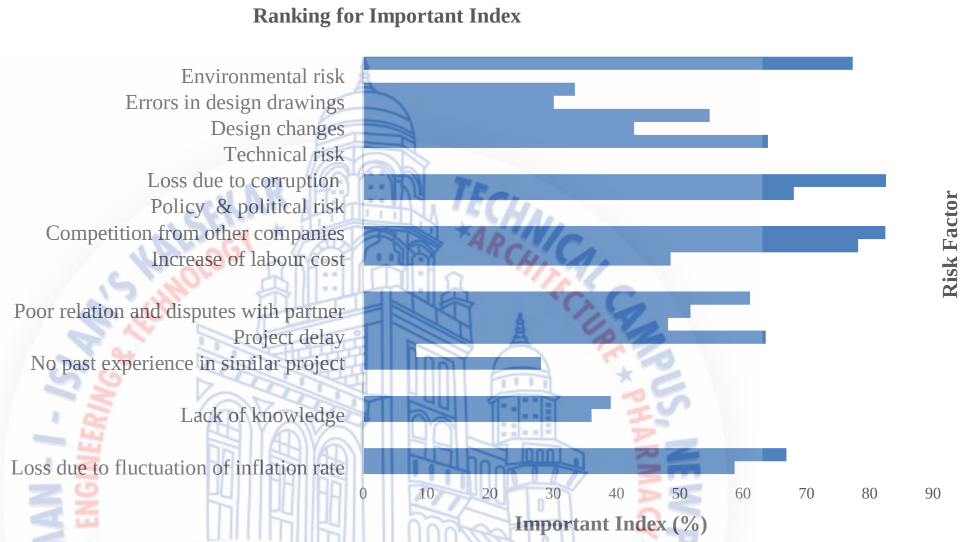

Fig 5.2. Ranking of Important Index for all companies

Table 5.4 shows the important index for each risk factor. Important index is used to rank the risk factors in this project. With respect to the magnitude of risk score, an average Index Score of 25 (Medium likelihood of occurrence 5 × medium level of impact 5) can be regarded as high as per (AS/NZS4360, 2004).

It is determined that out of 21 risk factors considered, 20 are having a risk index score of 25 or more and hence they are significant risks for building construction industry.

Table 5.4. Important Index

Sr. No.	Risk factors	Imp index (%)
A.	**Financial risk**	
1	Loss due to fluctuation of inflation rate	58.7
2	Bankruptcy of project partner	66.86
B.	**Legal risk**	
1	Lack of knowledge	36.09
2	Uncertainty and unfairness of court justice	39.13

C.	**Management risk**	
1	No past experience in similar project	28.11
2	Team work	8.38
3	Project delay	63.58
4	Time constraint	48.16
5	Poor relation and disputes with partner	51.72
6	Improper project planning and budgeting	61.12
D.	**Market risk**	
1	Increase of labour cost	48.58
2	Increase of material price	78.18
3	Competition from other companies	82.5
E.	**Policy and political risk**	
1	Cost increase due to changes of govt policies	68.02
2	Loss due to corruption	82.6
F.	**Technical risk**	
1	Site accidents	63.95
2	Design changes	42.8
3	Equipment failure	54.73
4	Errors in design drawings	30.14
5	Industrial disputes	33.44
G.	**Environmental risk**	
1	Impact on project dut to climatic conditions	77.34

Where Analysis indicated that most of the top 20 risk factors according to Companies point of view are:

1. Loss due to corruption: Corruption, defined as the abuse of power for private gain, comes in various forms. This includes embezzlement, bribery, nepotism, influence peddling, theft of public funds or assets, fraud, forgery, causing financial or property loss, false accounting in public affairs and tax evasion. In developing countries, corruption is considered to be one of the most severe frictions impeding economic growth.

2. Competition from other companies: Communication has become an essential item of modern life. Because of competition, communication between companies has reduced. However, communication between branches of a company is necessary because it coordinates work, reduces job overlapping, and increases the knowledge and experience of the employees.

3. Increase of material price: The increase of building materials prices is an indication that the construction sector is growing at a higher pace as the building industry is expanding with new projects and properties. This reflects a healthy outlook for the construction and the real estate sectors

4. Impact on project due to climatic conditions: Buildings can be vulnerable to climate change. In the future, there may be an increase in the risk of collapse, declining health and

significant loss of value as a result of more storms, snow or subsidence damage, water encroachment, deteriorating indoor climate and reduced building lifetime.

5. Cost increase due to changes of govt policies: Governments establish many rules and regulations that guide construction industry. It will normally change the way they operate when government changes these rules and regulations. Government economic policy and market regulations have an influence on the competitiveness and profitability of businesses.

6. Bankruptcy of project partner: Bankruptcy on a construction project affects the rights and obligations of all parties, including owners, general contractors, subcontractors, sureties, laborers, and suppliers.

7. Site accidents: Experiencing an injury as the result of a construction site accident can be frightening and stressful. Balancing the details of the situation between your lawyer, insurance, and medical claims can be difficult, but not impossible.

8. Project delay: Delay in construction project is considered one of the most common problems causing a multitude negative effect on the project and its participating parties. Therefore, it is essential to identify the actual causes of delay in order to minimize and avoid the delays and their corresponding expenses.

9. Improper project planning and budgeting: The results of poor planning are discussed below poor time management, Poor clear definitions of project's objectives, Budget not set out etc.

10. Loss due to fluctuation of inflation rate: Greater fluctuations bring a higher opportunity cost to the conservative strategy. As a result, most enterprises adjust their factor inputs to avoid the opportunity cost.

11. Equipment failure: Equipment failure can result in low production, delay in work etc.

12. Poor relation and disputes with partner: Understanding the causes and effects of disputes is fundamental to personal and project success

13. Increase of Labour cost: The Common Construction wage insulates construction unions from competition. It requires public bodies to frequently pay union wage scales on construction projects. This inflates the cost of construction labor with no benefit to taxpayers.

14. Time constraint: Constraints can specify the earliest date on which a task should be completed ('no earlier than'); the date by which a task should be completed ('no later than'); and the exact date on which a task must be completed ('on this date').

15. Design Changes: Design constraints are factors that limit the range of potential design solutions. In the early stage of a project only some of these constraints may be known, while others become apparent as the design progresses.

16. Uncertainty and unfairness of court justice: this factor may have adverse effect on construction industry.

17. Lack of knowledge: When there is no training, employees do not understand how to do their jobs and none of these goals are possible. This leads to low morale among workers, which results in employee turnover

18. Industrial disputes: Understanding the causes and effects of disputes is fundamental to personal and project success

19. Errors in design drawings: Design errors have an impact on the outcome of the effectiveness of the contractor's effort on the project it is essential that all parties determine what the definition of a design error should be.

20. No past experience in similar project: Experience gives you the theoretical knowledge and analytical skill to show why it does not work, Thus the experienced person learns new ideas processes or technologies,

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Chapter 6

Summary and Conclusion

6.1 Summary

As far as India is concerned risk management is still a new word in the construction sector and this should be changed as soon as possible. Currently the Government of India has proposed a risk rating system will help the developers to develop projects at a faster pace by taking quick decisions. Each rating agency will have its own methodology to rate projects. The system will help government to develop a strategy to mitigating risk. This will encourage more response from developers and investors for public-private partnerships projects. It could make the bidding projects more competitive. The system will enable bankers to take quick decisions for lending finances, which could lead to the financial closure of the project at a faster pace. Third party risk rating would certainly raise critical points, which are not normally raised during finalization of project.

This study has created a list of risk and it's in impact on the construction industry using survey. This study should assist management in identifying activities where there is a risk of injury or loss and hence provide a basis for management decisions on the application of resources. This enables management to take objective decisions on the reduction of risk to an agreed level

6.2 Conclusion

This project discusses the risk factors affecting the construction. It studies the importance of the risk factors based on their probability that event will occur and seriousness if event occurs. This project is a field survey research through a structured questionnaire directed to the contractor, manager working in this field. The results reveal that in the construction industry, risk analysis techniques are rarely used by the contractor's due to lack of knowledge. It was shown that there are many risk factors affecting various aspects of construction industry. These factors are considered to be an important field of study for the future advancement and stabilization of the construction industry and study needs to be done in detail. 20 risk factors were identified and described in this project. The field survey includes twenty-two companies who are working in field of construction. The questionnaire is divided into two parts: one part for general information about the respondents, and the second related to the respondent's opinion on probability of occurrence and degree of impact of the risk factors. All collected data were analyzed and "the important index and risk score were calculated for the risk factors as a function of their probability of occurrence and degree of impact. Ranking was given for each risk factor for each company as well based on their importance index and average risk score. Analysis indicated that most of the top 12risk factors affecting the companies working in the construction are:

1. Loss due to corruption
2. Competition from other companies
3. Increase of material price
4. Impact on project due to climatic conditions
5. Cost increase due to changes of govt. policies
6. Bankruptcy of project partner
7. Site accidents
8. Project delay
9. Improper project planning and budgeting
10. Loss due to fluctuation of inflation rate
11. Equipment failure
12. Poor relation and disputes with partner

13. Increase of Labour cost
14. Time constraint
15. Design Changes
16. Uncertainty and unfairness of court justice
17. Lack of knowledge
18. Industrial disputes
19. Errors in design drawings
20. No past experience in similar project

6.3 Recommendations

Following are the recommendations made for future work:

1. Experienced construction team is required for risk identification and management and cannot be done by one person alone, forming the right team to identify the risks involves serious investment of effort, time and selection of the right tools and techniques.
2. The contractor should study the inflation rate and define the contingences which enable him to finish the project and overcome the risk of inflation.
3. Risk management should be considered a primary tool to assess the project. From the survey, we can understand that risk management is not followed in most of the companies as such but if followed also it is not done systematically. Immediate mitigation measures are not in place if a risk event happens.
4. The contractor should be familiar with the changes of the material prices in the market and follow the effect of the changes in the international market in the local market also he should update his data base with changing rates.
5. The contractor should thoroughly go through the contract terms and conditions and to try to minimize his risk or to share it with the client.

6.4 Scope for future work

Future research will also look in more detail at risk management processes, such as risk management planning, identification, measurement, prioritization, and monitoring and control.

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APPENDIX

QUESTIONNAIRE (A)

ANJUMAN ISLAM KALSEKAR COLLEGE OF ENGINEERING

Master's Thesis Questionnaire Part

(A) BASIC & GENERAL INFORMATION

You are kindly requested to choose the appropriate answer from following question:

1. Name of Your Company?
2. Position:
3. Phone no. And email address
4. How many of Total years of experience you have working in the field?
   - Less than Five Years
   - From Five to ten Years
   - From ten to Fifteen Years
   - More Than Fifteen Years
5. Who is responsible for handling risks in the company?
   - Senior Manager
   - Site engineer
   - General Contractors
   - Risk Manager
   - All Staff
   - Others

If you have any suggestions or comments, please feel free to contact me: Mobile phone: 9768204921. E-mail: trupti.kadam10008@gmail.com

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QUESTIONNAIRE (B)

Appendix 1: Risk Assessment Questionnaire

Risk Assessment Questionnaire			
Characteristic	**Low risk**	**Medium risk**	**High risk**
Organization			
A. Scope			
1. Scope of the project is:	[ ] Well-defined and understood	[ ] Somewhat defined, but subject to change	[ ] Poorly defined and likely to change
2. The business requirements of the project are:	[ ] Understood and straightforward	[ ] Understood but very complex	[ ] Very complex
3. The quality of current data is:	[ ] well-defined and simple to convert	[ ] well-defined but complex	[ ] Poor or complex to convert
B. Budget			
1.The project budget is based upon use of a proven successful cost estimation process by personnel with estimation experience:	[ ] yes personnel with experience	[ ] Some experience or process	[ ] No
2. Project funding matches or exceeds the estimated cost and is stable:	[ ] funding is greater than estimated and is expected to be stable	[ ] Funding is marginally adequate	[ ] Funding less than estimated and stability is uncertain
C. Schedule			
1 Project duration is estimated at:	[ ] Less than 3 months	[ ] 3 to 12 months	[ ] Greater than 12 months
D. Human Resources			
1. The project managers experience and training is	[ ] Recent success in managing a project	[ ] No actual experience	[ ] No recent experience
2. Experience of personnel with tools and techniques to be used	[ ] Experienced in use of tools and techniques	[ ] Formal training in use of tools and techniques but no experience	[ ] No training and no experience
3. How would you rate the readiness level within the project recipient for changes this project will create	[ ] High	[ ] Moderate	[ ] Low

Appendix 2. Ranking given by each respondent

		Respondents																							Respondents																	
				1								Total	2		T	3		T	4		T	5		T	6		T	7		T	8		T	9		T	10		T	11		T
Sr. no.	Types of risks	Probablility level of the risk occurrrence (a)					Degree of impact (b)					(a x b)	(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)	
		very	small	Normal	large	very large	very	low	Medium	high	very																															
		1	2	3	4	5	1	2	3	4	5																															
A.	**Financial risk**																																									
1	Loss due to fluctuation of inflation rate				4						5	**20**	3	4	**12**	4	4	**16**	3	3	**9**	3	5	**15**	4	5	**20**	3	5	**15**	3	4	**12**	4	4	**16**	3	3	**9**	3	5	**15**
2	Bankruptcy of project partner			3							5	**15**	4	4	**16**	3	5	**15**	4	3	**12**	5	5	**25**	4	3	**12**	4	4	**16**	3	5	**15**	5	5	**25**	4	3	**12**	4	4	**16**
B.	**Legal risk**																																									
1	Lack of knowledge		2							4		**8**	3	3	**9**	4	4	**16**	2	3	**6**	2	5	**10**	3	3	**9**	2	3	**6**	2	4	**8**	2	5	**10**	2	4	**8**	2	3	**6**
2	Uncertainity and unfairness of court justice			3					3			**9**	3	4	**12**	3	4	**12**	2	2	**4**	3	3	**9**	3	4	**12**	3	3	**9**	2	2	**4**	3	5	**15**	3	4	**12**	3	3	**9**
C.	**Management risk**																																									
1	No past experience in		2					2				**4**	3	3	**9**	2	3	**6**	2	2	**4**	3	3	**9**	3	3	**9**	2	3	**6**	2	4	**8**	2	2	**4**	3	3	**9**	2	3	**6**
2	Team work	1					1					**1**	2	1	**2**	2	2	**4**	1	1	**1**	2	1	**2**	2	1	**2**	2	2	**4**	1	1	**1**	2	1	**2**	1	1	**1**	2	2	**4**
3	Project delay			3							5	**15**	4	5	**20**	3	3	**9**	4	4	**16**	3	5	**15**	3	3	**9**	4	4	**16**	3	5	**15**	4	5	**20**	4	4	**16**	5	4	**20**
4	Time constraint			3					3			**9**	3	4	**12**	3	4	**12**	3	3	**9**	3	4	**12**	3	4	**12**	3	3	**9**	3	5	**15**	3	3	**9**	3	4	**12**	3	4	**12**
5	Poor relation and disputes with				4					4		**16**	2	4	**8**	4	4	**16**	4	4	**16**	2	4	**8**	2	4	**8**	4	4	**16**	3	5	**15**	4	4	**16**	2	4	**8**	4	4	**16**
6	Improper project planning and budgeting				4						5	**20**	4	4	**16**	4	5	**20**	3	4	**12**	4	4	**16**	4	4	**16**	4	5	**20**	5	4	**20**	4	4	**16**	3	5	**15**	4	5	**20**

D.	**Market risk**																																									
1	Increase of labour cost		2							4		**8**	3	2	**6**	4	2	**8**	3	3	**9**	4	4	**16**	3	3	**9**	2	3	**6**	4	4	**16**	2	4	**8**	3	3	**9**	2	4	**8**
2	Increase of material price				4						5	**20**	3	5	**15**	4	5	**20**	3	5	**15**	5	5	**25**	4	5	**20**	3	5	**15**	5	5	**25**	4	5	**20**	3	5	**15**	5	5	**25**
3	Competition from other					5					5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	4	4	**16**	4	5	**20**	5	5	**25**	4	4	**16**	4	5	**20**	5	5	**25**
E.	**Policy & political risk**																																									
1	Cost increase due to changes of govt policies				4					4		**16**	4	5	**20**	3	5	**15**	3	4	**12**	5	4	**20**	4	4	**16**	3	5	**15**	4	5	**20**	3	4	**12**	5	4	**20**	4	5	**20**
2	Loss due to corruption					5					5	**25**	4	4	**16**	5	4	**20**	5	5	**25**	4	5	**20**	5	5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	4	4	**16**
F.	**Technical risk**																																									
1	Site accidents				4					4		**16**	3	4	**12**	4	4	**16**	5	4	**20**	4	4	**16**	5	4	**20**	4	4	**16**	3	4	**12**	4	4	**16**	3	4	**12**	4	5	**20**
2	Design changes			3					3			**9**	3	4	**12**	3	3	**9**	4	4	**16**	4	2	**8**	3	3	**9**	2	4	**8**	4	4	**16**	3	3	**9**	3	4	**12**	3	3	**9**
3	Equipment failure				4					4		**16**	3	5	**15**	3	4	**12**	3	3	**9**	3	5	**15**	3	5	**15**	3	4	**12**	4	4	**16**	3	3	**9**	3	5	**15**	4	4	**16**
4	Errors in design drawings		2						3			**6**	3	3	**9**	2	4	**8**	2	3	**6**	2	4	**8**	2	3	**6**	2	4	**8**	3	3	**9**	2	4	**8**	2	3	**6**	2	4	**8**
5	Industrial disputes		2							4		**8**	2	5	**10**	2	2	**4**	2	4	**8**	2	5	**10**	2	4	**8**	2	5	**10**	2	3	**6**	2	4	**8**	3	3	**9**	2	5	**10**
G.	**Environmental risk**																																									
1	Impact on project dut to climatic conditions				4						5	**20**	4	4	**16**	3	5	**15**	4	5	**20**	5	5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	4	4	**16**	5	5	**25**

		Respondents																									Respondents																	
		12										Total	13		Total	14		T	15		T	16		T	17		T	18		T	19		T	20		T	21		T	22		T
Sr.no.	Types of risks	Probabliloty level of the risk occurrrence (a)					Degree of impact (b)					(a x b)	(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)		(a)	(b)	
		very small	small	Normal	large	very large	very low	low	Medium	high	very high																																
		1	2	3	4	5	1	2	3	4	5																																
A.	**Financial risk**																																										
1	Loss due to fluctuation of inflation rate				4						4	16	3	4	12	4	5	20	3	3	9	3	5	15	4	5	20	3	5	15	3	4	12	4	4	16	3	5	15	3	5	15
2	Bankruptcy of project partner			3							4	12	4	4	16	3	5	15	4	4	16	5	5	25	4	3	12	4	4	16	3	5	15	5	5	25	4	3	12	5	5	25
B.	**Legal risk**																																										
1	Lack of knowledge			3						3		9	2	4	8	4	4	16	2	3	6	2	5	10	3	3	9	2	5	10	2	4	8	2	5	10	2	4	8	2	3	6
2	Uncertainity and unfairness of court justice				4				3			12	3	3	9	3	4	12	2	2	4	3	3	9	3	4	12	3	3	9	3	3	9	3	5	15	3	4	12	3	3	9
C.	**Management risk**																																										
1	No past experience in similar project		2						3			6	3	3	9	2	3	6	2	2	4	3	3	9	3	3	9	3	3	9	2	4	8	2	2	4	3	3	9	2	3	6
2	Team work	1						2				2	1	1	1	2	2	4	1	1	1	2	1	2	2	1	2	2	2	4	1	1	1	2	1	2	1	1	1	2	2	4
3	Project delay				4					4		16	4	5	20	3	3	9	4	4	16	3	5	15	3	5	15	4	4	16	3	5	15	4	5	20	4	4	16	5	4	20
4	Time constraint				4				3			12	3	3	9	3	4	12	3	3	9	3	4	12	3	4	12	3	3	9	3	5	15	3	3	9	3	4	12	3	4	12
5	Poor relation and disputes with partner				4					4		16	2	4	8	4	4	16	4	4	16	2	4	8	2	4	8	4	4	16	3	5	15	4	4	16	2	4	8	4	4	16
6	Improper project planning and budgeting				4						5	20	4	4	16	4	5	20	3	4	12	4	4	16	4	4	16	4	5	20	5	4	20	4	4	16	3	5	15	4	5	20

D.	**Market risk**																																									
1	Increase of labour cost		2							4		**8**	3	2	**6**	4	2	**8**	3	3	**9**	4	4	**16**	3	3	**9**	2	3	**6**	4	4	**16**	2	4	**8**	3	3	**9**	2	4	**8**
2	Increase of material price				4						5	**20**	3	5	**15**	4	5	**20**	3	5	**15**	5	5	**25**	4	5	**20**	3	5	**15**	5	5	**25**	4	5	**20**	3	5	**15**	5	5	**25**
3	Competition from other companies					5					5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	4	4	**16**	4	5	**20**	5	5	**25**	4	4	**16**	4	5	**20**	5	5	**25**
E.	**Policy & political risk**																																									
1	Cost increase due to changes of govt policies				4					4		**16**	4	5	**20**	3	5	**15**	3	4	**12**	5	4	**20**	4	4	**16**	3	5	**15**	4	5	**20**	3	4	**12**	5	4	**20**	4	5	**20**
2	Loss due to corruption					5					5	**25**	4	4	**16**	5	4	**20**	5	5	**25**	4	5	**20**	5	5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	4	4	**16**
F.	**Technical risk**																																									
1	Site accidents				4					4		**16**	3	4	**12**	4	4	**16**	5	4	**20**	4	4	**16**	5	4	**20**	4	4	**16**	3	4	**12**	4	4	**16**	3	4	**12**	4	5	**20**
2	Design changes			3					3			**9**	3	4	**12**	3	3	**9**	4	4	**16**	4	2	**8**	3	3	**9**	2	4	**8**	4	4	**16**	3	3	**9**	3	4	**12**	3	3	**9**
3	Equipment failure				4					4		**16**	3	5	**15**	3	4	**12**	3	3	**9**	3	5	**15**	3	5	**15**	3	4	**12**	4	4	**16**	3	3	**9**	3	5	**15**	4	4	**16**
4	Errors in design drawings		2						3			**6**	3	3	**9**	2	4	**8**	2	3	**6**	2	4	**8**	2	3	**6**	2	4	**8**	3	3	**9**	2	4	**8**	2	3	**6**	2	4	**8**
5	Industrial disputes		2							4		**8**	2	5	**10**	2	2	**4**	2	4	**8**	2	5	**10**	2	4	**8**	2	5	**10**	2	3	**6**	2	4	**8**	3	3	**9**	2	5	**10**
G.	**Environmental risk**																																									
1	Impact on project dut to climatic conditions				3						5	**15**	4	4	**16**	3	5	**15**	4	5	**20**	5	5	**25**	4	5	**20**	4	4	**16**	5	5	**25**	4	5	**20**	5	5	**25**	4	4	**16**

Appendix 3. Comparison between all respondent's risk score

Sr.no.	Risk factors	1		2		3		4		5		6		7		8		9		10		11	
		Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score	Rank	Risk score
A.	**Financial risk**																						
1	Loss due to fluctuation of inflation rate	High	**20**	Mediu	**12**	High	**16**	Medi um	**9**	High	**15**	High	**20**	High	**15**	Mediur	**12**	High	**16**	Mediu	**9**	High	**15**
2	Bankruptcy of project partner	High	**15**	High	**16**	High	**15**	Mediu	**12**	High	**25**	Medium	**12**	High	**16**	High	**15**	High	**25**	Mediu	**12**	High	**16**
B.	**Legal risk**																						
1	Lack of knowledge	Medium	**8**	Mediu	**9**	High	**16**	Mediu	**6**	Mediu	**10**	Medium	**9**	Mediu	**6**	Mediur	**8**	Mediu	**10**	Mediu	**8**	Medium	**6**
2	Uncertainity and unfairness of court justice	Medium	**9**	Mediu	**12**	Medi	**12**	Low	**4**	Mediu	**9**	Medium	**12**	Mediu	**9**	Low	**4**	High	**15**	Mediu	**12**	Medium	**9**
C.	**Management of risk**																						
1	No past experience in similar project	Low	**4**	Mediu	**9**	Medi	**6**	Low	**4**	Mediu	**9**	Medium	**9**	Mediur	**6**	Medium	**8**	Low	**4**	Mediur	**9**	Medium	**6**
2	Team work	Low	**1**	Low	**2**	Low	**4**	Low	**1**	Low	**2**	Low	**2**	Low	**4**	Low	**1**	Low	**2**	Low	**1**	Low	**4**
3	Project delay	High	**15**	High	**20**	Medi	**9**	High	**16**	High	**15**	Medium	**9**	High	**16**	High	**15**	High	**20**	High	**16**	High	**20**
4	Time constraint	Medium	**9**	Mediu	**12**	Medi	**12**	Mediu	**9**	Mediu	**12**	Medium	**12**	Medium	**9**	High	**15**	Mediun	**9**	Mediur	**12**	Medium	**12**
5	Poor relation and disputes with partner	High	**16**	Mediu	**8**	High	**16**	High	**16**	Mediu	**8**	Medium	**8**	High	**16**	High	**15**	High	**16**	Mediur	**8**	High	**16**
6	Improper project planning and budgeting	High	**20**	High	**16**	High	**20**	Mediu	**12**	High	**16**	High	**16**	High	**20**	High	**20**	High	**16**	High	**15**	High	**20**

D.	**Market risk**																						
1	Increase of labour cost	Medium	8	Mediu	6	Medi	8	Mediu	9	High	16	Medium	9	Medium	6	High	16	Mediun	8	Mediur	9	Medium	8
2	Increase of material price	High	20	High	15	High	20	High	15	High	25	High	20	High	15	High	25	High	20	High	15	High	25
3	Competition from other companies	High	25	High	20	High	16	High	25	High	20	High	16	High	20	High	25	High	16	High	20	High	25
E.	**Policy & political risk**																						
1	Cost increase due to changes of govt policies	High	16	High	20	High	15	Mediu	12	High	20	High	16	High	15	High	20	Mediun	12	High	20	High	20
2	Loss due to corruption	High	25	High	16	High	20	High	25	High	20	High	25	High	20	High	16	High	25	High	20	High	16
F.	**Technical risk**																						
1	Site accidents	High	16	Mediu	12	High	16	High	20	High	16	High	20	High	16	Medium	12	High	16	Mediur	12	High	20
2	Design changes	Medium	9	Mediu	12	Medi	9	High	16	Mediu	8	Medium	9	Medium	8	High	16	Mediun	9	Mediur	12	Medium	9
3	Equipment failure	High	16	High	15	Medi	12	Mediu	9	High	15	High	15	Medium	12	High	16	Mediun	9	High	15	High	16
4	Errors in design drawings	Medium	6	Mediu	9	Medi	8	Mediu	6	Mediu	8	Medium	6	Medium	8	Medium	9	Mediun	8	Mediur	6	Medium	8
5	Industrial disputes	Medium	8	Mediu	10	Low	4	Mediu	8	Mediu	10	Medium	8	Medium	10	Medium	6	Mediun	8	Mediur	9	Medium	10
G.	**Environmental risk**																						
1	Impact on project dut to climatic conditions	High	20	High	16	High	15	High	20	High	25	High	20	High	16	High	25	High	20	High	16	High	25

PUBLICATIONS

1. “Factors affecting Project Success in Construction Industry: A Review”, *International Conference on Construction, Real Estate, Infrastructure and Projects(CRIP) Management-ICCRIP-2017*, *NICMAR*, Pune. (Paper Communicated)
2. “Modern Approach to Minimize the Risk in Construction Industry*”, Journal of Construction Engineering and Project Management, Korea Institute of Construction Engineering and Management*, (Paper Communicated)

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