SENSITIVITY OF RISKS IN CONSTRUCTION SCHEDULING

Thesis

Submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

by

ROHAN MAXWEL COLACO

DEPARTMENT OF APPLIED MECHANICS AND HYDRAULICS

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA,

SURATHKAL, MANGALORE-575025

July, 2017

DECLARATION

I hereby declare that the Research Thesis entitled SENSITIVITY OF RISKS IN CONSTRUCTION SHEDULING which is being submitted to the National Institute of Technology Karnataka, Surathkal in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Civil Engineering is a *bonafide report of the research work carried out by me*. The material contained in this Research Thesis has not been submitted to any University or Institution for the award of any degree.

Register Number: 100526AM10P04

Name: ROHAN MAXWEL COLACO

Signature:

Department of APPLIED MECHANICS & HYDRAULICS

Place: NITK-Surathkal

Date:

CERTIFICATE

This is to *certify* that the Research Thesis entitled SENSITIVITY OF RISK IN CONSTRUCTION SCHEDULING submitted by ROHAN MAXWEL COLACO (Register Number: 100526AM10P04) as the record of the research work carried out by him in the department of APPLIED MECHANICS & HYDRAULICS is *accepted as the Research Thesis* submission in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Civil Engineering.

Prof. M.K. NAGARAJ

Research Guide

Date:

Prof. MAHESHA A.

Chairman-DRPC

Date:

ACKNOWLEDGEMENTS

It is my privilege to express my sincere and heartfelt gratitude to my respected guide Dr. M.K. Nagaraj, Professor, Department of Applied Mechanics and Hydraulics. I thank him for the invaluable guidance, meticulous correction and constant encouragement throughout the period of this research. My indebtedness to him shall be everlasting.

I am very grateful and thankful to the members of RPAC, Dr. Subba Rao, Professor and Head, Department of Applied Mechanics and Hydraulics, and Dr. Prasad Krishna, Professor and Head, Department of Mechanical Engineering for their valuable suggestions and support throughout my research work.

I sincerely express my gratitude to The Director of NITK Surathkal for permitting me to use the institutional infrastructure facilities for carrying out my research work.

I thank Dr. T.P.M Pakkala, Dean and Director, Department of Statistics, Mangalore University for his timely advice and inspiration.

I thank the members of Association of Consulting Civil Engineers (INDIA), Mangalore Chapter, for having obliged to fill the risk questionnaire and in turn helping me to complete the same in time.

I thank all my co students who have given me company during my course work.

I thank my assistant Mr. Gration for having lent me a helping hand throughout the progress of this research work.

Finally I wish to express love and affection to my family members, my wife Dr. Ashwini, our Children Jual & Callen, my parents and all my well-wishers for their constant support and encouragement that kept me going at all times.Above all, I am always indebted to the Almighty God for leading and guiding me in each and every moment of my life.

Rohan Maxwel Colaco

ABSTRACT

Construction industry is growing by leaps and bounds in recent times. The number of stakeholders and investments in the construction industry is increasing. With the growth in population there is a massive increase in demand for on time delivery of finished products. An overall wide spread public awareness and upsurge of rating agencies has increased the quality expectations of the customers. Due to challenges in construction, new processes are devised to improve efficiency and add value to the customer. Hence the construction projects are vulnerable to various technical and business risks that are significant in the execution of the project. The core of this research is based on recognizing the various risks in construction projects. Once the risks are recognized the attempt is to quantify the risks. Subjecting the risks to sensitivity analysis gives a better understanding when the accompanying costs are included. Sensitivity analysis of risks and costs helps to compare the various preferences that a constructor has by using present value analysis. The constructor is equipped to take a reasonable decision based on the data analysis available. This research seeks to identify and assess the risk and to develop a risk management framework which the investors, developers and contractors easily adopt.

Risks vary due to differences in prevailing conditions that are specific to a particular region. It is decided to approach a particular geographical region for the research study. The general methodology of this study relies largely on the survey questionnaire that is collected from the experienced engineers of Mangalore region. In order to analyze the risks they need to be quantified. Broad based attempts to quantify risks do not give a fair idea. The study of risks is concentrated to a particular geographical region through a questionnaire survey. The survey questionnaire is designed to probe the cross-sectional behavioral pattern of risks in construction industry. The questionnaire prepared for the pilot survey is formulated by reviewing the relevant literature in the area of construction risk management.

It is not possible to give a common risk matrix for construction projects in India. The geographical divide of India is a challenge due to prevailing risk factors. It is invariable to select smaller segments of geographical area for the purpose of study. These regions have similarity in conditions. A model developed in a particular region is easily replicable.

Construction activities vary with type of projects. They are classified as private, public or private public partnership projects and so on. In the present study the construction projects in Mangalore city are taken as the pilot sample. The private residential projects that consist of apartments, houses and commercial complexes are considered as the group under study. The risks associated with the above construction activity are obtained through a questionnaire survey. The study is limited to the private construction projects of Mangalore region. The opinions are collected from experienced engineers among the stakeholders.

The outcome of the survey is analyzed using various statistical formulae to obtain the risk in construction projects of Mangalore region. The weights given to the risk are an important measure to understand the importance and rank of the risks. The standard deviation of the responses signifies reliability of the data. The research proposes a risk management framework that uses the results of the survey to mitigate the risks in construction. It is done using sensitivity analysis of risk values and cost to obtain a risk cost that mitigates risk. It provides a comprehensive risk management system which is sensitive to the risks and cost of activities in project schedule. The use of time series for price forecasting and Present Value Analysis make the risk management system more credible.

Keywords: Risk Management, Questionnaire survey, Sensitivity Analysis, Construction risks, Risk cost, Time Series, Net Present Value.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

NPV	Net Present Value
x_i	mid value of i^{th} group
f_i	frequency of i^{th} group
S.D.	Standard Deviation
E	margin of error
n	sample size
W_m	weighted mean
W_v	weighted variance
i	rank of i^{th} group
$V(x_i)$	variance of the risks of i^{th} group
p	percentage of risk
φ	distribution function of the standard normal distribution
x	cost
μ	safe price
σ	parameter defining the curve of truncated normal
x_r	cost at risky level r
r	risky level
x_β	cost at risk level
β	various risk level
c_i	cost related to i^{th} activity
ϕ_1	constant
θ_1	constant
ε_t	white noise

CHAPTER 1

INTRODUCTION

1.1 Risk Management

Definition:

Risk management is the systematic process of identifying, analyzing and responding to project risk. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives. (A guide to project management body of knowledge PMBOK GUIDE 2000 Edition)

1.2 Risks in Construction Projects

Construction risk is the "Probability of loss associated with the physical (construction) phase of a construction project" (Source: Business dictionary).
The various risks in construction projects are shown in Fig 1.1.

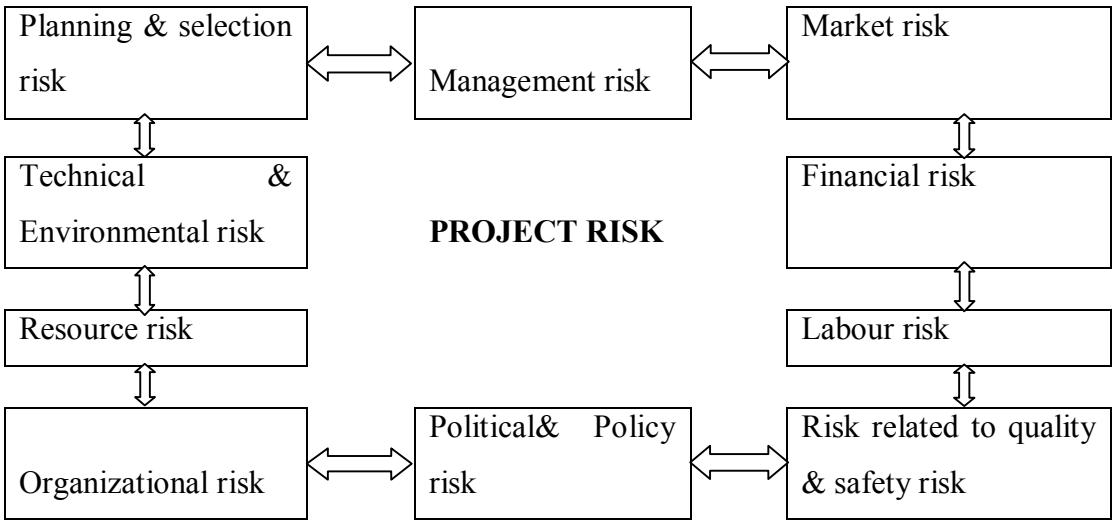

Fig. 1.1 Different risks in construction

1.2.1 Management risk

Management risk pertains to the management that is involved in the project. It involves all the stakeholders in the project. Defective decision by management affects the course of the project. Change in project team defers continuity. Delay in decision making

decreases the speed of the project. Thus an effective management is backbone of a project and reduces management risk considerably.

1.2.2 Policy and Political risks

Political risk involves local, regional and national political issues. Sometimes political scenario changes have abrupt changes in law that affects policy at local bodies. Vested interests and legal hassles have stalled or cancelled projects. Corruption is also a reason for delay in obtaining project approval.

1.2.3 Financial risk

Financial risk is one of the most important risks in construction which involves issues concerning financing of the project. It includes the execution period finance, operations finance and also equity financing of the project. Credit risk is a part of financial risk. Credit payment is important in construction projects. Changes in bank formalities together with increase and fluctuation of interest rate adversely affect projects. The rapid changes in costs of materials also affect planned financial outlay of projects.

1.2.4 Planning and selection risk

Inadequate project planning and selecting inappropriate project stakeholders are detrimental to a project. Such projects never meet their goals and are marred with changes in design and unplanned extra work. The quality of the construction decreases due to the use of substandard materials.

1.2.5 Risk related to quality & safety

Quality control is very important for a successful project. If safety is compromised it may lead to dire consequences during project time. Risk related to quality is mainly due to insufficient quality control and use of defective materials. Speed without adequate skill in work compromises quality. Changes in work schedule may require corrective measures such as chipping, demolition, and touchup work and compromises quality. Safety risk is mostly due to negligence and lack of safety plan.

1.2.6 Organizational risk

Organizational risk is concerned with all the participants in the project unlike management risk that involves only the top management. It is desirable for all the

stakeholders in a project to have good coordination and understanding else there are bound to be changes from the planned path of action. Due to organizational risk differences may arise that may at times stall the project. The project participants may act in a manner detrimental to each other's objectives in the project.

1.2.7 Labour risk

Labour shortage and especially skilled labour is a challenge to the construction industry. Labour risk is the risk that arises due to the changes in planned labour usage. Strikes are a part of construction business. Thus due to unavailability of labour the construction does not take place in a planned manner.

1.2.8 Market risk

The business environment being uncertain puts the project at risk that is market dependent. Changes in exchange rate, tender prices and other costs are associated with market risk which cause a challenge to the successful completion of a project.

1.2.9 Technical and environmental risk

Severity in weather conditions delay projects which pose a risk to projects called environmental risk. The risks associated to technical aspects of a construction project are called technical risk. Inappropriate technology combined with complicated site conditions pose a challenge in construction projects.

1.2.10 Resource risk

There is a large use of natural resources in construction projects. Sometimes constraint in the materials and inadequate supply of the same pose a threat. Quality of materials is also important. The risk due to changes in resources is resource risk. It also includes breakdown in other resources like machines.

1.3 Risk concepts

Risk is inherent in every project. The key is to identify it and take corrective measures. It is very difficult to predict risk. It doesn't have a particular structure and changes as per project conditions. The identification of risk also depends on the purpose of risk identification. Risk differs with projects and organizations undertaking the projects. Risk is a major hurdle for organizations to be successful. It leads to business failure, project

financial loss, occurrence of accidents and disputes. It is very essential to identify risk and treat it to successfully complete a construction project.

Fig 1.2 Shows the hierarchy of risks in construction

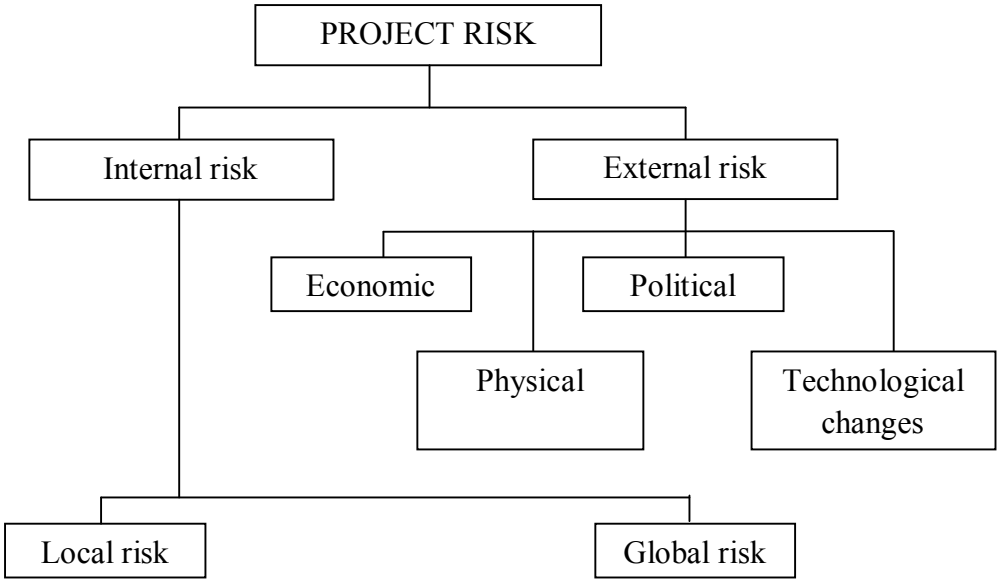

Fig 1.2 Hierarchy of risks in construction

A project risk is an uncertain event that, if it occurs, has a positive or negative effect on the prospects of achieving project objectives. (Source: Project Future Software)

The hierarchy of risks is very interesting and subjective. Risks are internal risks or external risks. External risks are very few but are the most difficult to quantify and identify. They are not dependent on the project participants. Internal risks are subdivided into two groups. The local risks depend on the place where the project is being executed. The global risk is the “External risk to worldwide environment outside the influence of a single country's government”.The global risks are the most common risks dealt by almost all construction participants. (Source: The law dictionary)

1.4 Projects risk management

Risk management is the process of identifying, analyzing and mitigating the risk. This process is very important as riskier the activity the consequences of wrong decision is exceedingly increased. Quantifying risk is important to know the monetary consequences. It helps in deciding if it is worth sharing the risk or absorbing it. Risk rating gains importance. It is graphically represented by plotting a graph between probability and seriousness as follows.

Fig 1.3 Shows the graphical representation of risk rating. As the probability and seriousness of the risk increases, the importance of the risk increases proportionally.

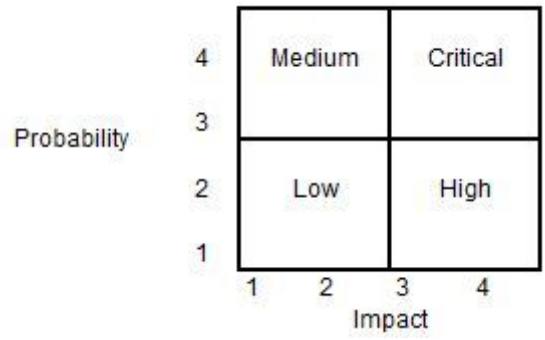

Fig 1.3 Graphical representation of risk rating (Source: Tutorials point-Project risk management)

Risks are very difficult to totally avoid them but efforts can be made to minimize them. It also depends on the historic data available about risks in construction. Once risks are assessed then they are mitigated in a right way. Historically probability is used to assess risk. In construction a lot of activities are used sometimes at the same time

Determination of risk in construction depends on reliable historical information. Subjective methods are also used in risk assessment.

Determination of risks is done qualitatively or quantitatively. The quantitative approach is based on statistical data, its probability and impact. Qualitative approach is based on judgments of experienced professionals and registry of events that have occurred. However there is no single method as each has merits and demerits. A combination of both methods sometimes yields best results. The approach is shown by a simple flow diagram as follows

Fig 1.4 Shows the risk forecasting methodology

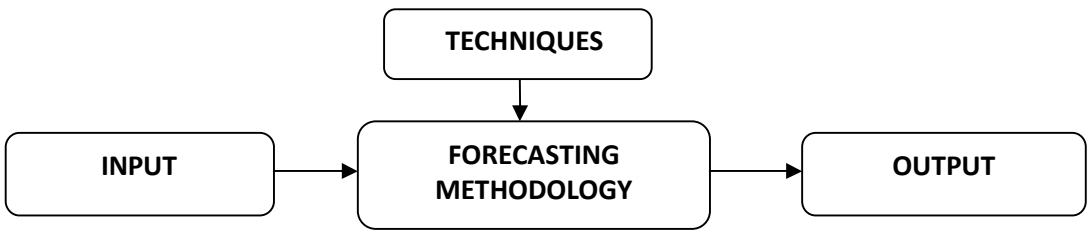

Fig 1.4 Risk forecasting methodology

1.4.1 Risk Identification

Risk identification involves determining the risks that affect the project and documenting their characteristics. Risk identification is not a one-time event. It is done throughout the project on a regular basis. Risk identification includes both internal and external risks. Internal risks are those that are concerned with project participants and processes in the project. External risks involve things that are beyond the control of project team. Risk identification is also an opportunity to better performance. It shows us the risk involved and threat to the project. The techniques involved for risk identification are brainstorming, interviews, workshops, feedback, surveys and reports from specialists.

1.4.2 Risk quantification

Evaluating the range of possible outcomes due to risks is quantification of risks. It is a complicated study and can alter the course of the project. Sometimes unanticipated results may occur. Risk quantification may show better prospects for the project. At times the opportunity of a stakeholder may be a threat to another. The mathematical quantification must be carefully done as it gives wrong impression of the facts. Risk quantification is important to avoid wrong interpretation which affects most of the components in a project.

1.4.3 Risk response development

Risk response development involves defining enhancement steps for opportunities and responses to threats. This is done in three ways

- Avoiding the risk – A particular activity that is risky is eliminated from the course of the project by avoiding the risky activity. But there are some activities that are critical to project completion. These activities cannot be eliminated or avoided. Avoidance of risky activity has its own limitations.
- Mitigation- Mitigation is done by using better technology and methods in construction. Mitigation is also done by purchasing insurance which is tradeoff for risk. Sometimes both mitigation methods are undertaken to control the project for smooth completion.
- Acceptance- Acceptance is to accept the occurrence of risk with a contingency plan. The occurrence of risk is uncertain. The plan of contingency triggers once the risk occurs. Acceptance is also accepting lower profit due to risk and not having a contingency plan to tackle the risk.

1.4.4 Risk response and control

Risk response and control is the process of executing risk management successfully. It is the plan of action that is taken during the course of a plan as it is not possible to identify all the risks correctly at the start of the project. The process of risk management is repeated. The following strategies are used in risk response and control

- Accept the risk- Accepting the risk means understand the risk, its consequences and probability but choose to do nothing. When a risk occurs then the project team reacts. This type of mitigation is popular when the probability of occurrence is lower and cost of mitigation higher than cost of the risk occurring.
- Avoid the risk- Avoid the risk by choosing not to do the activity. This is achieved by postponing the activity in the schedule. Choosing not to do an activity at critical level may be detrimental to achieve the goals of the project. It may decrease the risk but the returns of the business and purpose of the project may cease. There may be quality deficiencies in such a product. Avoiding the risk must be followed when the time of the activity can be altered.
- Monitor and prepare risk contingency plans- In this method a risk that is going to occur is monitored by using an indicator or a preceding event. A contingency plan is prepared which is the response to the risk. Most commonly setting aside extra finance is the contingency plan. The cost increases more than the pre-planned outlay due to a contingency plan. The increased cost cannot be used as a cover up for substandard performance and quality as it is normally done.
- Transfer the risk

To transfer the risk is to shift the onus of the risk to a different agency. Buying insurance is a form of transferring the risk. By insurance the risk is transferred to the insurance agency. This is a direct method of transferring risk. Effective contracting is a good method of risk transfer. Fixed price contract is a type of contract where the price is fixed for the work done by contractor at the beginning of the project. Therefore due to unforeseen risks if price increases the owner is not liable to pay extra. Hence the owner transfers the risk effectively to the contractor. The only drawback in this method is the contractor may have increased his price bid anticipating risks. The extra price is a loss to the owner. There is a disadvantage as the contractor may not absorb exceptional increase in tender prices and undergo losses. Cost plus contract is also a form of transferring the risk. Here all the costs are absorbed by the owner and contractor gets a fixed percentage

as profit. This type of contract is beneficial only when work is not clearly defined. The transfer of risks reduces newer risks in the project.

- Mitigate the risk

Mitigating the risk is to work on the risk and have a detailed plan of mitigation. It is to understand the consequences due to the event and review all the methods undertaken by the project team to overcome the ill effects of the risk. It is a method of firefighting. Improving technology and altering activities is best suited mitigation method.

Risk analysis has a lot of advantages and decreases uncertainty in the project considerably. Correct understanding of the objective of the project is obtained, thereby reducing the cost. The company that undertakes meticulous risk analysis gains stakeholder confidence and creates value for itself.

1.5 Sample size

Sample size is the total number of people that is selected for probing a particular purpose out of the total population. The sample is a representative of the population. Larger the sample size does not mean more accurate the result. The accuracy depends on confidence interval and confidence level.

Confidence interval is the margin of error. It is the plus or minus figure or range within which a result of a sample survey may vary. For example if one uses a confidence interval of five and fifty percent of sample picks an answer, then if the whole population would have taken part in the exercise the population that would pick similar answer would be between forty five percent and fifty five percent. It is also interpreted that if the answer to a sample survey is fifty percent then using confidence interval of five percent, the answer is between forty five percent and fifty five percent.

Confidence level is the confidence the researcher has on the sample. It is a measure that is very important in fixing sample size. Researchers use a confidence level of ninety five percent. Confidence levels of ninety five percent means one can be ninety five percent certain of the answer to be between the confidence interval.

There is no set percentage of population that determines the sample size. Larger dependable sample size gives accurate results and is a true representation of the population.

1.6 Questionnaire surveys

Questionnaire surveys are undertaken to know the opinion of the target population or the representative sample regarding a particular subject. This method of data collection is quite popular. A questionnaire consists of a number of questions regarding the subject that needs to be probed. It is constructed in a systematic, structured and scientific way to get the best representation of the required data.

1.7 Questionnaire design

The design of the questionnaire is very important so as to get accurate results for the survey. The questionnaire is carefully constructed. It is necessary to understand and revise the questionnaire from time to time to get best results.

1.7.1 General form

A questionnaire is either designed in the structured form or unstructured form. In the structured form it is definite and concrete. The questions are pre-determined in structured questionnaires. The wording and order of questions is maintained in similar manner to all the respondents. This is done to standardize the questionnaire and to compare the results with the same yardstick. If all the above are not present in a questionnaire then it is an unstructured questionnaire.

1.7.2 Question sequence

The question sequence helps the respondent to understand the relation between the questions. Clear and easier questions are listed in the beginning: The first few questions influence the attitude of the respondent and when they are in proper sequence chances of misunderstanding the questions is minimized. A better question sequence ensures quality of the replies received.

1.7.3 Question formulation and wording

The questions formed in questionnaire must be clear from misunderstanding. Logical and simple words must be used in questionnaire. Complicated and partial questions are not to be used.

There are either open ended or closed questions. Closed questions are multiple choice questions having two or more options which are useful in tabulating the survey results.

Open ended questions help the person answering the survey to give definite answers to the questions. Better innovative results are obtained by using open ended questions. The type of questions depends on the analysis and purpose of survey.

1.7.4 Essentials of a good questionnaire:

The questions are drafted from easy to difficult. The questions having definite answers with easily understood language is used. Open ended questions are avoided. It is difficult to analyze open ended questions. Size of the questionnaire is kept to a minimum and personal questions are avoided. A few related questions keep a check on the reliability of the respondent.

1.8 Interviewing methods:

The method of data collection is decided based on the population and sample size. Each method has its advantages. The method best suited for the chosen sample population is used.

1.8.1 Personal Interviews:

Fig 1.5 Depicts the personal interview method.

Fig 1.5 Personal interview (Source: Picgifs)

When the person seeking data personally meets the person giving information the method of data collection is called personal interview. The interview takes place anywhere at home, office or any other convenient place. The advantage of this method is that any doubt in the mind of the interviewee is cleared. The interviewer frames the questions and put it across to interviewee to avoid misinterpretation. This method of data collection is

very expensive. There can be bias as the interviewer may choose the population that is easily available for interview.

1.8.2 Telephone surveys:

Fig 1.6 Shows the process of telephone survey.

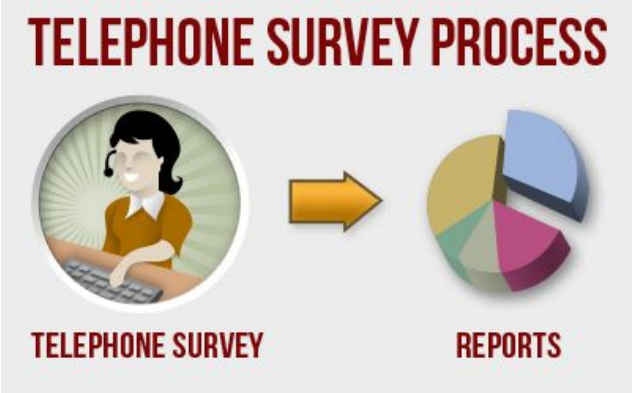

Fig 1.6 Telephone survey (Source: NBRII-Telephone surveys)

Obtaining information from respondents through telephone is a popular method of collecting data. It is a flexible method faster than other methods and is a quick way of obtaining information. It is cheaper than other methods of collecting data. The method has a few demerits. The respondents are given very less time in telephone surveys. The geographical area covered may be lower due to higher cost of collecting data for overseas calls. The survey is restricted to people having telephones.

1.8.3 Computer direct surveys:

Fig 1.7 shows the ease of computer direct surveys

Fig 1.7 Computer direct surveys (Source: Concordma)

The interview method in which the interviewee enters answers directly into a computer is called computer direct survey. The survey is set up on a computer through a program or is

web based for higher reach. The method is advantageous as data analysis is fast and less time consuming. Interviewer bias is avoided. The disadvantage is that this type of survey is accessible to people having a computer only. If the population is less educated there are problems in understanding the way in which response is given to a computer.

1.8.4 Email surveys:

Sending emails and gathering information is both very economical and fast method of gathering information. As most people have access to email the reach is bigger and data collection is faster. Email surveys are limited to simple questions only. The advantage in email surveys is the speed of collection in obtaining hundreds of responses within a day or two. The cost involved is less and features such as pictures can be added. The disadvantage is in obtaining a large number of correct email addresses. People may not like emails from unknown people and may not open them, which is a major hurdle in this type of survey.

1.8.5 Internet/ Intranet (web page) surveys:

Surveys set over the internet or web pages are gaining popularity in recent times. They are fast but have sampling limitations. Software selection is very important and demands better selection of target population. A web survey yields thousands of results. It is interactive and additional features can be added. The software is altered to ask differential questions based on initial answers. The disadvantage is that this type of survey is not able to reach people who do not have access to computers. People may quit long questionnaire midway.

1.8.6 Scanning questionnaires:

Using OMR sheets for surveys is a good method of data collection. The method is mostly used for multiple choice answers type of surveys, where the data entry is very fast using OMR sheet readers. The error in data entry is omitted. The disadvantage is that the method requires additional investment for hardware and training to the respondents.

1.9 Response rates:

The percentage of people who respond to a survey is called the response rate. It is a measure that is very important for the success of the survey. Though response rate is a good measure of the survey, maximum respondents give best result. Response rate is

obtained by dividing the number of completed surveys by the number of people contacted. Response rate is dependent on the purpose of research and type of statistical analysis. The better the respondents are known to the interviewer more accurate are the replies and higher the response rate. It is always better to plan a survey to get higher response rates. Information is given beforehand to respondents with terms of anonymity and confidentiality to better response rates. Clear instructions and sufficient time to answer surveys helps the respondents in filling the questionnaire.

1.10 Scale construction techniques:

Scaling is the procedure of assigning numbers to various opinions, attitudes and other concepts. There are two ways of scaling. Firstly once an opinion is obtained, a judgment is made about some characteristic and the opinion is placed on a scale that is defined in terms of that characteristic. Secondly the opinion is obtained in such a way that the score of individual responses assigns it a place on a scale.

Scaling of opinions is a very important step in analyzing the responses of participants. Scale construction is preparing the scale in such a way that the score of the individual response is assigned a place on the scale. There is no sure method of measuring attitude and it is an attempt to measure expressed opinion. In order to obtain meaningful responses the researcher must have proficiency in various scale construction techniques.

1.10.1 Arbitrary scales:

Arbitrary scales are developed and designed largely through the researchers own subjective selection of items. The researchers first collect few statements which he believes are appropriate to a given topic. These are selected for inclusion in the measuring instrument. People are asked to check in a list the statements with which they agree and an opinion is obtained.

1.10.2 Differential scale:

Differential scales are developed using consensus scale approach. The person who developed them is L.L Thurstone and hence they are also known as Thurstone type scales. The selection of items is made. An evaluation of the items is made so that they are relevant to the topic and are not ambiguous.

1.10.3 Summated scales (or Likert type scales)

Likert scale is a psychometric response scale primarily used in questionnaires to obtain preference of a participant to the statement. They are one-dimensional and are non comparative. By way of an ordinary scale, respondents are asked to indicate their level of agreement with a given statement.

Commonly Likert is a five point scale ranging from “strongly disagree” on one end to “strongly agree” on the other. In between the other three choices “neither agree nor disagree” are fitted in to complete the scale. Some practitioners advocate a seven point Likert scale. The scale is chosen based on requirement and at times even four point scales is chosen. Scores are assigned to each point on the scale and the replies are summated.

Likert scales are very easy to construct and give clear and reliable outcomes to required experiments. To construct Likert firstly a dry run is made of questions that are likely to be included in the survey. A part of the target population is selected for this purpose. Based on the responses the score is given for most favorable answer as 5 and so on. The questions that have high discriminatory power are added to the survey. Even though Likert is an efficient survey tool it suffers from central tendency. Participants may avoid extreme response categories and want to please the experimenter.

1.10.4 Cumulative scales:

Cumulative scales are also called Louis Guttman’s scalogram analysis. They consist of a group of statements and the respondents either agree or disagree to them. The statements form a cumulative series. They are hence called scale analysis or scalogram analysis. Scalogram analysis refers to the procedure for determining whether a set of items forms a one-dimensional scale. The pattern is such that the item reflecting the extreme position results in endorsing items which are less extreme.

1.10.5 Factor scales

Factor scales are developed based on inter-correlations of items which indicate that a common factor accounts for the relationships between items. They are useful in uncovering latent attitude dimensions. The multiple dimension attribute space is important in factor scales and they approach scaling through this concept.

1.10.6 Semantic differential scale

The psychological meaning of an object is very important for an individual. This scale based on psychology was developed by Charles E Osgood, G J Suci and P H Tannenbaum (1957). They presumed that an object has different dimensions of meanings. The meanings are located in multidimensional property space. It is also called semantic space. Semantic differential scale is developed based on psychological interpretation of objects or statements.

1.11 Statistical measures

Mean is the average of all the generated outputs. Variance is calculated by using the mean. The variance is obtained by summing the square of difference between the value and the mean for each value. It is a measure of dispersion around the mean.

Standard deviation (σ) is the square root of variance. It gives measure of dispersion around mean of a distribution and is used with normal distributions. It gives level of certainty of value within the range of mean.

Median is the fiftieth percentile and the value of equal percentage chance. It is rarely used as it does not indicate a range. The nth percentile of a variable is the n percentage chance of it lying at or below that value. It is used to measure the range of a variable.

Mode is the most likely value. It is the value having maximum probability or the value with the greatest frequency observed.

Skewness (S) is a measure that shows lopsidedness of a distribution. If the tail on the distribution is longer it is positively skewed and vice versa. Zero skewness indicates symmetric normal distribution. This measure is often used to understand how normal a distribution.

Kurtosis is a measure of peakedness of the distribution. Different distributions have different kurtosis. If the skewness is zero and Kurtosis 3 it is a normal distribution.

Coefficient of variability is standard deviation divided by the mean. It allows comparison between large standard deviations of small variable and so on and so forth. It is a dimensionless quantity.

Mean standard error is a measure of accuracy of the simulation and indicates if enough iteration has been made.

Skewness and kurtosis are significant in communicating the normal nature of the distribution. Remaining measures have limited use in communication of results of risk analysis. It is desired to keep these statistical measures to a minimum.

1.12 Time series

A time series is a sequence of data points, which are measured typically at successive points in time spaced at uniform intervals. They are used in statistics for forecasting future data. Time series analysis helps to extract meaningful statistics and other characteristics of the data.

Regression analysis is used in comparing values of two different time series and also to forecast values of particular time series. Time series data have a particular nature of order. The forecast data depends on the space gap of data. If the time series is closely spaced with data at close time intervals then the forecast data is more accurate and reliable. When data time points are placed wide apart in time the trend may not be visible clearly in analysis. The forecast data deriving from past values is possible by using time series analysis.

Time series and projections follow definite patterns. The patterns are specific to the probed series of events. The pattern may be different combinations of seasonal and linear or non linear movements which are fitted as a time series. The time series is analyzed to obtain the projections. R software is a good tool used in the time series projection. It helps to give input and obtain output in an understandable manner.

1.13 Net Present Value (NPV)

Net present value is the difference between the present value of the future cash flows from an investment and the amount of investment. The present value of expected cash flows is computed by discounting them at the required rate of return.

If the net present value is zero then the project meets the discounted rate of return as computed. A positive net present value means a better rate of return than originally estimated. A negative net present value indicates worse performance by the investment

than expected. It is an important tool used for comparative appraisal of investment proposals.

Money has a time value. The value of money is an opportunity cost which earns interest elsewhere. Thus future payments need to be higher if they have to equal today's value of money. Net present value equates different investment proposals to today's value of money to calculate precise returns for comparison.

1.14 Monte Carlo Simulation

Monte Carlo simulation is a technique used to understand the impact of risks in forecasting models. Forecasting through simulation represents probabilities and not certainty. Estimates are a part of life. While dealing with unknown future outcomes it is a practice to draw estimates. Estimates depend on historical data and experience of the person drawing up the estimate. The estimate doesn't take care of risks in the market as it is based on previous data. As risk is incorporated in a forecasting model the outcomes are ranged. If the range of values is modeled it gives a better understanding of forecasts. This is done by Monte Carlo simulation. By previous knowledge and experience a range is fixed for the forecast with a pattern of probable distribution. A random value is selected for the forecast based on the range of estimates. The process is repeated many times. A lot of forecast data is generated. These results are used to describe the risks in estimates.

1.15 Sensitivity analysis

Sensitivity analysis is an important part of risk analysis. It is applied whenever a system is developed. It helps in decision making. The changes in input values and parameters give a measure of output and performance indices. Sensitivity analysis helps to validate a model, detect critical criteria and identify important drivers. It helps to understand the risk cost to a project. The different risks adopted and its costs are emphasized. This is validated by a comparison to market situations. The basis of risk analysis is with the initiation of qualitative analysis. It infers certain activities to be risky. These activities or events need further investigation for a better understanding and smooth completion of the project. The need for in depth quantitative analysis arises. The analysis identifies the prospective risks and adapt to changes in the course of the project.

Risk analysis is conducted to understand mainly three parameters of a project. Technical performance analysis identifies the success of a project. Schedule risk analysis determines

the time duration of project completion. The most important is based on project risk and called cost risk analysis. All three parameters put together determine the project path. The need is to integrate all the three parameters in a meaningful way.

A few of the risk analysis methods are

- Traditional methods where cost contingencies are primarily computed. A risk factor is assigned to each activity. The risk factor is multiplied by cost to get cost contingency. The important risks are given a higher risk factor. This is a simple technique which is in vogue.
- Analytical methods understand risk through probabilities with their mean and variance. The method relates mean and variance of the input variable to the mean and the variance of output variables respectively. These methods are used when the output is a simple sum of the various input values. They are simple to understand the distribution of variables involved. They are limited in use.
- Simulation models or Monte Carlo methods use random number generators to draw samples from probability distribution. The effect of multiple uncertainties on a value quantity of interest, such as cost on duration is obtained by simulation. Complex problems are analyzed and its risk effects determined by simulation. The advantage of simulation is that they help in understanding the effect of risk on whole project and its cost on specific events. They are used widely and require expert knowledge. Monte Carlo simulations produce hundreds or thousands of outcomes for a probability distribution. The simulation technique is useful in model evaluation and validations. It builds up confidence in the model. Quantities that are difficult to evaluate are obtained and its degree of precision estimated.

In analysis of risks it is crucial as to how scrupulous an analyst explores input assumptions and the resulting inference variations. There are pitfalls in sensitivity analysis. They mostly have a few reasons. They are analyzing a non important factor, discounting an important factor and analyzing a wrong problem.

Purpose of analysis is clearly defined. Too many variables in analysis are avoided and analysis is concentrated on the purpose of analysis. Outputs are limited. Many outputs help in validation. Sensitivity analysis is done on the whole model only required results

are retained. Most of the time a single parameter is varied to understand the changes. For better understanding of the model it would be better to vary two parameters.

A variable in risk analysis is the formulation of uncertainties into quantity. The quantifying of risk renders it to be measured or estimated. The decision variables are not be quantified as the decision maker has direct control over it. The same holds good for value parameters as they have no true value and represents the reflection of a value that is selected as appropriate for the situation. The danger of double counting risks, missing out important risks and inclusion of rare events has to be done in a systematic matter. This is done by having summary checklist.

1.16 Probability Distribution and its types

When quantifying risk and using it for risk analysis by sensitivity analysis it becomes necessary to choose the right distribution. The probability distribution describes the probability of the variables and range of occurrence. The cost is within the range of cost.

1.16.1 Continuous/discrete distribution

Smooth profiles within which any value occurs are continuous distributions. When variables represent discrete items, a discrete distribution is more appropriate.

1.16.2 Bounded/unbounded distribution

Distributions that are bounded by a range of values and lye between these values are bounded distribution. Unbounded distributions may vary from plus to minus infinity. It is a rare phenomenon, for values to be away from the mean.

1.16.3 Parametric/non parametric distribution

Parametric distributions are derived after massing calculations and taking into account assumptions and nature of process. Non parametric distributions are assumed distributions. It is most commonly used distribution and has no theoretical justification. It is simple to use and understand. The size of the tail is over estimated at the expense of values close to the mean. It is used where normal distribution is not suitable to be used and distribution is unknown. It is used in cases where there is simple understanding of values corresponding to the distribution.

1.16.4 Normal distribution/ Gaussian distribution

Most frequently used distribution is normal distribution. The theory points that the mean of a set of values (σ) drawn independent from the same distribution are normally described. When the distribution is not known and is symmetrical around a mean, normal distribution is used. Natural variables fall into normal distribution.

Fig 1.8 Shows the normal distribution curve.

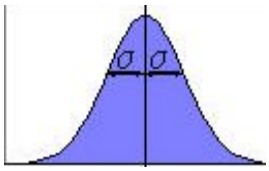

Fig. 1.8 Normal distribution

1.16.5 Uniform distribution

Uniform distribution is used if all the variables are bounded by a known maximum and minimum. The values in-between occur with equal livelihood. The distribution is non parametric. Thus it has the advantage of obvious results. It is helpful in cases where there is very little information about the distribution.

Fig 1.9 Depicts uniform distribution

Fig.1.9 Uniform distribution

1.16.6 Binomial distribution

Binomial distribution is used when a trial has two outcomes. The result of a trial does not affect the other. The results are independent. The probability is plotted. The distribution is used when many events have different probabilities of occurrence.

Fig 1.10 shows the plotting of binomial distribution

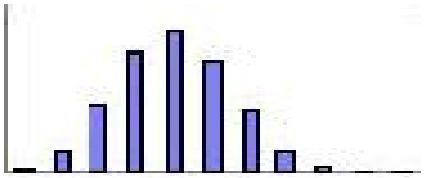

Fig. 1.10 Binomial distribution

1.16.7 Poisson distribution

When the occurrences are independent and rate of occurrences remain constant, but number of occurrences not limited Poisson distribution is used. When rate is known it gives the number of events that occur in unit time. Poisson distribution is graphically represented in Fig 1.11.

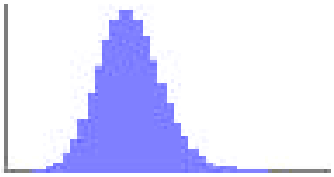

Fig. 1.11 Poisson distribution

1.16.8 Exponential distribution

This distribution is used when rate of occurrence is independent of previous occurrences. It describes time between occurrences. Exponential distribution is depicted as shown in Fig 1.12

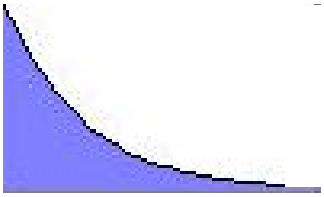

Fig. 1.12 Exponential distribution

1.16.9 Log normal distribution

This distribution is used frequently. The distribution tends normal when quantity is the product of two or more independently chosen variables and is shown in Fig 1.13.

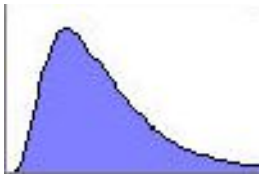

Fig. 1.13 Log normal

1.16.10 Beta Distribution

Beta distribution is used to estimate the probability of an event. The data of recorded successes for a given number of trials 'n' has to be available. If data from a sample is available the data for the whole population is extrapolated using beta distribution. When data is limited and probability of occurrence is required rather than number of events beta distribution is best suited.

There are two ways of fitting a distribution for an experiment. If historical data is available, a distribution is obtained by plotting the data. But this method has pitfalls. The data collected may have been over a historical period and there may be changes in market dynamics. The other method is to employ experts to fit a distribution. Experts normally are not confident fixing a distribution. In such a case the best is to arrive at a conclusion regarding distribution through consensus and group discussion. The confidence level of experts is high when they discuss in a group. Anchoring is avoided where a value is given in advance and consensus is obtained around it. The question is well defined to avoid misunderstanding. When group discussion is undertaken the experts are influenced by each other's opinion and narrow the range which leads to conformity. Bias is achieved due to the views of senior most experts and loudest expert in the group. Therefore a combination of individual review, together with group discussion, a study of historical data and grouping it, with present market dynamics helps in fitting a true distribution for the data.

1.17 Presenting of Results

Presenting of results is an important part of analysis. Interpretation is an important form of communication without which the model has no value. Presentation is done in many ways.

1.17.1 Histogram

It is the most commonly used presentation. Care is taken not to include too many bars as the significant value looses importance. Probability and frequency are plotted against cost and risk. It is very useful for understanding degree of uncertainty. The histogram that is

commonly used in practice is as shown in Fig 1.14

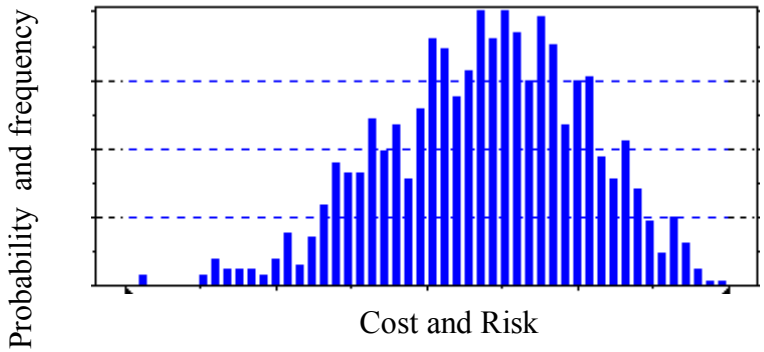

Fig. 1.14 Histogram

1.17.2 Cumulative frequency chart

Quantitative information is best represented by cumulative frequency chart. The probability of a value lying within a given range and above or below a given value is easily read in a cumulative frequency chart.

The measures of the spread or width are easily determined.

Fig 1.15 shows the cumulative frequency chart

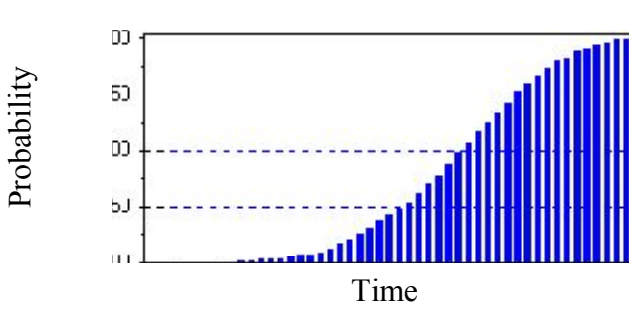

Fig. 1.15 Cumulative frequency chart

1.17.3 Tornado chart

Tornado chart is very useful in communicating the relative significance of different risks. It is a pictorial representation of sensitivity analysis of model. The sensitivity values are plotted as horizontal bars ranked in descending order. Bars go to right if there is a positive correlation and to the left if there is a negative correlation.

1.17.4 Scatter plots

Scatter plots are used when relationship patterns between inputs and outputs are required. The independent variable is put in the X axis and dependent variables in the y axis. The relationships between different variables are clearly depicted through dots in scatter plots.

Risk analysis is a complex subject. There are varying results that are generated. The numbers of results that are generated vary in size. The results are always presented in common English language. Common language in research expresses the results to the audience in a simple understandable measure. Not using too complicated sentences is a way of effective communication.

CHAPTER 2

LITERATURE REVIEW

2.1 Preface

Research has shown that construction activity is prone to high risk. This is because it involves numerous agencies. The construction industry is compounded with lot of risks that are attributed to various agencies involved in the project. Research in the field of risks in construction projects in India has been limited. There have been few studies on scheduling techniques from its development to the present day. The combination of risks and cost has seen very little research. It is difficult to find research in risks and its literature in India.

2.2 Review of literature

At the beginning of this study as part of research a thorough literature review was conducted on international and national research conducted to date in the field of construction risk.

Alexander Laufer and Dora Cohenca (1990) emphasized that it is important to incorporate uncertainty factors in project cost and time forecasts. The study involves measuring the schedule and man hour variances of the project and its financial implications for various variables.

Mulholland and Christian (1999) made an attempt to consider and quantify uncertainties in construction schedules. The study involves lessons learned from past projects. It also describes a risk assessment process involving typical inputs and expected outputs. The model proposed by them helps in understanding the effect of critical and significant risk factors by using sensitivity analysis. The model incorporates knowledge from experienced expert information for decision information, to calculate quantum of risk.

Li Bing et al (1999) categorized risk mitigation into eight groups. Partner selection, agreement, employment, control, subcontracting, engineering contract, good relationship and renegotiation are very important in risk mitigation and is explained in detail. The risk management measures are explained using examples for joint ventures in international

projects. Risks are grouped as internal, project specific and external. The study mainly concentrated on projects in East Asia and concluded that joint ventures can be successful by adopting the measures enlisted.

C. William Ibbs and Young Hoon Kwak (2000) had a principle goal to study project management with its organizational impact, financial impact to better the project management processes and measure its maturity. A questionnaire survey is constituted with one hundred forty eight multiple choice questions, which measure project management maturity and cover eight knowledge areas and six project phases. The findings work as a benchmark and help companies to understand the scope of improvement.

Hastak and Shaked (2000) have classified the risks in construction into three broad classifications that is country, market and project specific. The country specific risks depend on the monetary policy of the country and its vulnerability to economic shocks. Vulnerability of resources, complexity of regulatory processes and advantage in technology are market specific risks. The project specific risks are specific to construction sites and include logistic constraints, improper design, site safety, improper quality control and environmental protection. By grouping the risks they can be easily addressed.

Wayne A. Haga and Tim Okeefe (2001) studied the program evaluation and review technique. The method ignores the stochastic model. It only uses activity time means in calculations. A computer simulation model is created to determine the order in which activities are crashed. The best order to crash program evaluation and review technique network is to minimize cost overrun for a particular penalty function.

Le Roy F. Simmons (2002) studied the critical path method and program evaluation and review technique. The main drawback of critical path method that assumed time to be a constant and that of program evaluation and review technique that it assumed project to be distributed as Beta distributions and resulting project time to be normal distribution. The experiment is conducted with process model simulation. The activity times represent variety of distributions and the resulting project time also represents a variety of distributions. The method showed better results and improved efficiency.

Alfredo et.al (2002) developed a project risk management process for construction projects from owners and consultants view point. A complex risk management system is

developed and later simplified it by working out an example. Delphi technique is used to validate the results. The authors are of the opinion that better co-operative contract agreement improves project performance.

Chien-Ho Ko and Min-Yuan Cheng (2003) found that fuzzy logic, neural networks and genetic algorithms have been used to deal with complexity in risk of construction projects. Considering the merits of each method they developed evolutionary fuzzy neural inference model. It combines with computer programs and solves manifold construction management problems.

Ming Lu and Heng Li (2003) improved the critical path method by studying its applications in various situations and in previous researches. A suggestion of resource activity critical path method (RACPM) is made to integrate activity with resource. Resource and activity were synchronized. The method provides users with the ability to integrate technology or process perspective with resource use perspective in construction planning. The method improves over other methods of planning and provides for an integrated scheduling and cost estimating process. It produces best results for realistic schedules and estimates to control budgets.

Ming T Wang et.al (2003) study the risks in construction industry of Taiwan particularly the highway construction. A study on risk reduction through contract clauses is conducted to analyze the influence of risk allocation on contractors risk handling strategies. The owner allocates risks through stipulated clauses in contracts to contractors. If contractor has more tendencies to accept a few risks due to his strategy in superior execution then the risk is retained, if not the contractor conducts mitigation.

Daud Nasir et al (2003) developed a method using program evaluation and review technique or Monte Carlo simulation to determine the lower and upper activity duration values for schedule risk analysis. An expert review and interview is conducted. Sensitivity analysis is performed on the model by testing seventeen case studies and incorporating probabilities for each risk.

Thomas et al (2003) of IIT Madras, worked in the field of build operate transfer road projects. A risk perception analysis to evaluate criticality, capability, allocation, sharing and factors influencing risk acceptance of major stakeholders is carried out. A survey is conducted to include project participants such as government officials, promoters, lenders

and consultants. It is found that traffic revenue risk is the most critical for build operate transfer road projects in India.

Thomas A. Carbone and Donald D. Tippett (2004) identify risks by prioritizing the risk and the management process of risk controls. It proposes a method that improves on the FMEA method (Failure Mode and Effect Analysis) by adding risks. Hence a risk score is available for evaluation by the project team.

Shou Qing et.al (2004) identified twenty eight critical risks in international construction projects in developing countries into various categories. The three hierarchy levels the researchers categorized risks are based on country, market and project. Twenty two risks are categorized as critical or very much critical based on a seven degree rating system. Based on the study eleven top risks are categorized as approval and permit, change in law, justice reinforcement, local partners credit worthiness, political instability, cost overrun, corruption inflation and interest rates, government policies, government influence on disputes and termination of joint venture. Market level risks are more risky than project level risks. For each risk practical mitigation measures are provided and evaluated. The research showed risk priority using the seven degree rating system. A risk model, named Alien eyes risk model is proposed. The model categorizes risks and reveals sequence of mitigating and prioritizing the risks.

Terry Lyons and Martin Skitmore (2004) conducted a survey of Queensland construction industry in Australia to study the risk management techniques. The study is linked to four other similar studies done around the world. The study indicated that risk management is used more in the planning and execution stages of the project rather than conceptual phase. Risk identification and risk assessment are most often used risk management elements ahead of risk response and risk documentation. Brain storming of project teams is the common method to obtain risks. Risk reduction is done by qualitative methods. It is preferred to reduce risk by contracts rather than insurance.

Hyun-Ho C.H.N Cho and J. W. Seo (2004) study the risk in underground construction. The four steps for risk management are identified. Identifying, analyzing, evaluating and managing the risks inherent in construction projects are the four steps. A risk analysis software and uncertainty model based on fuzzy concept is developed. Survey sheets are used to collect data and detailed check sheets for risk identification and analysis. Finally the research is concluded using a case study for subway construction in Korea.

Seung H. Han et.al (2004) focused on financial portfolio risk management for international projects. The risk hierarchy of both individual projects and at corporate level is integrated. The study included a multi criteria decision making method to maximize the total value of firms. The method is demonstrated through a case study by collecting data from multinational general contractors. Guidelines are given according to the study to industry practitioners by conducting a workshop.

Ahmet Oztas and Onder Okmen (2005) felt that risks in construction projects make them delay the project and exceed their budget. Risk also affects projects safety and quality. A method of risk analysis is devised called JRAP (Judgmental Risk Analysis Process). It is pessimistic risk analysis methodology using Monte Carlo simulation, where a new project risk equation is written using the risks in construction.

Jaser Hmaid Abu Mousa (2005) studied the risks in construction in the Gaza Strip. The study included the dangerous situation in the area. Forty questionnaire surveys were conducted. The survey interpreted that contractors and owners perceived risks differently having own reasons for inherent risks. The contractors gave importance to delayed payments on contract working in dangerous areas and defective design. On the other hand owners concluded that important risks are occurrence of accidents, unqualified designers and inaccurate quantities.

N.B. Kasim et.al (2005) published a paper on materials management. In a competitive environment design and material procurement happen together, hence very efficient management is required. The focus is on early stages of the project and concluded material management currently is not followed up to the mark. The findings reveal need for more sophisticated material management solutions.

Wong and Hui (2006) conducted a survey to know the risks in construction industry of Hong Kong among contractors. They found uncertainties in cost estimates, urgent need for work, past experience in similar projects, contract size and required cash are the important factors that decide uncertainty of cost estimates. Small contractors are more concerned about lack of past experience.

Anna Klemetti (2006) says that construction activity is risk inherent as it has lot of agencies networking together in a project. A questionnaire is distributed among the entire

main and sub agencies including the clients to understand the risk. Informal risk management methods are adopted in this study other than legally binding contracts.

Nigel J. Smith et.al (2006) in the study on risk conclude that the decisions made by a manager change when the manager is aware of the risks in the project. The study deals comprehensively with the various risks mitigation methods.

Bayu Aditya Firmansyah et.al (2006) felt that though the investment in construction projects gives higher returns, it has risks inherent to it and a feasibility study is a must. Cash flows have to be studied with inherent risks. A method where risk probability matrix is used to obtain risk priority is proposed. It is continued with financial analysis with sensitivity analysis. It shows that investment increases with risk.

Piotr Jaskowski and Anna Sobotka (2006) used evolutionary algorithms to solve problems of construction project duration in deterministic conditions. It is done within time changeable and limited accessibility of renewable resources. Construction process with complicities must be executed with technological and organizational variants according to this method. The method can be used to plan for the whole organization, including all the projects the firm is executing.

Praveen Sukumaran et.al (2006) studied the schedules of highway projects. The probable severity of various factors is evaluated to understand the impact on project duration. The stochastic analysis gives a newer schedule that is more meaningful towards time and expected value of the project.

Alin Veronika et.al (2006) studied that project cost variance is important in construction projects. As material is the main component of construction project if it is not properly managed then there is surely going to be a cost variance in the project. The material usage and ordering techniques of high risk building is studied. The Delphi method with consultation of experts to identify better management techniques and decrease cost overruns of projects is used.

Florence Yean Yng Ling and Linda Hoi (2006) conducted a study on risks involved for architectural, engineering and construction firms from Singapore operating in India**. A** study of the local risks and also interviewed project managers is conducted. It is found out that political and social risk, high cost of financing, fluctuating currency rates and huge cultural difference between foreigners and Indians to be major risk factors for Singapore

firms in India. The advice is to adopt proper planning and management as well as adequate insurances as risk response techniques. Foreigners who work in India are recommended to accept local ways of working and not try and change it. Being extremely patient and flexible is the key to success in India.

Kyoo-Jin Yi and David langford (2006) deal with the issue of safety risks on construction sites. Direct and indirect causes of accident due to risk are combined. The study either eliminates the hazard or makes proper safety precautions for the risks. The study reveals that the best method to tackle risks is to reschedule the activity times such that the risks are well distributed among the various time lengths of the project.

Luis F. Alarcon et al. (2006) presented a project case study that combined contingency model for risk management and contingency resolution process. A huge project is selected. A contingency model for the program cost and schedule is developed taking care of the conceptual level of design at the time of proposal and the inherent uncertainty in the project. By identifying the risks for the project the contingency mode based on Monte Carlo simulation of cost and schedule estimates is developed. This model allows multiple scenarios planning for overall risk.

Gabriel A. Barraza (2007) proposed a stochastic allocation method, which is based on Monte Carlo simulation to estimate the project time contingency and allocate it among project activities. The approach is applied to a three span bridge and successful in controlling time contingencies. Subjective methods are used to estimate project time contingency. Time constraint is fixed based on performance of each activity rather than human judgment.

Amani Suliman BU-Qammaz (2007) studied the risks in the Turkish construction industry. The study is extended to understand the risks in international construction projects. It is found that legal system, geographical distance, vagueness in contract conditions and lower advance payment are the major risks in international construction projects.

John G. Zhao (2007) compared risk quantification and decision making to conclude that both are interrelated. Decision making using risk quantification is facilitated by integrating risk register, Monte Carlo simulation, decision trees and force field analysis.

Young Hoon Kwak and Lisa Ingall (2007) published a paper on the useful technique of Monte Carlo simulation for modeling and analyzing real work systems and situations. The paper is a conceptual paper on managing risks and uncertainties. The paper stresses the importance of risk management education, training and computer application of Monte Carlo simulation. It helps the project manager get a better understanding of project performance statistically.

Wenzhe Tang Maoshan Qiang et.al (2007) concluded that little research has been conducted to systematically investigate risk management on the perspective of various project participants. Chinese construction industry for various objectives relating to risk is surveyed. The risk management strategies used in the three gorges project is studied. The findings of their study are that most project risks are commonly of concern to project participants. The industry prefers risk reduction to risk transfer. The current risk management efforts are inadequate to jointly mitigate risks.

Harisaweni (2007) attempted to study the time and cost overruns and construction practices in the Indonesian construction industry. The study conducted included contractors and consultants perspectives. Data is collected by historical research and structured interview techniques. Descriptive statistic technique is used to interpret and analyze the study. The study highlighted that lack of labours, equipment and material supply with frequent design changes is predominant. There is a gap between planned and actual time-cost performance. The requirement of a clear and efficient time and cost management framework with guidelines for reference is asserted.

Jamal F. Al-Bahar and Keith C. Crandall (2007) conclude that most projects fail to achieve time, budget and quality goals as risk is inherently present in all construction projects. The contractors use intuitive unsystematic traditional methods for risk management. A method called construction risk management system is advised. It helps contractors identify risk and also systematically manage it after analysis. Influence diagram technique is used with Monte Carlo simulation to analyze and evaluate project risks. It is suggested to use alternative strategies such as risk avoidance, transfer, retention, prevention, insurance and loss reduction.

Himadri Guha and Partha Pratim Biswas (2008) have projected the risk due to severe weather condition and heavy rainfall. There is delay due to heavy rainfall in many parts of India. By simulation it has been found that monsoon in India increases project duration by

5% and cost by 12%. The study indicates that it is beneficial to separate planning of construction activities done during monsoon.

Ekaterina Osipova (2008) concludes that the types of contracts that are adopted in construction are important in understanding the risks inherent and their mitigation. The study compares different procurement options like design-bid-build contracts, design build contracts and collaborative form of partnering. The study involves construction projects in Sweden and reiterates the fact that the project execution design has to be bettered to decrease risk.

Diane Kelly et.al (2008) studies the best method for a survey. Large number of subjects is evaluated by giving questionnaires in three modes that is pen and paper, electronic and interview. It is concluded pen and paper give the best results as the subjects can express themselves in the best way.

Onder Okmen and Ahmet Oztaş (2008) say that schedules are the means of determining project duration accurately, controlling project progress and allocating resources efficiently in managing construction projects. Correlated schedule risk analysis model (CSRAM) is proposed to evaluate construction activity networks under uncertainty when activity duration and risk factors are correlated.

Edem O. P. Akpan et.al (2008) study time and cost overruns in project. An implementation plan using network scheduling technique is presented on time phased graphs, one on top of the other. The top graph displays actual durations and costs of individual activities during the project implementation stage. The bottom graph shows the budgeted costs and durations of these activities. The extension gives the cumulative costs over a period. A vertical line passing through the two graphs is drawn at certain intervals to monitor any variation of time and cost.

Francis K. Adams (2008) understands the effect of construction risks on construction contracts. Risks in construction are seldom incorporated in contracts while planning projects. A structured questionnaire survey in the United Kingdom to study risks is conducted. It is found that predominant approaches to construction contract risk identification rely heavily on single expert assessments and are inappropriate.

Gunnar Lucko (2008) dealt with project schedules and conducted a study on linear scheduling techniques and also reviewed scheduling methods. The steps of formulating

initial questions, stacking and consolidating them and deriving information about their criticality are described in detail. A mathematical model is developed that allows integrated treatment of activities regardless of the number of changes.

Bert Bielefeld (2008) covers the topic of organizing, the planning and construction process. The basics of scheduling are goal oriented and used in real world situations. Project managers are guided to plan according to goals. The call for results is when time is right. Systematic approach for managing projects successfully is stressed upon.

Dikmen et.al (2008) concludes risk management is very important for construction projects. Risk management comprises of risk identification, analysis, planning, monitoring and action. Risk management has to be conducted throughout the life of the project. Risk management model is developed after studying the historical reasons for risks in various previous projects. The model is employed for a project and found to be fitting to be used. The main drawback is people are not ready to share information about risks and failures encountered by them.

Jay S. Newitt (2008) wrote a volume on project scheduling and included the complete coverage of scheduling from basics to advance. A detailed tutorial on Microsoft project and primavera software's for project management is included. The calculations and examples are worked out are compared with the working of the software. It helps in understanding all concepts in a very systematic manner.

G. Emre Gurcanli and Ugur Mungen (2009) propose a method for risk assessment using fuzzy rule based safety analysis to deal with insufficient and uncertain data. The historical data are combined with expert view to obtain the likelihood of future risks in construction.

HUANG Jian-Wen and WANG Xing-Xia (2009) predict that project duration plays a vital role in project risk. The researchers simulated using Monte Carlo simulation, the duration of project that had been estimated by program evaluation and review technique. The result helped in understanding the risk associated with project and its duration.

Amiruddin Ismail et.al (2009) has an objective to acquire knowledge concerning the resource constrained critical path method technique (RCPMT). Traditional critical path method assumes unlimited supply of resources which is not true. The paper outlines the

study of six previous researches to understand and develop different algorithms to overcome problems in critical path method.

Daniel Castro-Lacouture et.al (2009) conducted an interesting study to evaluate the viability of using mathematical models for construction schedules. The contingencies created by schedule compression and delays due to unforeseen material shortages are included. The critical path method used manually as well as primavera project management software to analyze networks. Fuzzy mathematical models and sensitivity analysis is used for optimization of project schedules with constraints and material allocation. The opinion is that project duration is dependent on the way materials are allocated to activities and not on shortage of material. It is important to give higher priority to activities that have minimum float values.

Dezhi Jin et.al (2010) published a paper that describes Monte Carlo simulation to consider and quantify uncertainty in construction scheduling. The paper shows the importance of construction project scheduling, risk analysis and assessment. Limitations of critical path method and program evaluation and review technique are discussed.

Tarek Hegazy and Wail Menesi (2010) explain in their paper that critical path method has drawbacks due to the length of each activity. The critical path method for each activity is taken as a continuous activity in time. A new system called critical path segments (CPS) is proposed where durations are separated into time segments with finer level of granularity of decomposition.

Alfred E. Thal Jr. et.al (2010) say that cost overrun due to risks associated with construction is a serious problem. In practice certain contingency costs are fixed for cost overruns. It is a flat percentage of total cost of project. Significant variables that affect project cost overruns are studied. A study of air force construction projects is conducted. Using linear regression the researchers developed a model to predict contingency funds. It is found that budgeting error is reduced from 11.2% to only 0.3%.

Gary Mitchell (2010) researched on critical tasks in a project network. It is observed that when task times are not deterministic and when stochastic task times are encountered it is difficult to identify the sources of delay and the source of schedule risk. The stochastic slack concept developed a number of matrices that helps project manager to directly

identify schedule risks. This method is a better prediction to indicate the extent of project delay due to risk.

Saleh Mubarak (2010) has a view that an efficient well thought schedule is crucial to achieving success, no matter how large or small the construction project. The schedule manages all aspects overseeing all the requirements such as setting up tasks, adjusting and estimating time needs, overseeing equipment and material needs, organizing resource requirements and all other requirements of the project. The researcher covers upto date coverage detailing steps to device technologically advanced schedule. The study combines fundamental and advanced techniques for schedule risk management.

Simaan Abou Rizk (2010) concentrated on simulation theory to understand intricacies in modern construction. The reasons for accepting simulation to solve construction problems and its advantage are explained. A combination of knowledge of computers with simulation theory helps to develop an automated project planning and control tool.

Abdullah et al. (2010) tried to combine risk with construction cost and conducted a questionnaire survey among project management personnel to understand the factors affecting cost and the project. The rank for factors affecting construction cost is calculated using statistical tools. It is concluded that cash flow and financial difficulties faced by contractors, contractor's poor site management and supervision, inadequate contractor experience, shortage of site workers, incorrect planning and scheduling by contractors are most severe factors.

Amir Reza Karimi Azari et.al (2011) found out the best method to assess the risks by comparing various methods. By using fuzzy TOPSIS method they realized the best model for risk selection under each of the selection criteria.

Ewelina Gajewska and Mikaela Ropel (2011) conducted a survey at different stages in a project on risks. The changes in risk at different life cycles of the project are clearly listed and the importance of risk mitigation at the early stage of the project is asserted.

R. C. Walke (2011) studied risks with respect to expected monetary value analysis and checked the practicability of the system. It is mentioned that to have a thorough understanding about risks that occur at various stages in project, their probability of occurrence and their consequences in detail is important.

Liisa Lehtiranta (2011) gives importance to relational risk management in multi organizational construction projects. The risk and uncertainty due to collaborative working force is emphasized here. The suggestion to researchers is to adopt complexity thinking more frequently.

Taroun A Yang J.B. and Lowe D. (2011) estimate risk assessment to be the most difficult component of risk management process. The literature over last 27 years is reviewed. It is found that in recent years subjective probability has been given more importance. The risk analysis of project cost and duration is mostly prevalent. Project performance risk is not given due importance. Most of the existing risk assessment approaches gave a risk rating and do not quantify risks. It is not possible to compare risks on a common scale. The risk cost as a measure is the best for risk assessment of projects.

Hisham Said and Khaled El-Rayes (2011) conclude efficient material management, which is procurement and storage of materials on construction sites can improve productivity and profits. Present practice does not integrate procurement and storage of materials. This paper presents a new optimization technique that includes all the factors affecting materials management. The model incorporates newly developed algorithms to estimate the impact of potential material shortages on site. It uses genetic algorithms to minimize all costs covering materials.

Arazi Idrus et.al (2011) find contractor's judge cost contingency to be 5-10% from cost estimated by considering similar project. Most methods used by contractors rely on formal modeling techniques, which cannot be applied easily in construction industry. The research proposes a method to estimate cost contingency using flexible and rational approach based on risk analysis and fuzzy expert system concepts. It is found that in infrastructure projects of Malaysia actual cost contingencies are within 20% accuracy to the estimated.

P. Jaskowski and S. Biruk (2011) feel the environment in which projects are executed is not static. The uncertainties have a negative effect on durations. The risks are dependent on project, contractor and location. It becomes important to assess and evaluate risks in construction projects. The proposed model is based on evaluating and giving weights to particular project characterizes and expected outcomes.

Jeong Wook Son and Eddy M. Rojas (2011) conclude an unrealistic expectation at the planning stage is the main reason for schedule delays and cost overruns in large scale construction projects. Computer simulation is used to calculate optimism bias and organizational dynamics that incur unrealistic schedules. From a series of what if scenarios the study is concluded. The project managers who are not biased either optimistically or conservatively fair much better than the ones who are biased and their projects are more risk averse.

Seyed Hossein Hashemi Doulabi et.al (2011) feel there is an opportunity in resource leveling problem that could decrease risks and improve efficiency of the project drastically. The project time can be split. Some activities can be interrupted and resumed in different time intervals with added costs. A practical algorithm for resource leveling which in turn improves efficiency of projects is developed.

Marques R. and Berg S. (2011) analyzed infrastructure projects for risks. They concentrated on water utility projects. Intensive capital requirement in public projects with complexities is a risk to the private contractual projects execution companies. These risks need to be recognized and mitigated. The company that executes the contracts has to mitigate or bear them. Two contracts in Portugal are studied by them and it is concluded that it is not possible to make a public project a success without effective risk management.

Bernard R. Fortunato et.al. (2011) were interested by a report that stated the accident rate is very high in construction projects that are LEED certified in the USA. They probed by using 8 projects in detail to validate their findings. It is found that LEED certified building workers have to work at heights and with material that is quite risky which is not usually encountered in normal construction projects. Hence safety management is to be given utmost importance in such projects.

Mehdizadeh Rasool (2012) developed prototype software based on risk database by identifying the main sources of risks. The risks are broken down into smaller structures with several constraints to understand them better.

Lee Chun Siang and Azlan Shah Ali (2012) studied the risks prevalent in construction industry of Malaysia. A structured questionnaire survey is undertaken to study the risks and its interference on project performance. Risks are prevalent in construction industry

due to its complexity. Risk assessment is a vital tool. Risk management practice in Malaysian construction companies is low and lacks standardization. There is no evidence that improvement in risk management improves project performance.

O.N.Aneziris et.al (2012) conducted a study and quantified construction occupational risks in Netherlands. The various tasks, activities and hazards to construction workers are studied. The risks are divided into three criteria of consequences recoverable injury, permanent injury and death. The risk to workers due to various hazards is quantified and concluded that installing timber formworks have the highest fatality risk, followed by the workers installing reinforcement.

Rita L. Sousa and Herbert H. Einstein (2012) presented a methodology to predict the risks in tunnel construction. By studying the boring machine performance a prediction of the geological structure is combined with construction strategy and predicted risk free tunneling. The method is tried for Porto Metro, Portugal. The predictions are very significant in mitigating risks in tunnel construction.

Ivan W.H. Fung et.al (2012) creates a risk model. A study is conducted and found that safety professionals are the key decision makers dealing with project safety and risk assessment in construction industry. The safety professionals heavily relied on their experience to assess risks that may occur. In the first part of their study, a study is made on the current beliefs and practices in the industry by safety professionals. In the second part they made a quantitative study of the methods that are followed by safety professionals. A study of a few projects over a three year period is conducted and risks are registered. A risk mitigation and assessment model Q2REM is introduced which is a useful supplementary guideline of risk assessment for construction safety professionals.

R. K. Kansal and Manoj Sharma (2012) inferred that risks are very common in construction sector. The purpose of their study was to assess the use of risk identification techniques in construction industry. Risks affect construction sector negatively. It is important to identify and mitigate risks. The construction sector is divided as industrial, infrastructure and heavy construction. A survey is conducted using a questionnaire to understand risks in construction industry.

Chidambaram Ramanathan et.al (2012) attempted to understand the reason for delay in construction projects and corresponding increase in cost. The questionnaire survey

constituted reviewed 41 samples around the world. The study concentrated on construction delay in east Malaysia. The data is categorized into 18 groups with 113 causes of delays. The different statistical measures are calculated. The study concluded that reasons for delay varied with regions and cannot be generalized.

Xiang P. et.al (2012) dealt with asymmetric information and risk arising from the same in construction projects. They concluded that asymmetric information is very vital in construction project risk. They clearly distinguished risks due to asymmetric method of information in construction projects and listed methods to overcome the same. They found that asymmetric information gives rise to opportunistic behaviour and increases risk in construction.

Mehran Zeynalian (2012) wanted to study the risk over the whole life of a project. The whole life of the project includes the life project cycle of use of the project. It includes the risk in managing, maintaining and managerial risk in the project life cycle. This is true in the case of government projects like road projects where a substantial amount of money is spent on maintaining the project. A risk mitigation method called modified programmatic risk analysis and management method is proposed by the researchers.

Rafiq M. Choudhry and Khurram Iqbal (2012) study the risk management in construction projects of Pakistan. Risk management is relatively a new subject but gradually gaining importance due to increased construction activity. The study concentrates on risks in Pakistan construction industry and the measures to minimize the risks that are prevalent. The study reveals that financial and economic factors, followed by quality are important risks that are avoided or transferred. The risk management is only reactive in nature. There is an effort to study from mistakes. The study concludes that joint risk management by all stakeholders is the most effective.

Richard C. Thompson and Gunnar Lucko (2012) researched the theory of schedule management to manage risks in construction projects. The float if reduced increases risk due to shorter schedule time. An intelligent construction execution expert uses this concept to his advantage in risk analysis. Risk is attributed to cost. If the float is increased to trade for risk avoidance then it is a good option. This is suggested by the authors. This also suggests a system wherein a participant in the project trades float for a cost to reduce the impact of risk.

Hariharan Subramanya et.al. (2012) probed the risk in construction projects of India. They said India is growing rapidly with a construction industry worth $120 billion. They aimed to recognize the risks in construction industry of India and mitigate the same. A survey undertaken to collect the risks in construction industry of India 93 attributes of risks were enlisted. The survey conducted is with 6 contractors, 4 owners and 5 project management experts with 20 years of experience. They noticed the small size of population used for survey is a disadvantage for the results. The study is grouped into two groups and risk percentage listed. The risk percentage of 10.5% to 12% is found for risks associated with owner, contractor, project manager, finance and resource specific risks with standard deviation less than 1.66. Risk percentage of 9.5% to 13% is found for risks associated with project consultants, external environment and contract specific factors with standard deviation 3.3 which is very high indicating wider variation. Higher standard deviation makes it difficult to predict the risk in the project. Validation of the findings is done by comparing the same with executed projects. The study reveals that the easiest method of risk mitigation in Indian construction industry is by effective contract management to avoid most of the risks.

P.K. Marhavilas et.al (2013) evaluated the risks in Greek construction projects through time series. The historical data is used to quantify risks. The HATS technique evolved is an efficient risk assessment framework that uses history. It evaluates the probable risks through time series.

Goh Cheng Siew and Hamzah Abdul-Rahman (2013) conducted questionnaire interview surveys to understand the risks in Malaysian construction industry. The outcomes showed that financial and time risks are found to be the major risks in Malaysian construction industry. The contractors said that lack of knowledge of risks and risk cost is main reason for not implementing risk management.

Patrick. X.W. Zou et.al (2013) recognized, to achieve the objective of a construction project it is very important to manage risks. All the past research is based on a particular aspect of risk in construction rather than a holistic approach. The constituted study includes stakeholders and life cycle perspective. Postal questionnaire surveys are used to collect data. The research found that risks are mainly due to contractors, clients and designers. Only few risks are related to government bodies, subcontractors and external issues. The study indicates that risks are prevalent at different stages of project and some

of the risks repeat themselves through various stages of project. The study concludes that all the stakeholders must act collectively for effective risk management.

Jolanta Tamosaitiene et.al (2013) researched on the risk assessment of commercial center construction. The method is based on multi-criteria decision making methods with fuzzy information. it takes into account macro, mezzo and micro levels of risks. Optimality of risks is achieved by applying TOPSIS method.

O. O. Odimabo and C. F. Oduoza (2013) knew that the socio-economic growth of a country is boosted by the construction activity that plays a vital role. They studied the possibilities of risk management in the construction industry of Nigeria. The popular belief in Nigeria is that construction projects are plagued with cost overrun, time overrun and poor quality work. All these occur due to non-consideration of risk factors in construction during the project planning and implementation stage. Hence they targeted at developing a risk assessment framework that improved performance of construction projects. The risks were identified, quantified and meaningfully interrupted. The risks in construction are analyzed using MATLAB and Monte Carlo simulation. This helps in achieving a framework that delivers projects within time frame, minimizing cost overruns and optimizing project quality.

Nicholas Chileshe and Geraldine John Kikwasi (2013) understand that the construction projects and their environments are affected by risks. Risk management and assessment become necessary. These are used to propose appropriate strategies that mitigate risk. The goals of a company are rightly set to enable competition. The difficulty in achieving the desired results due to the shortage of empirical study method in risk management. This is particularly seen in Africa. Construction professionals of Tanzania were given questionnaires to assess risk in construction. The lack of knowledge of risk is ranked most important reason for not implementing risk management. The 67 questionnaire responses of professionals were examined for implementation of scientific risk management. The findings are important to apply risk management in developing countries specially Africa.

Pankaj Vijay Naphade and Pankaj P. Bhangale (2013) reflect on the assessment of major risks in construction. Their approach is concentrated more towards qualitative risk management. Risk is inherent in every industry. The non treatment of risk and absence of risk management inducts losses and averts new opportunity in better markets. This limits an organization. They suggest a standard procedure of recognizing the risks, valuating the risk and finally risk treatment. The

effect of risk management is studied. Risk mapping is important and risk is calculated as "risk is equal to the probability of event multiplied by the cost of the event. The strategy suggested includes risk prevention, impact mitigation, risk sharing, risk retention and insurance. The final topic dealt by them is risk insurance. Most of the construction industry experts depend on risk insurance. The cost involved decides on whether to accept the risk or to insure the risk.

Patel Ankit Mahendra et al. (2013) in their paper wanted to study risk management techniques and propose a scientific method to risk mitigation. A thorough literature review is conducted. All the risks are enlisted with the factors affecting the same. They divided the risk management process into four categories. Risk identification is done by brainstorming, Delphi techniques, interview/expert opinion, past experience and checklists. The risk assessment is done qualitatively by developing a risk priority matrix. Quantitative methods include sensitivity analysis, scenario analysis, decision trees and probabilistic analysis. Risk response planning is done by risk avoidance, risk transfer, risk mitigation/reduction, risk export, risk share, risk enhance, risk acceptance and contingency plan. Finally risk control is the tracking of the progress and effectiveness of the risk management plan. The authors conclude that risk management is not undertaken in India due to lack of knowledge and well documented processes are not available. There is shortage of data to conduct risk management.

M. J. Kolhatkar and Amit Bijon Dutta (2013) give a broad framework of risk management. Their descriptive paper enlists in detail the risk management process. Risk management is important to achieve time, cost, quality, safety and environmental objectives of a project. The risks in construction projects are business risks, financial risks, technology risk, project risk and political risk. The factors affecting risks are history, management stability, staff expertise-experience, team size, resource availability, time compression and complexity. The main objective of risk management is to accept the risk, risk quantification, monitor risk, prepare risk contingency plan, transfer and mitigate the risk. They conclude that knowledge sharing and expertise is important for effective risk management of construction projects.

Ivana Burcar Dunovic (2013) develops a methodology for development of risk register system in construction projects. The geographical area is the country of Croatia. The aim is to integrate the risk register into the risk management process. Risk register takes risk management to a higher level and improves the project management process drastically. The study advices to breakdown the risk and create a risk breakdown structure similar to

work breakdown structure. This is done after recognizing the risks and analyzing them. A proper framework is then prepared to integrate risk register and risk management. This study is an original study that develops a risk registry in construction projects. Risk registry acts as storage of data. The data is stored for individual projects and centralized for further use. It helps in accurate reporting and communication in the project with regard to risk.

Qing-Fu Li et.al. (2013) knew that construction of huge bridges is a complex process. The risks encountered in construction of large bridges make the general method of risk recognition ineffective. They involved modular analysis to recognize risk based on work and risk breakdown structure. The method included establishing work breakdown structure with risk breakdown structure. The two are then combined to obtain risk breakdown structure. The possibility for risk existence and risk alternation is analyzed. Effective and accurate method is obtained for risk identification of large bridge projects. The data is structured to be easily stored in computerized format. A data base is built and helps future projects in recognizing risk.

Bon-Gang Hwang et.al. (2014) were of the opinion that risk management is vital for construction projects and should be implemented irrespective of the size of the project. It leads to the achievement of project objectives. The study aims at risk management of small projects in Singapore. The aim is to study the status, barrier and impact of risk management on project performance. A questionnaire survey of 34 companies is conducted to include the 668 projects executed by them. The result show low level of project risk management. The hindrance to risk management is lack of time, lack of budget, low profit margin and uneconomical process. The results showed positive correlation between risk management implementation and overall betterment in execution of projects. The finding helps in convincing the small project participants to undertake risk management.

Liisa Lehtiranta (2014) concentrates her work on risk management with a multi-organizational perspective. The present risk management is concentrated on a single organization. A complex construction project involves many organizations. It is important to have a risk management framework that works from a multi-organizational perspective. The research concentrates on goals of the project, data and methods. It takes a problem and develops functionality to represent the inter dependency between organizations. Both qualitative and quantitative methods are used to solve the problem in a complimentary method. The systematic framework that is developed provides the

guidance on roles of various stakeholders. It provides parallel multi-organizational risk management process. The results after applying to real life situation are theoretically justified, empirically grounded and partly tested in practice.

Satyendra Kumar Sharma (2014) developed a paper on risk management using analytic hierarchy to map the risk in construction projects. The method is demonstrated in Amravati, Maharashtra (India) on an ongoing construction project. The background work included the collection of risks in construction and the present methods used in risk management. The various stakeholders are contacted and data is collected. Analytic hierarchy process is used to map the risks. This helps to identify the most important risk factors. The hierarchy of risks is established. The most important risk recognized is dealt with to minimize the risk effect.

M. Angeline Swarna and R. Venkatakrishnaiah (2014) use fault tree analysis for risk management for construction projects in India. Construction industry has inherent risks. The risks in construction impact cost, time, and quality. The objective of this study is to gain understanding of risk factors and effectiveness of risk prevention. Fault trees are drawn up for risk time, risk quality and risk cost. Evaluation of fault tree is done by qualitative and quantitative methods. In the qualitative method the minimum cut sets are obtained using Boolean equations. Quantitative analysis is done through Poisson distribution. The probability of occurrence for cost, time and quality is obtained through this process. The authors suggest that better planning and contract management go a long way in risk management. The standardization of the approach and effort to apply risk management in all projects go a long way in improving the effectiveness of risk management in the long run.

Luka Goji Tipili and Muhammad Sa'adiya Ilyasu (2014) study the Nigerian construction industry for risks. The cost overruns and delivery of projects within budget is the main problem in Nigeria. The delay in projects increases cost and affects quality. It is important to know the degree of impact of risks and likelihood of occurrence of risks. They rely on the development of an index score to assess risk. A questionnaire pertaining to risk is initially distributed among industry professionals. Fifty eight successful questionnaires are analyzed for descriptive static and analysis variance (ANOVA). The impact levels of probability and exposure to risk are analyzed and categorized. The broad based categories of low, medium and high impact levels are formed. The findings of the

study show that the risk impact due to increase in cost of the project is the most important factor affecting construction projects in Nigeria.

Alberto De Marco and Muhammad Jamaluddin Thaheem (2014) observed that though project risk management is gaining importance due to the numerous techniques available the analyst is often confused about the method that needs to be applied. They analyzed projects that help the project managers to select practical method of risk mitigation. It takes into account various projects and their management criteria in choosing the right method of risk management. The project is divided into four levels. The scale in risk management and efficiency of the project is achieved. The methodology is demonstrated to two projects with post risk analysis and reporting. The probability impact and risk charts are drawn with diagrams. These studies analyze different methods available in risk mitigation and help the analyst to choose the right method for his project.

Alfredo Federico Serpella et.al. (2014) noticed that risk management is often done in construction project by the project manager. The project risks get complicated if it is not followed from the start. They studied and researched risk management in Chile to systematically avoid risks. The study concentrated on knowledge based approach for risk management. The importance of risk identification, developing the model and evaluating the options available is the method followed in risk mitigation method given by them. The model risk evaluating prototype is advised to be unique for each company or project based on the core competency. It improves in time as the knowledge base develops.

Yoojung Yoon (2014) says that risk management is a very important criteria for a profitable construction project. A long term business plan of any company must include risk mitigation to make the company profitable. As construction projects are complex it is difficult to analyze the probability and impact of risk. This is done by the study of projects that previously executed. Risk management is done at project level and then at the company level. Different risk centers are established. Project risk analysis helps in establishing better profitability across various risk centers in projects.

2.3 **OBJECTIVE OF THE STUDY**

The objective of the study is to:-

- Propose a risk management framework that mitigates the risk in construction.
- Make a meaningful scientific evaluation of risks in construction.

- Quantify the risks in construction.
- Create a risk register and model for reference to the construction industry of Mangalore region.
- Relate risks with risk cost in construction risk analysis.
- Study the latest trends in construction industry and their effect on risk.

CHAPTER 3

METHODOLOGY

Literature review indicates that there has been very little research on construction risk assessment management in India. A thorough study of project risk assessment and management is conducted. It suggests that construction activity is subject to more risks than other businesses due to its complexity. Construction projects are unique requiring people with different skills and coordination of a wide range of activities. There is a need for recognizing risks in construction and to have a definite risk mitigation framework for the successful completion of a construction project

3.1 Research Methodology

The general methodology of this study relies largely on the survey questionnaire which is collected from the local engineers of Mangalore region. A thorough literature review is initially conducted to identify the risk factors that affect the performance of construction industry.

The questionnaire is prepared after literature and historical survey of the risks that are prevalent in the industry. The percentages for the options are chosen to get the best possible risk measures. An element of experience of the researcher in the field of construction and the consensus with experienced engineers through group discussions helped in deriving the risk factors from literature study. The participant in the survey has to assign the percentile risk associated to that risk. The survey methods were researched and it is found that personal interview method is the best suited to get accurate response for questionnaire. The survey questionnaire is designed as per modified Likert scale which is the most commonly used scale in questionnaire surveys so as to include five variants of percentage group over the hundred percentile range. Before the questionnaire survey is distributed a critical review is obtained from group discussion.

The geographical area selected for the questionnaire survey is Mangalore. Mangalore in recent time is rated as one of the fastest growing cities in the country. The city has seen high growth in construction activity in both residential and commercial projects. Most of the construction activity is managed by consulting engineers who are members of a renowned association called Association of Consulting Civil Engineers of India,

Mangalore Chapter. The association has 289 registered members. Each member of this association is well experienced, knowledgeable individual and has handled multiple construction projects. While collecting the questionnaire data the background information of the respondents is also collected which is not included in thesis. The 289 members of the association are inducted into the association after deliberation on their repute. Hence the response is representative and technically sound.

To understand the trend of risk in construction projects the questionnaire is initially distributed among 10% of population size that is among 28 engineers who are chosen randomly by lots. The questionnaire survey is commonly found to be the best judge in obtaining reliable data. The best form of questionnaire survey that is the interview method is strictly followed in the present study with detailed personal interviews with the respondents. The sample size is obtained by time tested statistical method.

The questionnaire distributed initially is in APPENDIX I

For each question in questionnaire, based on the percentage marked by engineers, mean risk and standard deviation (S.D.) of the responses is calculated using the formulae.

Mean risk $=\frac{\sum f_i X_i}{\sum f_i}$

Where x_i is the mid value of the risk in the i^{th}group with frequency f_i

Variance$=\frac{\sum(f_i)(X_i)^2}{\sum(f_i)} - (Mean)^2$

Standard deviation of the responses=√variance

The scale used is a modified Likert scale. Using this scale the risk position values are computed. Using Likert scale it is not possible to find mean risk but in the questionnaire the group indicates position values and hence mean risk is obtained.

The determination of sample size is based on standard deviation (S.D.) of the responses, margin of error E (5% mostly used in practice) and critical level based on standard normal distribution. That is

Sample size: $n=\left[\frac{(1.96*S.D)^2}{E^2}\right]$

It is observed that for different standard deviation in different questions, the formula gives different sample size. In such case it is needed to consider the maximum of the standard deviations. However it is observed that all of the standard deviation is almost similar. Hence an average of standard deviation is considered as an estimate of that standard deviation to calculate the sample size. The standard deviation (S.D.) of the responses calculated is 22.37. The responses are validated by calculating the standard deviation of the responses which is an important measure. The unreliable response with significant variation is clearly denoted by variations in standard deviation. If there is a large variation in standard deviation the sample size is altered accordingly to accommodate this change.

E= Margin of error=5% (mostly used in practice)

Sample size: $n=\left[\frac{(1.96*22.37)^2}{5^2}\right]$

=77

It is found that the optimum sample size is 77 for a sample population of 289. It is important to know the preference and importance of risks. A column is added in the questionnaire for the respondents to rank the different risks. The risks are divided into various categories and sub categories and have to be ranked subsequently.

The final questionnaire is given in APPENDIX II

The survey for the remaining sample size of engineers is conducted. The responding engineers are chosen randomly by lots. The aim of the survey was to interview a minimum of 77 respondents. When the survey was completed 79 responses were collected. Personal interview and discussion was conducted with all the 79 respondents. All the ambiguity in the questions is cleared with respondents at the time of interview. The rate of return is absolute.

The sample size of 79 is tabulated for mean risk and standard deviation of the responses. The data collected in the questionnaire survey from the respondents is included in APPENDIX III.

In APPENDIX III, 79 responses are tabulated to represent the choice of percentage risk that is 15%, 35%, 55%, 75%, and 95% respectively of the respondents. For each risk

grouping the respondents have given ranks. The rank for each risk is obtained by calculating simple average of the ranks given by 79 respondents for a particular rank.

The time frame of the survey is from July 2012 to June 2013 for the period of 1 year. For the sample size weighted mean risk is calculated. This is used to obtain weighted mean risk using the formula.

$$W_m = \frac{\sum[(n+1)-(i)]X_i}{[n(n+1)]/2}$$

Average risk is estimated using a weighted average of risks. The weights are according to the ranking of the risks by the respondents. The lowest ranked group (rank value is n) has weight 1/T, second lowest has 2/T and so on and the highest rank (rank value equal to 1) gets n/T as weights. T is adjusted so that sum of weights is 1. In which case T= (n+1). According to same weights variance is also determined.

$$W_v = \frac{\sum[(n+1)-(i)]^2 V(X_i)}{\frac{n^2(n+1)^2}{4}}$$

W_m= Weighted mean

i=Rank of i^{th} group

X_i= Mid risk value of i^{th} group

n= number of group

W_v= Weighted Variance

$V(X_i)$= Variance of the risks of i^{th}group

For all the results the standard deviation of the responses is calculated. The quantification of risk is attained. The percentage of risk, for various risks in construction activities in Mangalore region is obtained. In the questionnaire some of the risks are repeated which give similar results. The percentages indicate the risk level in construction industry of Mangalore. The results are interpreted and tabulated to be used in risk mitigation.

3.2 Risk mitigation and decision taking model

Risk mitigation is more of an art rather than science. It depends on the analyst's decision making ability to choose the right method based on unique situations. The approach is

concentrated around the cost of the project when time is a constant. A combination of risk and cost for a project of given duration is suggested. It uses time series for price forecast and present value for investment analysis. Simple simulation is used for risk analysis. Method suggested in this study involves

1. The percentage of each risk in construction is obtained. This is done by a questionnaire survey or by expert review.
2. If there is more than one risk corresponding to an activity or stage then the risk percentage is got by calculating the weights of the corresponding risk. The weighted risk is calculated in a similar way as weighted mean risk. Each risk is ranked and the ranks are considered as weights. If the risks have similar risk percentages then an average of all the risk percentages is found to be representing weighted risk at any stage.
3. An estimate of cost is done for the project. A schedule of work is finalized for the time period fixed for the project. As time is the essence of the project it is estimated based on experience and requirement at the beginning. Time estimated is not changed in the course of the project. It is assumed that the project is done using the best technology available with constraints. The outflow and inflow of payments is estimated based on the schedule. The present value of the project for the transactions of amount 'x' to be done in future of duration't' is calculated by the formula, xexp(-rt). 'r' is the rate of interest. The present value of the project is obtained. The calculation of present value includes all possible inward and outward payments at all stages of the project. For the investments done already in the past the present value is obtained by the formula, xexp(+rt). The rate of interest chosen is the prevailing bank interest rate or the rate chosen by the analyst which is the effective prevailing business interest rate.
4. The present value obtained for all the expenses and income is compared to understand the profit margin. The profit margin is increased or decreased at this point by using present value analysis. The present value analysis helps in justifying price increase of the product as the project progresses due to diminishing value of money. This is the first part in analysis.
5. Materials like cement and steel, used in construction have clearly indicated data of historical prices. The future price of these materials is calculated by time series analysis. The risk in the price of these materials to the projects is decreased by

appropriately predicting its future price. The price of cement and steel are separated and added back to the estimate after forecasting its future price. Alternatively the method may be used by skipping this step.

6. The risk percentage is interpreted for analysis. The risk percentage is expressed with respect to a hundred percentile scale. If risk percentage is 100p then the price of that category of item increases from its basic price with probability p. With probability 1-p the price remains at basic price. It is seen that as price goes higher than basic price, the risk increases. It is observed that the probability graph of risk and cost follows a truncated normal distribution. Going forward the probability of risk surfaces and decreases as the cost increases. The increase in cost is due to the increase in risk. The extra cost is a tradeoff for the risk. Risk cost is inversely proportional to probability of risk.

   The price increase is modeled through normal distribution over that risky period. Hence the cost assumes to follow a mixture of truncated normal and the basic price.

   The cost function is modeled using a mixture of safe cost and risky cost. Where safe cost is the minimum guaranteed cost which occurs with probability (1-p). Probability p is of risk, which means 100p% is the percentage of risk. That is, the percentage of cost increase is 100p%. Increasing cost is modeled using truncated normal with parameters μ and σ and truncated below μ. This follows a distribution function of the cost related to a specific activity which is based on parameters μ and σ and is given by

$$F(x) = \begin{Bmatrix} 0 & if x < \mu \\ 1 - p + p\left[2\varphi\left(\frac{\{x-\mu\}}{\sigma}\right) - 1\right] & if x \geq \mu \end{Bmatrix}$$

   where 'p' is the percentage of risk.

   'φ' is the distribution function of the standard normal distribution.

   'x' is cost.

   $\left(\frac{\{x-\mu\}}{\sigma}\right)$ is the standard normal variate used to standardize the cost probability curve.

   As x->∞ φ(x) =1 then F(x)=1.

   When x= μ φ(x) =1/2 then F(x) =1-p

   $'\mu'$ is safe price.

   If price goes above 'μ' then it is considered as risky with p%.

'σ' is the parameter defining the curve of truncated normal.

The inverse of this function is the solution of the equation F(*x*)=*r*,

that is if r < 1-p then x_r= μ else

$$x_r = \mu + \sigma\varphi^{-1}(0.5\left[1 + \frac{r-1+p}{p}\right])$$

'x_r' is cost at risky level 'r',

'r' is the risky level.

'μ' is estimated based on safe cost.

'σ' is estimated using the relation

$$x_{0.95} = \mu + \sigma\varphi^{-1}\left(0.5\left[1 + \frac{p-0.05}{p}\right]\right)$$

Where $x_{0.95}$ is cost at 0.95 quantile or 95th percentile.

$x_{0.95}$ is estimated or obtained.

Hence $\sigma = (x_{0.95} - \mu)/\varphi^{-1}(0.5\left[1 + \frac{p-0.05}{p}\right])$.

'σ' is different for different products.

After estimating 'σ' the above model is used to predict cost at various levels. Risk at level β (> p) is estimated by

$$x_\beta = \mu + \sigma\varphi^{-1}(0.5\left[1 + \frac{p-(1-\beta)}{p}\right])$$

x_β is cost at risk level 'β'.

β' is various risk levels.

The relation of risk and risk cost is shown in fig 3.1

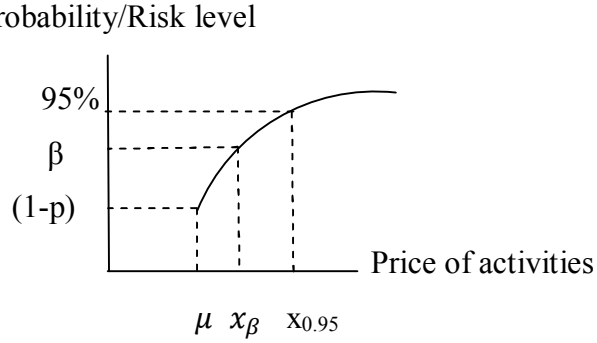

Fig 3.1 Relation of risk and risk cost

This is typical for an activity. For different activities parameters are different. When the activities are combined total cost is

$$C = \sum_{i=1}^{m} c_i$$

Where 'c_i' is the cost related to i^{th} activity.

7. In this study normal distribution is used for the cost of items. Normal distribution is well tested to represent price of an item. However, any other appropriate probability distribution in case it differs may be used. In such cases finding inverse of the distribution function is not always possible. One can use simulation to obtain estimate of different percentile values and hence the problem is solved. Even in case of normal distribution simulation results are obtained and it converges to the values obtained through the formula given for x_{β}.
8. The estimate of risk cost is very important. It is estimated by the analyst based on prior experience in the field. The more experienced and competent the analyst, the estimate mirrors true value. However estimates are always plagued with an error due to uncertainties of the future. The cost of maximum risk is estimated by the analyst. The maximum risk percentage corresponding to maximum probable cost increase is taken as 95%. An error of margin of 5% by the analyst is accounted for as it is not always possible to estimate the future. The further analysis includes this 5% to give a more accurate representative of risk cost.
9. Risk cost is estimated at different points in the schedule of the project. This may also be done for every individual activity. Suppose the increase allowed to a risk percentage of 95%, such a price is estimated.

10. The values for the cost corresponding to different risk levels are obtained by sensitivity of the price function. The increased price to risk levels of 90%, 99% ….are calculated and tabulated. Then the cost refers to different risk levels.
11. Based on the risk taking ability, the highest price at that level is estimated. Based on this price the total cost is estimated.
12. The analyst based on market realities and appetite for risk chooses the corresponding cost that is passed on to the customer to de-risk the project or activity to a certain extent. It is not possible to totally de-risk the project as it may become a non viable option. It depends on the prevailing market conditions and the judgment of the analyst.
13. The outward and inward costs at different points on the schedule are recalculated to include risk cost. The present value of income and expenditure is calculated which gives a clear indication of the true profit in the project which covers risks to an absorbable extent.

CHAPTER 4

CASE STUDY

A case study is worked out to show the practical use of the risk mitigation method. It is a reference to the user when the risk mitigation is done. The project selected is any random project. In the thesis a case study project that mirrors the risk data collected. The method is applied in totality to the project. Data collection and data analysis is conducted. The execution of the project is planned from September 2013 to November 2014. The project execution is planned ahead of the project start. Irrespective of the time of execution the method of risk mitigation is very efficient. The application is done for real life construction projects. This example uses the risks that are derived from the questionnaire survey. It deals with stakeholders of the project that is a developer who is the promoter of the project and the contractor who executes the projects on behalf of him. All the cash flows of the stake holders are calculated in order to apply the methodology suggested in this thesis.

4.1 Application for an apartment building

The case study is a demonstration of the risk mitigation and decision taking method. A case study that mirrors the data is taken into consideration and selected for analysis in the thesis.

Fig 4.1 Shows the three dimensional view of apartment building of 15500sqft area

Fig 4.1 Three dimensional view of apartment

The example illustrates the application of the methodology for the developer and contractor of a 15500 sqft apartment building in Mangalore region. The cost of construction is only taken into account. The land price is a variable which is easily estimated from time to time or known to the stakeholders based on their expected price.

4.1.1 Developers Problem

a) Developers Work Schedule

The schedule of work for the developer is given in table 4.1 that shows developers commitment based on the work that is completed at the end of each month from pre launch of the project to completion. Developers work starts before the launch of the project.

Table 4.1 Developers work schedule

Month end	**Work schedule based on cash flow**
Pre Launch	Municipal fees, Consulting fees
Pre Launch	Municipal fees
Pre Launch	Municipal fees, Consulting fees
First	Advance
Second	Excavation, Plain cement concrete, Consulting fees
Third	Footing, Consulting fees
Fourth	Pedestal, Plinth beam, Soil filling, Consulting fees
Fifth	Ground floor column, Slab, Consulting fees
Sixth	1st floor column, Slab, Ground floor laterite, Consulting fees
Seventh	2nd floor column, Slab, 1st floor laterite, Consulting fees
Eighth	3rd floor column, Slab, 2nd floor laterite,1st floor plumbing & electrical, Consulting fees
Ninth	3rd floor laterite, 2nd floor plumbing & electrical, Ground floor plastering, 1st floor plastering, Consulting fees
Tenth	3rd floor plumbing & electrical, 2nd floor plastering, Consulting fees
Eleventh	3rd floor plastering, Consulting fees

Table 4.1 continued….

Twelfth	Outside plastering, Tilling 1st floor, Rain water harvesting, Sump tank, Consulting fees
Thirteenth	Ground floor &1st floor painting, 2nd floor tilling, Parapet, Stair case head room, Consulting fees
Fourteenth	Tiling 3rd floor, 2nd floor painting, Over head Tank , Arch finish, Door & window 1st floor, Consulting fees
Fifteenth	3rd floor paint, External paint, Elevator, Sheet roof, Door & window 2nd floor, Interior fixtures, Consulting fees
Sixteenth	Sheet roof, Leach pit, Compound wall, door & window 3rd floor, Interior fixtures, Yard concrete, Consulting fees, Municipal fees

From the table the cost incurred for the developer is estimated. Estimate is done using all the work that qualifies based on cash flow that is dependent on the schedule that is listed in detail.

b) Risks associated with the project.

All the risks associated with the project with their risk percentages for each stage in the project are listed. Table 4.2 shows the risk associated with the project.

Table 4.2 Risks associated with the project of developer

Month end	**Risks in the project**	**Risk percentage**
Pre launch	Financial risk, Management risk, Market risk, Planning & selection risk, Political & policy risk, Organizational risk	40.95
Pre launch	Financial risk, Management risk, Market risk, Planning & selection risk, Political & policy risk, Organizational risk	40.95
Pre launch	Financial risk, Management risk, Market risk, Planning & selection risk, Political & policy risk, Organizational risk	40.95
First	Financial risk, Management risk, Organizational risk	40.39

Table 4.2 continued….

Second	Labour risk, Risk related to quality & safety	45.33
Third	Labour risk, Management risk, Resource risk	41.20
Fourth	Labour risk, Management risk, Resource risk	41.20
Fifth	Labour risk, Financial risk, Planning & selection risk	45.46
Sixth	Labour risk, Financial risk, Market risk, Risk related to quality & safety, Resource risk, Technical & environmental risk	50.58
Seventh	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk	50.58
Eighth	Labour risk, Financial risk, Market risk, Risk related to quality & safety, Resource risk, Technical & environmental risk, organizational risk	49.23
Ninth	Labour risk, Financial risk, Market risk, Risk related to quality & safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62
Tenth	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62
Eleventh	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62
Twelfth	Labour risk, Financial risk, market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk , Management risk	41.46

Table 4.2 continued….

Thirteenth	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk , Management risk	41.46
Fourteenth	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk , Management risk	41.46
Fifteenth	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk , Management risk	41.46
Sixteenth	Labour risk, Financial risk, Market risk, Risk related to quality& safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk , Management risk	41.46

The table lists all the risks that are encountered in the project. The major risks are listed for each stage in the project. The risk percentage is obtained by averaging all the major risks that occur at a particular stage. The percentage of risk is obtained by questionnaire survey. When sub risks occurs the major risk to which the sub risk belongs is considered as the major risks. They are the weighted average of the sub risks. Subsequently the sub risks may be considered.

c) Cash flow of the project

The actual cash flows are calculated according to the work schedule for different activities. Actual expense is the actual expenditure of the developer at any given stage. The expense at any stage of the project is obtained by adding the expenses of all the activities that occurs at a particular stage. Detailed rate analysis is used to calculate the cost of every activity. The forecast price of steel and cement is calculated separately. It needs to be deducted from the actual expense and added back later with the increased forecast prices. The expense of steel and cement is as shown in table 4.5. This value is increased to a level as thought apt by the person estimating it. It is considered to be

almost the maximum possible increase to this project during its project duration. The estimate is done as per present rate. As market risk is included in calculating risk it is not required to adjust present value of expenditure. The cash flow details are shown in table 4.3.

Table 4.3 Developers cash flow of the project

Month end	**Expenditure (Rs)**	**Actual expense (Rs)**	**Actual expense- steel & cement (Rs)**	**Increased Cost (Rs)**
Pre launch	480000	480000	480000	480000
Pre launch	430000	430000	430000	430000
Pre launch	480000	480000	480000	480000
First		2796122	2796122	2796122
Second	114380	104942	90703	92971
Third	436325	394963	201951	207000
Fourth	373572	338215	187697	197082
Fifth	989193	892274	495990	520790
Sixth	1134661	1023195	591747	636128
Seventh	1614342	1454808	983273	1130764
Eighth	2972250	2677025	2205490	2536314
Ninth	2215737	1996163	1859541	2231449
Tenth	1651127	1488014	1411245	1693494
Eleventh	301127	273014	196245	245306
Twelfth	1354589	1221130	1015464	1320103
Thirteenth	1151061	1037811	920265	1242358
Fourteenth	3326277	2995650	2608229	3651521
Fifteenth	6359349	5725414	5725414	8301850
Sixteenth	4367500	3942750	3770813	5656220
Total	**29751490**	**29751490**	**26450189**	**33849470**

In table 4.3 the actual cash flow of the developer does not include the advance that has already been paid by the developer for the start of the project to the tune of 10% which is deducted second month onwards proportionately for the subsequent payments made after

the payment of the advance . The actual expense is the base cost of the project. The risk percentages associated with each stage in the project is the present risk associated with the base cost. The project is risky above the base cost and for the risk percentage other than the risk associated with the base cost. The projected cost is the estimated maximum possible increase in base cost of the project associated with 95% risk cost. As estimate is plagued with error increased cost is taken with error margin 5%. The further analysis includes this 5% to give a more accurate representative of risk cost.

d) Risk cost of the project

The risk cost for different risk percentages is obtained by applying base cost, projected cost and risk percentage to the cost function at every position in the schedule. Table 4.4 shows the risk cost of the project that is obtained from the cost function for the different risk percentages.

Table 4.4 Developers risk cost of the project for various risk percentages.

Month end	**Risk cost for various risk percentages(Rs)**				
	50%	75%	90%	95%	99%
Pre launch	480000	480000	480000	480000	480000
Pre launch	430000	430000	430000	430000	430000
Pre launch	480000	480000	480000	480000	480000
First	2796122	2796122	2796122	2796122	2796122
Second	92470	92632	92831	92971	93271
Third	205865	206233	206683	207000	207678
Fourth	194972	195656	196492	197082	198341
Fifth	515312	517086	519257	520790	524067
Sixth	626508	629620	633432	636128	641897
Seventh	1098794	1109135	1121803	1130764	1149936
Eighth	2464263	2487576	2516125	2536314	2579496
Ninth	2147984	2175047	2208111	2231449	2281272
Tenth	1630150	1650689	1675782	1693494	1731306
Eleventh	234296	237866	242227	245306	251879
Twelfth	1251687	1273872	1300974	1320103	1360939
Thirteenth	1170022	1193478	1222133	1242358	1285533

Table 4.4 continued….

Fourteenth	3417217	3493193	3586010	3651521	3791370
Fifteenth	7723231	7910855	8140069	8301850	8647211
Sixteenth	5232793	5370094	5537830	5656220	5908952

From the table the cost associated with the risk in the project is clearly indicated. This helps the decision maker to choose the risk that needs to be mitigated keeping in mind the market condition and appetite for risk.

e) Projected prices of steel and cement for the project

The actual requirement of steel and cement for the project at each stage is calculated. The price of steel and cement that is fixed for the project is deducted at each stage based on the calculated requirement of steel and cement. The projected prices of steel and cement are obtained by forecasting using time series. The projected steel and cement price is added back to the project at each stage. Table 4.5 shows projected prices of steel and cement.

Table 4.5 Projected prices of steel and cement for the project

Month end	**Cement**	**Unit**	**Steel**	**Unit**	**Projected steel & cement (Rs.)**
Pre Launch					
Pre Launch					
Pre Launch					
First					
Second	40.11	Bags			13654
Third	300.30	Bags	2047.50	kg	188107
Fourth	146.65	Bags	2333.14	kg	145894
Fifth	462.49	Bags	5500.02	kg	391066
Sixth	514.46	Bags	5896.10	kg	453435
Seventh	627.38	Bags	5896.10	kg	490175
Eighth	627.38	Bags	5896.10	kg	517592
Ninth	384.85	Bags			139797
Tenth	216.25	Bags			78494
Eleventh	216.25	Bags			78224

Table 4.5 continued….

Twelfth	541.30	Bags	320.00	Kg	205714
Thirteenth	253.61	Bags	652.00	Kg	121570
Fourteenth	1036.76	Bags	459.00	Kg	394986
Fifteenth					
Sixteenth	484.33	Bags			184791

From the table the risk associated with steel and cement prices is nullified by obtaining the projected prices through time series. The steel and cement prices are obtained by time series. The project is executed from September 2013 to November 2014 and the corresponding projected prices are used.

f) Projected cost for different risk percentages and final cost

The final cost of the project is obtained by adding the projected risk cost obtained for different risk percentages that are 50 %, 75%, 90%, 95%, 99% and the projected price of steel and cement. Table 4.6 shows the final cost of the project for 50% risk cost.

Table 4.6 Developers final cost of the project for 50% risk cost

Month end	**50% Risk cost (Rs)**	**Projected steel & cement(Rs)**	**Final cost(Rs)**
Pre launch	480000		480000
Pre launch	430000		430000
Pre launch	480000		480000
First	2796122		2796122
Second	92470	13654	106124
Third	205865	188107	393972
Fourth	194972	145894	340866
Fifth	515312	391066	906378
Sixth	626508	453435	1079943
Seventh	1098794	490175	1588969
Eighth	2464263	517592	2981855
Ninth	2147984	139797	2287781
Tenth	1630150	78494	1708644

Table 4.6 continued….

Eleventh	234296	78224	312520
Twelfth	1251687	205714	1457401
Thirteenth	1170022	121570	1291592
Fourteenth	3417217	394986	3812203
Fifteenth	7723231		7723231
Sixteenth	5232793	184791	5417584
Total	**32191686**	**3403499**	**35595185**

If the developer chooses to execute the project with a risk cost of 50% then the final cost is obtained from the table.

Table 4.7 shows the final cost of the project for 75% risk cost.

Table 4.7 Developers final cost of the project for 75% risk cost

Month end	**75% Risk cost (Rs)**	**Projected steel & cement(Rs)**	**Final cost(Rs)**
Pre Launch	480000		480000
Pre Launch	430000		430000
Pre Launch	480000		480000
First	2796122		2796122
Second	92632	13654	106286
Third	206233	188107	394340
Fourth	195656	145894	341550
Fifth	517086	391066	908152
Sixth	629620	453435	1083055
Seventh	1109135	490175	1599310
Eighth	2487576	517592	3005168
Ninth	2175047	139797	2314844
Tenth	1650689	78494	1729183
Eleventh	237866	78224	316090
Twelfth	1273872	205714	1479586
Thirteenth	1193478	121570	1315048
Fourteenth	3493193	394986	3888179

Table 4.7 continued….

Fifteenth	7910855		7910855
Sixteenth	5370094	184791	5554885
Total	**32729154**	**3403499**	**36132653**

Table 4.8 shows the final cost of the project for 90% risk cost.

Table 4.8 Developers final cost of the project for 90% risk cost

Month end	**90% Risk cost (Rs)**	**Projected steel & cement(Rs)**	**Final cost(Rs)**
Pre Launch	480000		480000
Pre Launch	430000		430000
Pre Launch	480000		480000
First	2796122		2796122
Second	92831	13654	106485
Third	206683	188107	394790
Fourth	196492	145894	342386
Fifth	519257	391066	910323
Sixth	633432	453435	1086867
Seventh	1121803	490175	1611978
Eighth	2516125	517592	3033717
Ninth	2208111	139797	2347908
Tenth	1675782	78494	1754276
Eleventh	242227	78224	320451
Twelfth	1300974	205714	1506688
Thirteenth	1222133	121570	1343703
Fourteenth	3586010	394986	3980996
Fifteenth	8140069		8140069
Sixteenth	5537830	184791	5722621
Total	**33385881**	**3403499**	**36789380**

Table 4.9 shows the final cost of the project for 95% risk cost.

Table 4.9 Developers final cost of the project for 95% risk cost

Month end	**95% Risk cost (Rs)**	**Projected steel & cement(Rs)**	**Final cost(Rs)**
Pre Launch	480000		480000
Pre Launch	430000		430000
Pre Launch	480000		480000
First	2796122		2796122
Second	92971	13654	106625
Third	207000	188107	395107
Fourth	197082	145894	342976
Fifth	520790	391066	911856
Sixth	636128	453435	1089563
Seventh	1130764	490175	1620939
Eighth	2536314	517592	3053906
Ninth	2231449	139797	2371246
Tenth	1693494	78494	1771988
Eleventh	245306	78224	323530
Twelfth	1320103	205714	1525817
Thirteenth	1242358	121570	1363928
Fourteenth	3651521	394986	4046507
Fifteenth	8301850		8301850
Sixteenth	5656220	184791	5841011
Total	**33849472**	**3403499**	**37252971**

Table 4.10 shows the final cost of the project for 99% risk cost.

Table 4.10 Developers final cost of the project for 99% risk cost

Month End	**99% Risk Cost (Rs)**	**Projected Steel & Cement(Rs)**	**Final cost(Rs)**
Pre Launch	480000		480000
Pre Launch	430000		430000

Table 4.10 continued….

Pre Launch	480000		480000
First	2796122		2796122
Second	93271	13654	106925
Third	207678	188107	395785
Fourth	198341	145894	344235
Fifth	524067	391066	915133
Sixth	641897	453435	1095332
Seventh	1149936	490175	1640111
Eighth	2579496	517592	3097088
Ninth	2281272	139797	2421069
Tenth	1731306	78494	1809800
Eleventh	251879	78224	330103
Twelfth	1360939	205714	1566653
Thirteenth	1285533	121570	1407103
Fourteenth	3791370	394986	4186356
Fifteenth	8647211		8647211
Sixteenth	5908952	184791	6093743
Total	**34839270**	**3403499**	**38242769**

The developer obtains the cost associated with different levels of risk and has to make a choice to go ahead with the option that is perceived as a good business strategy. The choice is dependent on the prevailing business conditions and risk appetite of the developer. It also depends on the market position, competition and various other conditions. The method is advantageous to get a clear picture of associated project risk cost. If it is assumed that the developer chooses 99% risk cost as the option for the project then the risk taken is 1% which is the most minimal risk. At this risk percentage the chances of failure are very minimal. The present value of developers actual cost and risk cost is shown in table 4.11

Table 4.11 Developers actual cost and risk cost for different risk percentages.

Types of problem	Actual expense (Rs.)	Risk cost (Rs.) for different risk percentages				
		50%	75%	90%	95%	99%
Apartment building 15,500 square feet area (present value)						
Developer problem	27176239	32311692	32783541	33360096	33767097	34636081

From the table it is evident that the developer has to make a choice for the best possible path to be followed by them. The schedule of work is followed month wise for all calculations. The present value that guides decision making for the case study of a residential construction is given in the table. The stake holders of the project generate a number of alternatives for different risk percentages. The profit margin can be altered easily by using these alternatives.

The current cement rate for the project is Rs. 355/- per bag. The current steel rate is Rs. 42.20/- per kg.

The conditions of the project to be adhered by the developer and the contractor are as follows.

- 10% of total cost is to be given as advance to the contractor.
- Running bills are to be settled on a monthly basis.
- 10% amount of a bill is to be deducted as advance paid.
- Steel and cement price to be paid as per actual to the contractor.

4.1.2 Contractors problem

a) Contractors work schedule

The schedule of work for the contractor is given in table 4.12 that shows contractors work that is completed at the end of each month from project start to completion.

Table 4.12 Contractors Work Schedule

Month End	Work Schedule Based on Cash Flow
First	Advance
Second	Excavation, Plain cement concrete
Third	Footing
Fourth	Pedestal, Plinth beam, Soil filling
Fifth	Ground floor column & Slab
Sixth	1st floor column & Slab, Ground floor laterite
Seventh	2nd floor Column & Slab, 1st floor laterite
Eighth	3rd floor Column & Slab, 2nd floor laterite,1st Plumbing & Electrical
Ninth	3rd floor laterite, 2nd floor Plumbing & Electrical, Ground floor, 1st floor Plastering
Tenth	3rd floor Plumbing & Electrical, 2nd floor Plastering
Eleventh	3rd floor Plastering
Twelfth	Outside plastering, Tilling 1st floor, Rain water harvesting, Sump tank
Thirteenth	Ground floor,1st floor painting, 2nd floor tilling, Parapet, Stairecase head room
Fourteenth	Tiling 3rd floor, 2nd floor painting, Over head Tank , Arch finish, Door & window 1st floor
Fifteenth	3rd floor paint, External paint, Elevator, Sheet roof, Door & window 2nd floor, Interior fixtures
Sixteenth	Sheet roof, Leach pit, Compound wall, Door & window 3rd floor, Interior fixtures, Yard concrete

From the table payment schedule for the contractor is estimated. Estimation is done using all the work that is listed in detail which qualifies based on cash flow and is dependent on the schedule.

b) Risks associated with the project.

All the risks associated with the project with their risk percentages for each stage in the project are listed. Table 4.13 shows the risk associated with the project.

Table 4.13 Risks associated with the project of contractor

Month End	**Risks**	**Risk Percentages**
First	Financial risk, Management risk, Organizational risk	40.39
Second	Labour risk, Risk related to quality & safety	45.33
Third	Labour risk, Management risk, Resource risk	41.2
Fourth	Labour risk, Management risk, Resource risk	41.2
Fifth	Labour risk, Financial risk, Planning & selection risk	45.46
Sixth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk	50.58
Seventh	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk	50.58
Eighth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk	49.23
Ninth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62
Tenth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62
Eleventh	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk	41.62

Table 4.13 continued….

Twelfth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk, Management risk	41.46
Thirteenth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk, Management risk	41.46
Fourteenth	Labour risk, Financial risk, Market risk, Risk related to quality & Safety, Resource risk, Technical & environmental risk, Organizational risk, Planning & selection risk, Management risk	41.46
Fifteenth	labour risk, financial risk, market risk, Risk related to quality & Safety, resource risk, technical & environmental risk, organizational risk, Planning & selection risk, management risk	41.46
Sixteenth	labour risk, financial risk, market risk, Risk related to quality & Safety, resource risk, technical & environmental risk, organizational risk, Planning & selection risk, management risk	41.46

The table lists all the risks that are encountered in the project. The major risks are listed for each stage in the project. The risk percentage is obtained by averaging all the major risks that occur at a particular stage. The percentage of risk is obtained by questionnaire survey. When sub risks occurs the major risk to which the sub risk belongs is considered as the major risks. They are the weighted average of the sub risks. Subsequently the sub risks are considered.

c) Cash flow of the project

The actual cash flows are calculated according to the work schedule for different activities. Actual income is the actual income of the contractor at any given stage. The income of the contractor includes the profit margin. Column D is got after deducting the

profit margin of 10% is from the actual income and added back later. The forecast price of steel and cement is calculated separately. It needs to be deducted from the actual income and added back later with the increased forecast prices. The expense of steel and cement is as shown in table 4.5. This value is increased to a level as thought apt by the person estimating, to be almost the maximum possible increase to this project during its project duration. The estimate is done as per present rate. As market risk is included in calculating risk it is not required to adjust present value of income. The cash flow details are shown in table 4.14.

Table 4.14 Contractors cash flow of project

Month End	**Estimated Income (Rs)**	**Actual Income (Rs)**	**(Column D) Income – Profit (Rs)**	**D-Steel & Cement (Rs)**	**Increased Cost (Rs)**
First		2796122	2516510	2516510	2516510
Second	94380	84942	76448	62209	63764
Third	416325	374693	337223	144211	147816
Fourth	353572	318215	286393	135875	142669
Fifth	969193	872274	785047	388763	408201
Sixth	1114661	1003195	902875	471427	506784
Seventh	1594231	1434808	1291327	819792	942761
Eighth	2952250	2657025	2391322	1919787	2207755
Ninth	2195737	1976163	1778547	1641925	1970310
Tenth	1631127	1468014	1321213	1244444	1493333
Eleventh	281127	253014	227713	150944	188680
Twelfth	1334589	1201130	1081017	875351	1137956
Thirteenth	1130901	1017811	916030	798484	1077953
Fourteenth	3306277	2975650	2678085	2290664	3206930
Fifteenth	6339349	5705414	5134873	5134873	7445566
Sixteenth	4247500	3822750	3440475	3268538	4902807
Total	**27961219**	**27961219**	**25165098**	**21863797**	**28359795**

In table 4.14 the actual cash flow of the contractor does not include the advance that has already been paid by the developer at the start of the project to the tune of 10% which is

deducted second month onwards proportionately. The actual expense is the base cost of the project. The risk percentages associated with each stage in the project is the present risk associated with the base cost. The project is risky above the base cost and for the risk percentage other than the risk associated with the base cost. The projected cost is the estimated maximum possible increase in base cost of the project associated with 95% risk cost. As estimate is plagued with error increased cost is taken with error margin 5%. The further analysis includes this 5% to give a more accurate representative of risk cost.

d) Risk cost of the project

The risk cost for different risk percentages is obtained by applying base cost, projected cost and risk percentage to the cost function at every position in the schedule. Table 4.15 shows the risk cost of the project that is obtained from the cost function for the different risk percentages.

Table 4.15 Contractors risk cost of the project for various risk percentages

Month	**Risk Cost for various risk percentages(Rs)**				
End	50%	75%	90%	95%	99%
First	2516510	2516510	2516510	2516510	2516510
Second	63420	63532	63668	63764	63970
Third	147006	147268	147589	147816	148300
Fourth	141142	141637	142242	142669	143581
Fifth	403907	405298	406999	408201	410770
Sixth	499120	501599	504636	506784	511380
Seventh	916106	924728	935290	942761	958746
Eighth	2145038	2165331	2190182	2207755	2245343
Ninth	1896612	1920509	1949703	1970310	2014302
Tenth	1437476	1455588	1477715	1493333	1526675
Eleventh	180211	182957	186312	188680	193735
Twelfth	1078980	1098104	1121466	1137956	1173157
Thirteenth	1015190	1035541	1060404	1077953	1115415
Fourteenth	3001154	3067879	3149395	3206930	3329752
Fifteenth	6926628	7094900	7300471	7445566	7755305
Sixteenth	4535781	4654793	4800187	4902807	5121874

From the table cost associated with the risk in the project is clearly depicted. This helps the decision maker to choose the risk that needs to be mitigated based on market condition and risk appetite.

e) Projected income for different risk percentages and final income

The final income of the project is obtained by adding the projected risk cost obtained for different risk percentages that are 50 %, 75%, 90%, 95%, 99%, the profit margin of the contractor and the projected price of steel and cement. Table 4.16 shows the final income of the project for 50% risk cost.

Table 4.16 Contractors final income of the project for 50% risk cost

Month End	**50% Risk Cost (Rs.)**	**Projected Steel & Cement (Rs.)**	**New Income (Rs.)**	**Final income (Rs.)**
First	2516510		2516510	2768161
Second	63420	13654	77074	84782
Third	147006	188107	335113	368624
Fourth	141142	145894	287036	315739
Fifth	403907	391066	794973	874471
Sixth	499120	453435	952555	1047811
Seventh	916106	490175	1406281	1546909
Eighth	2145038	517592	2662630	2928893
Ninth	1896612	139797	2036409	2240050
Tenth	1437476	78494	1515970	1667567
Eleventh	180211	78224	258435	284279
Twelfth	1078980	205714	1284694	1413163
Thirteenth	1015190	121570	1136760	1250436
Fourteenth	3001154	394986	3396140	3735754
Fifteenth	6926628		6926628	7619291
Sixteenth	4535781	184791	4720572	5192629
Total	**26904281**	**3403499**	**30307780**	**33338558**

If the contractor chooses to execute the project with a risk cost of 50% then the final income is obtained from the table.

Table 4.17 shows the final income of the project for 75% risk cost.

Table 4.17 Contractors final income of the project for 75% risk cost

Month End	**75% Risk Cost (Rs.)**	**Projected Steel & Cement (Rs.)**	**New Income (Rs.)**	**Final income (Rs.)**
First	2516510		2516510	2768161
Second	63532	13654	77186	84904
Third	147268	188107	335375	368913
Fourth	141637	145894	287531	316284
Fifth	405298	391066	796364	876000
Sixth	501599	453435	955034	1050537
Seventh	924728	490175	1414903	1556393
Eighth	2165331	517592	2682923	2951215
Ninth	1920509	139797	2060306	2266337
Tenth	1455588	78494	1534082	1687490
Eleventh	182957	78224	261181	287299
Twelfth	1098104	205714	1303818	1434200
Thirteenth	1035541	121570	1157111	1272822
Fourteenth	3067879	394986	3462865	3809152
Fifteenth	7094900		7094900	7804390
Sixteenth	4654793	184791	4839584	5323542
Total	**27376174**	**3403499**	**30779673**	**33857640**

Table 4.18 shows the final income of the project for 90% risk cost.

Table 4.18 final income of the project for 90% risk cost

Month End	**90% Risk Cost (Rs.)**	**Projected Steel & Cement (Rs.)**	**New Income (Rs.)**	**Final income (Rs.)**
First	2516510		2516510	2768161
Second	63668	13654	77322	85054
Third	147589	188107	335696	369266

Table 4.18 continued….

Fourth	142242	145894	288136	316949
Fifth	406999	391066	798065	877872
Sixth	504636	453435	958071	1053878
Seventh	935290	490175	1425465	1568012
Eighth	2190182	517592	2707774	2978551
Ninth	1949703	139797	2089500	2298450
Tenth	1477715	78494	1556209	1711830
Eleventh	186312	78224	264536	290990
Twelfth	1121466	205714	1327180	1459898
Thirteenth	1060404	121570	1181974	1300171
Fourteenth	3149395	394986	3544381	3898819
Fifteenth	7300471		7300471	8030518
Sixteenth	4800187	184791	4984978	5483476
Total	**27952769**	**3403499**	**31356268**	**34491895**

Table 4.19 shows the final income of the project for 95% risk cost.

Table 4.19 final income of the project for 95% risk cost

Month End	**95% Risk Cost (Rs.)**	**Projected Steel & Cement (Rs.)**	**New Income (Rs.)**	**Final income (Rs.)**
First	2516510		2516510	2768161
Second	63764	13654	77418	85160
Third	147816	188107	335923	369515
Fourth	142669	145894	288563	317419
Fifth	408201	391066	799267	879194
Sixth	506784	453435	960219	1056241
Seventh	942761	490175	1432936	1576230
Eighth	2207755	517592	2725347	2997882
Ninth	1970310	139797	2110107	2321118
Tenth	1493333	78494	1571827	1729010
Eleventh	188680	78224	266904	293594

Table 4.19 continued….

Twelfth	1137956	205714	1343670	1478037
Thirteenth	1077953	121570	1199523	1319475
Fourteenth	3206930	394986	3601916	3962108
Fifteenth	7445566		7445566	8190123
Sixteenth	4902807	184791	5087598	5596358
Total	**28359795**	**3403499**	**31763294**	**34939623**

Table 4.20 shows the final income of the project for 99% risk cost.

Table 4.20 final income of the project for 99% risk cost

Month End	**99% Risk Cost (Rs.)**	**Projected Steel & Cement (Rs.)**	**New Income (Rs.)**	**Final income (Rs.)**
First	2516510		2516510	2768161
Second	63970	13654	77624	85386
Third	148300	188107	336407	370047
Fourth	143581	145894	289475	318422
Fifth	410770	391066	801836	882019
Sixth	511380	453435	964815	1061297
Seventh	958746	490175	1448921	1593813
Eighth	2245343	517592	2762935	3039229
Ninth	2014302	139797	2154099	2369509
Tenth	1526675	78494	1605169	1765686
Eleventh	193735	78224	271959	299155
Twelfth	1173157	205714	1378871	1516758
Thirteenth	1115415	121570	1236985	1360684
Fourteenth	3329752	394986	3724738	4097212
Fifteenth	7755305		7755305	8530836
Sixteenth	5121874	184791	5306665	5837332
Total	**29228814**	**3403499**	**32632313**	**35895544**

The contractor obtains the income associated with different levels of risk and has to make

a choice to go ahead with the option that is perceived as a good business strategy. The choice is dependent on the prevailing business conditions and risk appetite of the contractor. It also depends on the market position, competition and various other conditions. The method is advantageous to get a clear picture of associated project risk cost. If it is assumed that the contractor chooses 99% risk cost as the option for the project then the risk taken is 1% which is the most minimal risk. At this risk percentage the chances of failure are very minimal. The present value of contractors actual cost and risk cost is shown in table 4.21

Table 4.21 Contractors actual cost and risk cost for different risk percentages.

Types of problem	Actual expense (Rs.)	Risk cost (Rs.) for different risk percentages				
		50%	75%	90%	95%	99%
Apartment building 15,500 square feet area (present value)						
Contractor problem	25395954	30112475	30568056	31124726	31517691	32356697

From the table it is evident that the contractor has to make a choice for the best possible path to be followed by them. The schedule of work is followed month wise for all calculations. The present value that guides decision making for the case study of a residential construction is given in the table. The stake holders of the project generate a number of alternatives for different risk percentages. The profit margin can be altered easily by using these alternatives.

4.2 Time Series Analysis of Prices

Prices of commodity could be modeled as a time series. Time series accounts for the fact that data points taken over time may have an internal structure, such as autocorrelation, trend or seasonal variation. In order to study future behavior of prices it is important to understand the time series structure.

Autoregressive series Y_t satisfies $Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots\ldots + \phi_p Y_{t-p} + \varepsilon_t$

where ε_t is white-noise and the ϕ_1's are constants, then Y_t is called an autoregressive series of order p. That is, for example prices depend only on previous prices and an error component.

If a time series Y_t satisfies $Y_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q}$

where $\{\varepsilon_t\}$ is a white-noise and the θ_1's are constants. This series is said to be a moving average of order q. Here the series are random variables that depend on only error or white noise.

A combination of these is autoregressive moving average process ARMA(p,q) is defined by

$Y_t = \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q} \theta_j \varepsilon_{t-j}$ with θ_0=1.

A further extension of this is autoregressive integrated moving average process ARIMA(p,d,q), its d^{th} difference is an ARMA(p,q) process.

Appropriate model that fits the given data is tested using autocorrelation function (ACF) and partial autocorrelation function (PACF). Once the model is identified forecasting of the prices is done based on the fitted model.

Using packages and functions of R programming the data is analyzed. R provides the functions acf( ) and pacf( ) for computing and plotting of ACF and PACF. Using acf() and pacf() function model is identified and then predictions are carried out. Seasonality effect is taken into consideration. The function predict( ) is used for predicting future values of the levels under the model.

Fig 4.2 shows the elements of a time series. A time series normally has a definite trend. The other variations in a time series may be due to seasonal effects. There is a possibility of noise in a time series due to sudden changes that occur.

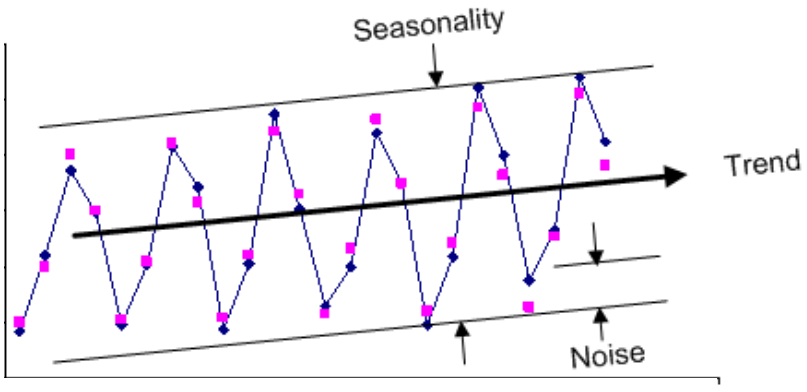

Fig 4.2 Elements of time series

Time series is often used in forecasting models. Time series is sequence of data points, which are measured typically at successive points in time spaced at uniform intervals. The

price of commodities used in construction varies in time. If this is forecast then the risk due to price variation of materials is avoided.

The analysis of construction cost is a summation of various costs of activities. The material cost can be easily separated. After the prices are forecast using time series analysis they can be added back to the original cost. Time series analysis of prices mitigates the risk in construction due to changes in prices of materials.

Accuracy of the forecasting method depends on the past data that has been collected. When the data collected is extensive, reliable and at numerous points on time series the forecasting becomes easier and reliable. The accuracy percentage also increases drastically. Four years of data collected by the researcher at various points of time is used to forecast prices in this thesis.

4.2.1 Projection of steel and cement prices

The data of market prices for steel and cement are collected for the last three and half years. For the projection of future prices time series evaluation is done using R software to obtain the projected prices

a) Analysis of steel prices

The price of steel is collected for the years 2010, 2011 and 2012 for the months January to December in Mangalore region. The price for the year of 2013 is collected for the months January to August. Table 4.22 shows the collected steel price.

Table 4.22 Steel Price collected

YEAR		**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**
2010	**PRICE/kg (Rs)**	33.18	32.64	37.66	37.43	33.37	32.62
2011	**PRICE/kg (Rs)**	39.58	38.74	40.91	43.04	43.31	41.85
2012	**PRICE/kg (Rs)**	47.29	49.05	54.22	51.78	48.91	46.65
2013	**PRICE/kg (Rs)**	46.13	45.03	45.77	46.63	43.93	43.64
YEAR		**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
2010	**PRICE/kg (Rs)**	33.59	33.93	35.45	35.71	35.01	36.84
2011	**PRICE/kg (Rs)**	42.87	44.25	43.02	44.67	42.66	44.96
2012	**PRICE/kg (Rs)**	36.63	45.45	45.00	44.50	44.50	44.50
2013	**PRICE/kg (Rs)**	42.72	42.20				

The collected price of steel is the weighted average price for a particular month. There is variation in the prices on a daily basis. Hence the average price is collected.

Table 4.23 shows the projected price of steel. The collected steel prices are analyzed using R software to obtain the projected prices of steel as an output.

Table no. 4.23 Steel Price Projected

Steel Price (Rs)/Kg	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**
2013						
2014	46.10	45.77	49.24	48.68	46.99	44.76
2015	49.26	48.93				
Steel Price (Rs)/Kg	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
2013			40.92	41.11	39.89	40.93
2014	41.10	44.26	44.16	44.35	43.13	44.17
2015						

From the above table the projected price of steel is obtained which is a forecast of the future price. The forecasted price is used to mitigate the risk due to changes in price of steel. From the projected price a clear picture is obtained of the price variations in steel that are encountered in future course. This helps in attenuating the risk in the project due to changes in steel price.

b) Analysis of cement prices

The price of cement is collected for the years 2010, 2011 and 2012 for the months January to December in Mangalore region. The price for the year of 2013 is collected for the months January to August. Table 4.24 shows the collected price of cement.

Table 4.24 Cement Price collected

YEAR		JAN	FEB	MAR	APR	MAY	JUN
2010	**PRICE/Bag (Rs)**	315	315	315	315	283	279
2011	**PRICE/Bag (Rs)**	293	295	315	315	315	316
2012	**PRICE/Bag (Rs)**	313	313	325	335	340	340
2013	**PRICE/Bag (Rs)**	345	345	345	355	355	355
YEAR		**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
2010	**PRICE/Bag (Rs)**	279	247	238	255	302	304
2011	**PRICE/Bag (Rs)**	315	315	315	313	313	313
2012	**PRICE/Bag (Rs)**	340	340	340	345	345	345
2013	**PRICE/Bag (Rs)**	355	355				

The collected price of cement is the weighted average price for a particular month. There is variation in the prices on a daily basis. Hence the average price is collected.

Table 4.25 shows the projected price of cement. The collected cement prices are analyzed using R software to obtain the projected prices of cement as an output.

Table 4.25 Cement price projected

Cement Price (Rs)/Bag	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**
2013						
2014	353.04	351.16	362.25	363.25	362.98	361.73
2015	374.37	372.49				
Cement Price (Rs)/Bag	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
2013			340.41	346.1	360.21	358.82
2014	355.74	365.57	361.74	367.43	381.54	380.15
2015						

From the above table the projected price of cement is obtained which is a forecast of the future price. The forecasted price is used to mitigate the risk due to changes in price of steel. From the projected price a clear picture is obtained of the price variations in cement

that are encountered in future course. This helps in insulating any project due to changes in cement price.

4.3 Recent developments in construction and risk

4.3.1 Recent concepts- Green Technology

Green buildings are a common term in the construction industry in recent times. It is more of on unique selling point rather than a source to reduce carbon footprint. An attempt to understand the advantages of green buildings and the risks they inherit compared to regular construction is done.

The salient features of a green building are

- Effective use of soil, landscapes and water.
- To use recycled materials and renewable energy.
- To improve energy efficiency.

Fig 4.3 shows the features of green building

Fig 4.3 Features of green building (Source: Lsquaresoultions- green buildings in India)

Green buildings and normal buildings look the same. There are huge operational benefits in green buildings. From day one the saving in operating cost with regard to energy and water savings is substantial. The initial cost of a normal and green building is relative. It depends on the features considered. On the long run the green building compensates for initial investment and reduces overall cost of the building inclusive of operating cost. Green buildings enhance the quality of living and improve the efficiency of the inhabitants.

a) Criteria for green buildings

Green buildings have many criteria's that to be fulfilled. Green buildings encounter additional risks along with the risks that normal buildings possess. Some important criteria of green buildings and probable risks they may attach to the project are

- The green buildings adhere to certain constraints in site selection and planning. The site selected confirms to the urban planning and developmental plan of the city. Residential planning is done in areas marked for residential development. Ample water sources must be available. There must be convenient transport systems available with required infrastructure and waste management systems. If the above are not available it is made available with minimum damage to the environment. The site selected makes use of natural resources such as solar energy, natural vegetation and geographical features.

Fig 4.4 shows criteria of the green building.

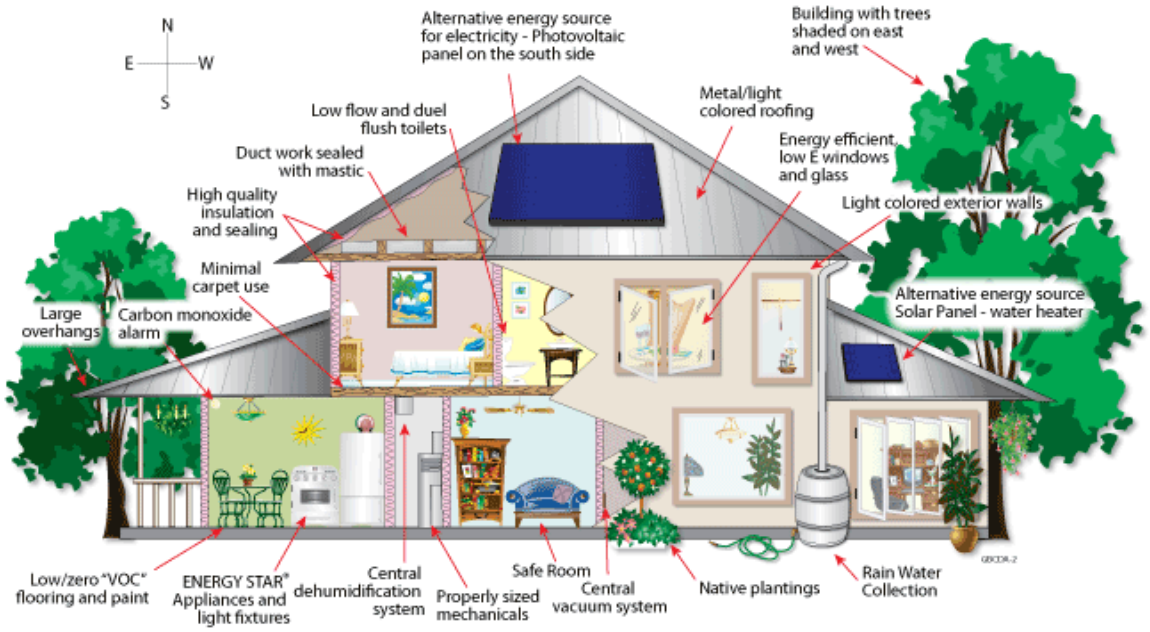

Fig 4.4 Criteria of the green building (Source: My Florida green building- How to get started being green)

- The landscape is preserved and protected during construction. The existing vegetation and contours are preserved at all times. Trees are retained as much as possible. Young trees or saplings are protected with guards. The damage to roots of existing trees is prevented. Trees are not damaged by using them for support or nailing for advertisements.

The existing drainage patterns are maintained. Lighting fires is avoided in the site. The soil is preserved by staging the soil at different levels. Sedimentation basins are constructed to avoid runoff of soil due to water basins. Soil is covered to avoid runoff.

- Top soil is conserved. Since it is the soil with highest nutrients which has been formed by organic decomposition over a long time it is considered the best for growing natural vegetation. Hence the top soil is stored at a safe place in the site to be used at a later stage. The nutrients in the soil are checked at regular intervals. Necessary nutrient additives are mixed with soil to keep the nutrient levels as desired.
- The design includes the existing site features and all the natural environmental features that are accounted for. The access for light is such that it provides winter heating and summer cooling. There is easy flow of wind. The building type chosen should not trap heat which is normally more in heavy urban construction. The constraints and variables are well managed.
- Hard pavements are avoided on sites. Covered pavements by planting trees are best suited. Light colours are to be used in roofs, walls and pavements. Bright colours absorb heat and emit it when temperature is cooler. Hard pavements decrease the permeability of the site and water retaining capacity.
- The lighting for outdoors must use minimum electricity. An attempt is made to use renewable sources of energy like solar lighting. Lighting is to be judiciously managed to minimize the use of energy.
- The site is used optimally for circulation. The internal movement is well regulated to decrease unwanted energy use. Most of the systems are gravity designed.
- The workers well being is taken care of. They are given protective gear. Protective safety nets are used. Proper training in safety is imparted to workers. The extinguishers and first aid kits are made available. Construction workers are provided with clean and habitable living spaces.
- Steps are taken to decrease air pollution during construction. Vegetation is removed only from places where building is constructed. Areas not used as roads are pitched. Roads must not have fine particles and are watered. Speed of traffic is regularized. Nets are used to stop dropping of materials from heights. Dusty materials are covered.

b) Criteria at the time of planning and construction

The criteria that green buildings have to follow at the time of planning and construction are helpful in maximizing benefits to environment.

- Reducing landscape water requirement is important. This is achieved by creative landscaping. It involves retaining native vegetation. Planting less lawn and more trees that require less water is important. Drip irrigation saves the runoff of water. Sprinkler system evenly distributes the water. Understanding the requirement of water by plants in different seasons saves water. It is important to reduce the use of water in the building. Water efficient fixtures that use innovative flushes, auto controlling valves and pressure reducing devices save a lot of water. The use of automatic flushing system for toilets saves a lot of water.

Fig 4.5 shows the aspects of green building

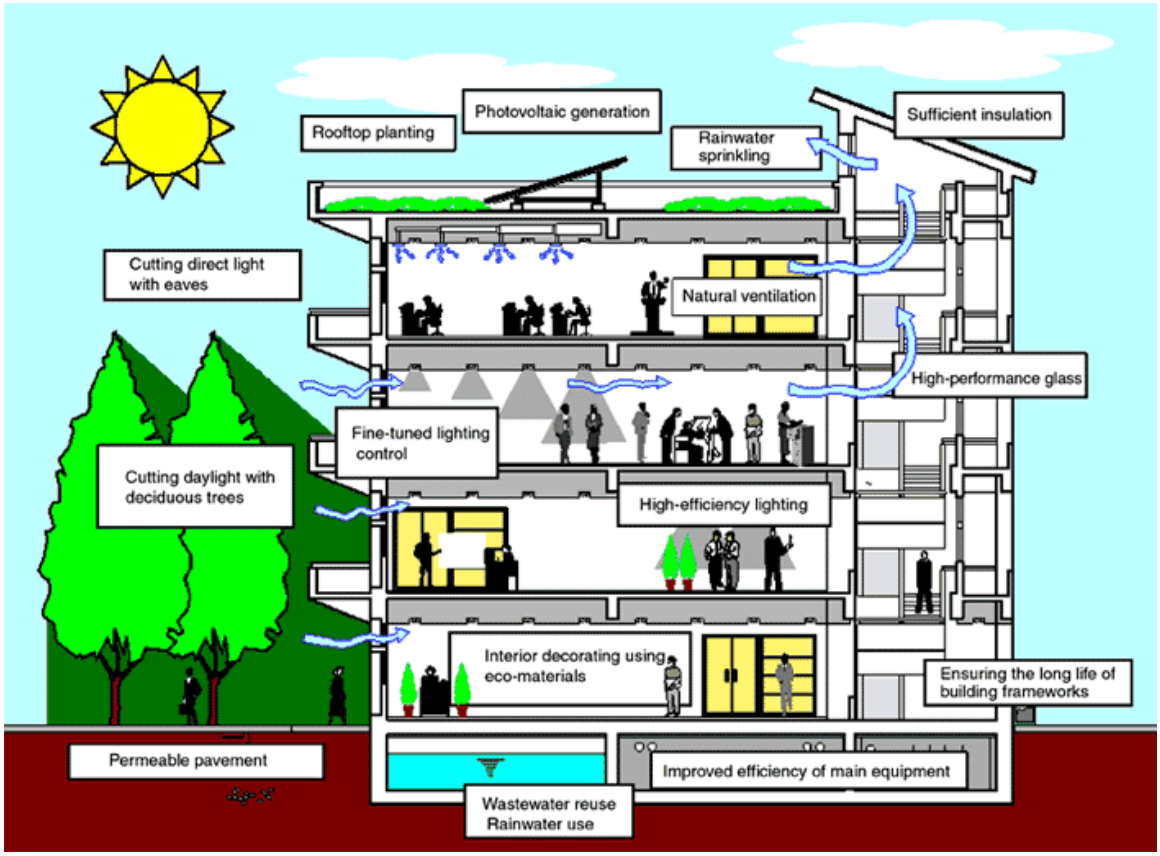

Fig 4.5 Aspects of green building (Source MLIT- green government buildings)

- During construction efficient use of water is monitored. At the time of curing bunds are created so that water does not flow out. Free flowing water is not used for curing. Water must be sprinkled on cloth or gunny bags. Curing chemicals are sprayed on concrete structures after the first day of curing.

- Efficient building design reduces conventional energy demand by planning spaces that require natural lighting by placing them at the right spot in the building. Simulation devices are available to study the performance of the building for natural lighting. The use of power for lighting and other requirements is audited to be within permissible limits. Use of energy efficient equipment's saves a lot of energy.
- Fly ash based concrete is more environment friendly. It is advisable to use ready mix concrete as parameters are controlled more efficiently. Fly ash based bricks also reduce the carbon footprint. They are not required to be plastered. Fly ash based cement can be used for all works. It is more workable than ordinary cement.
- An attempt is made to reduce the construction time by adopting efficient technologies. Compressed blocks made from available earth are a good alternative. Use of reinforced chicken mesh walls reduces weight and increases area.
- Low energy materials are used in interiors. Use of recyclable wood and materials manufactured from recyclable materials is best suited.
- The renewable energy utilization is cultivated. It includes the use of solar energy for lighting and heating. Dual lighting system with alternate solar and electric lighting saves a lot of electricity. Hot water from solar is distributed to all regions in building. Minimum required sizes of taps, showers and bath tubs are used. Wind energy can be harnessed by using smaller wind mills atop building. To reduce carbon footprint big corporate developers develop wind mills in waste lands and supply to the required building or to the grid. They take credit elsewhere for the supply.
- Water is one of the most scarcely available and widely used resources. It depletes very fast. It has to be used with care. Wherever possible it is conserved. Treatment of used water is very useful. Treatment avoids contamination of water sources by used water. The other advantage is treated water is reused by installing a sewage treatment plant. The solid waste in sewage is converted to manure. Treated water is used for gardening by the method of filtration and for flushing by ultra filtration. This reduces the use of fresh water. The water from roofs is collected and passed through sand filters to be stored for later use or recharged into the ground. Recharging increases the ground water table of the surrounding areas. Water being a scarce resource is handled carefully to be conserved for future generations.
- The waste product reduction is important in construction to lessen the burden on the landfill, which contaminates the environment. Plastics used for packaging, waste oils

used for shuttering, grease, coolants, flammable liquids, tubes, lamps, pesticides, tarpaulins, paints, bitumen, electronic wastes and many other such wastes are totally avoided in construction sites.

- Organic waste is segregated from inorganic wastes at the time of disposal. The organic waste is decomposed to make manure. The inorganic waste is segregated. The paper, glass and plastics are used to manufacture recycled product. Other wastes are used in an incinerator to obtain energy by heating. They are burned without depleting nature and energy is obtained from them.
- Use of low VOC points improves the health of people using the building. Ozone depleting chlorofluorocarbons should not be emitted by gadgets in buildings. Air conditioning and refrigeration is limited by improving thermal insulation of buildings. Latest gadgets are very efficient and emit very low harmful ozone depleting agents.
- The quality of water supplied to inhabitants is ensured. The biological oxygen demand, the chemical oxygen demand and hardness is maintained to required standards. The bacterial contents are cleaned by treatment otherwise harmful diseases may spread through them. The outdoor and indoor noise levels are maintained at levels indicated by living standards. Nowadays noise reducing windows and glasses are available for noise reduction. The use of tobacco is restricted to areas with ample ventilation. Non smokers are avoided from inhaling passive smoke. Minimum accessibility is provided for disabled persons. Special stairways and other spaces especially for disabled are designed.
- During the life cycle of the project all the special objectives towards which the building is designed have to be maintained and operated to obtain maximum efficiency. Audit is performed at various time points to review the input and output parameters. Innovation is a must when we counter green buildings. When encountered with them regularly innovative ways enhance standard of living. The companies have to educate the people using green buildings about their features. This helps in obtaining maximum use of all the features. The building inhabitants create a long term commitment for the environment which goes a long way in preserving natural resources.

c) Perceptions and Realities

- Perception is that green buildings are costlier. It is observed that green buildings are little costlier than regular buildings at the time of construction. The operating costs over a longer period of time decreases considerably for green buildings. As green buildings have lot of features to save natural resources the advantages are innumerous.

Longer the life of buildings the operating cost difference between regular and green buildings increases. As green buildings improve the health of its inhabitants there are intangible benefits also.

- The perception is that green buildings have to be air conditioned. This is not right. There are many green buildings in India that are not air conditioned. They give the same cooling effect desired by green buildings. The uses of superior envelop, lighting and roof insulation in these green buildings give the same effect as air conditioned buildings.
- There is a debate about the time of construction of green buildings. The perception is green buildings take longer time than normal buildings for construction. This is not true. Initially when the green building revolution started design stage took a much longer time. All the technologies had to be evolved. But in recent times it is only the application of available technologies. There are innumerous literature on green buildings and their design parameters. Nowadays green buildings take the same time as normal buildings for construction. As the perceptions of not using green buildings diminish more people are accepting them due to their low operational cost savings. The productivity of people working in green buildings is much higher than that of people working in normal buildings. It is found to be 12-15% higher. Due to access to daylight and interior as well as exterior views of green buildings, they give a soothing effect and improve the efficiency of the people working. As the air quality in green buildings is very superior the people living in green buildings are healthy and happy.

d) Popularizing green buildings

- To popularize green buildings is a commitment. This commitment is responsibility of top level management of companies. The passion is to deliver the best green buildings and integrate the effort. All the stakeholders like architect, builder, consultants and vendors must contribute. When there is an integrated effort work progresses in a scientific manner from the start. Perseverance and determination to reach the highest level in green buildings is must be the goal.
- There are various green building materials available in India. Some of them are fly ash cement, fly ash block, recycled steel, low VOC paints, building controls and recycled wood. In recent times roof paints and cooling towers have evolved. It is the onus of stakeholders to use these effectively.
- Some observations have been done regarding green buildings. These have improved the efficiency of executing green buildings. The onus to deliver a green

building is on the whole team. The role of each stakeholder and team member is clearly defined. The baseline costs are clearly indicated at the start of project. This helps in evaluating the incremental cost due to green buildings. Doing this helps in comparison and justifying green buildings with cost as a yardstick. Green design is thought off from conception. At later stages it is not possible to achieve the required results. It is advisable to do the simulation at design stage to understand the design parameters. There is proper monitoring of waste disposal and use of green products to ensure a better green building. Fig 4.6 shows the benefits of the green building

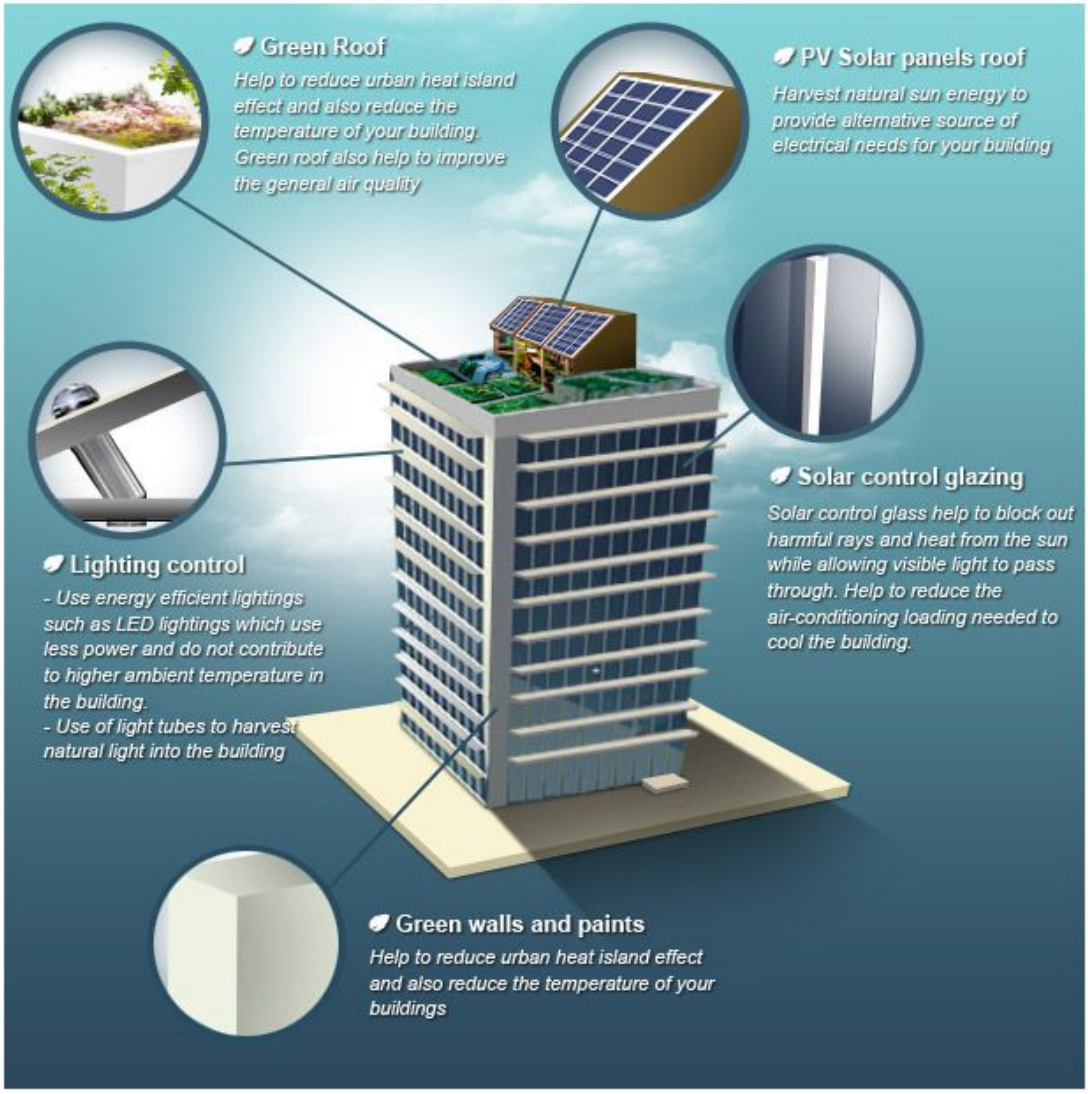

Fig 4.6 Benefits of green building (Source Allwin global- Green building)

e) Risks associated with green buildings

Together with the risks associated with normal buildings green buildings in Mangalore region have risks associated with them. Some of the additional risks associated with green buildings are

- Non availability of technical persons having knowledge of green buildings.
- Non availability of green materials.
- Non availability of skilled labour to execute construction work.
- Budget constraints due to market price of finished products.
- Pressure for certification and confusion in choosing the right rating agency.
- Lack of knowledge of green buildings among clients and their advantages among broad public. Due to this lack of knowledge by clients, builders use green building as a unique selling point for marketing of projects rather than give their true benefits.
- High cost of certification.
- The lack of maintenance of buildings would make the green facilities non functional.
- The lack of proper audit of the functionalities of green buildings does not give a true picture of the savings on a longer run.

4.3.2 Recent Trend- Affordable Housing

Affordable housing is the buzzword doing rounds in the real estate market of India. Affordability is comparative. It means different to the people it is addressed to. Affordability depends on the income of the people. The common yardstick to define affordability is the ratio of EMI to monthly income. If the EMI ranges from 30 to 40 percent and the house price to annual income is less than 5.1 then such housing is defined as affordable housing in India.

Affordable housing is often confused with low cost housing. Both mean the same and are mostly interchanged based on the amenities offered in the projects. Affordable housing without amenities is low cost housing. The units of low cost housing are smaller than that of affordable housing. Low cost housing caters to economically weaker sections only. Affordable housing caters low income groups and mid income groups. The size of dwelling of low cost housing is less than or equal to 300 square feet and is financed by micro finance institutions.

The world has seen a global downtown in business in recent times. Market dynamics have changed rapidly. Growth is negative in most sectors. Jobs are not growing at a pace seen earlier. The money supply has decreased. Banks and other financial institutions are not lending due to the uncertain economic conditions prevailing in the country. The shock

proof Indian real estate industry is experiencing a downturn as sales decrease and the developers are stuck with parcels of land bought at higher prices.

In the past the developers acquired land by part payment. They launched the projects, collected advances and paid the land dues. They availed loan for construction and used surplus funds as down payment for additional land. The present crisis has changed the dynamics. As banks are not issuing easy credit and with muted sales developers are stuck with high leverage. Stake sale at distressed valuations and lowering prices by 20 to 30 percent is thought apt by some developers than to undergo high losses. In such scenario the concept of affordable housing has picked up. The area of houses is decreased to make them affordable to the people under economic crisis. This gives developer's breathing space as working capital is available. The concept is better conceptualized with varied mix of technology, finance options and strategic locations.

a) Reasons for growth of affordable housing

There are lots of reasons fueling growth of affordable housing. There is a housing shortage in India. It is estimated that the housing shortage will grow to 30 million homes by 2020. The challenge is catering this shortage and provides affordable homes. There is rapid urbanization and the growth in population is the main reason for housing shortage. It is estimated that by 2021, 40% of the Indian population will live in cities. This puts a lot of pressure on the housing segment. People are attracted towards cities due to better standard of living. This trend increases the demand for housing. The slums need to be rehabilitated. Housing is to be provided to people coming to cities to avoid new slums. The population of India is increasing at a fast pace. Newer families are created which needs to be catered with housing. There is a mismatch between housing production and the demand for new homes. This gives a great opportunity to affordable housing sector.

b) Location of Affordable Housing

Affordable housing is suitably located. The distance from amenities like schools, hospitals and offices is low. Distances away from cities have an advantage of reasonable land price. If integrated facilities are not provided the long term incremental costs may negate the effect of affordable housing. Such development is not attractive to the clientele.

c) Finance options to affordable housing

The growth of affordable housing requires financial backing. A lot of private housing financial institutions have evolved in the recent years to finance affordable housing. The clients of affordable housing have certain constraints. They are unable to meet the stringent requirements of housing finance. The micro financing institutions have tailor made schemes for these customers. The schemes offered with less stringent terms and conditions encourage lower and mid income groups towards affordable housing.

d) Benefits of Affordable housing

Affordable housing has a lot of tangible and intangible benefits.

- Affordable housing improves health of family. It frees up family resources which are saved due to affordable housing. These resources are used to provide better nutrition to the family especially the children. The families afford better medical and health care.
- Affordable housing reduces the stress and adverse health related ailments of the families. Having residential stability is a boon. It is known that homeless children are vulnerable to mental health problems and depression. Affordable housing reduces the stress related to keeping up with high mortgage payments and frequent moves in residences.
- Affordable housing gives a sense of security and greater self esteem to the residents. Alcohol abuse and blood pressure is found to be lower in home owners. Home owners have greater sense of satisfaction as they live in better quality homes. They are free to adapt to a stable environment and get its benefits.
- Residents of affordable housing are spared by health problems by exposure to allergens and neurotoxins as affordable housing is well constructed and managed. Affordable housing gives lot of options to home buyers who otherwise would have settled for available substandard housing. The risk of asthma, lead poisoning and accidental injury will have increased. Unsafe homes may be prone to fire. Lead based paints increase health hazards. Home owners are spared the misery of staying in badly maintained rental homes. Residents maintain owned homes better than rental homes. The use of green building techniques improves health considerably.
- Affordable housing is a boon to people with illness, senior citizens and people having disabilities. People having illness and senior citizens have a stable health program

due to permanent housing. They choose the areas having better and friendly environment towards their well being. The same is true for physically handicapped people.

- Affordable housing helps to decrease crowding in homes. It improves family life of people. Two or more families need not use the same home. This increases happiness quotient of the residents. People who are subjected to abuse may stay at the place as they do not have other choices of housing. Affordable housing gives a chance for dignified living for people undergoing abuse. When there is crowding of people the spread of infectious diseases is more. By spreading the population over larger areas in affordable housing it arrests the outbreak of infectious diseases.

e) Construction Technology in affordable housing

There is technology that helps affordable housing to be delivered on time and at the right price. It provides an advantage to provider and user. Some of them are

- Pre-cast technology

Pre-cast technology involves construction of buildings where majority of the parts are manufactured in an industry. The components of the building are standardized. They are produced under controlled conditions. The components are transported to the site and put in place. 70% of the components are pre cast and 30% of the building construction is done at site.

Fig 4.7 shows the pre cast manufacturing unit.

Fig 4.7 Pre cast manufacturing unit (Source: Alfanar precast)

In India there is acute shortage of skilled manpower and hence pre cast technology is suitable. Skilled manpower is used whenever required. At other times the main

components are manufactured in the factory. The increase in demand for structures has enabled the use of pre cast technology for on time delivery.

The advantage of pre cast technology is the speed of delivery of the project. Greater quality control is achieved by pre cast. Economy of framework is achieved by repetitive reuse. Standardization of design and dimensional accuracy are achieved. Wastage is minimized by using pre cast technology. It provides better health and safety standards for the workers.

Pre cast technologies is used with or without pre stressing. A combination of shear walls with pre cast components is used in some buildings. Pre casts can be made fire proof. They can be cast using used or recycled materials. Green technologies can be easily adhered in pre cast components. Hollow pre cast technology saves materials.

There are a few deterrents to the use of pre cast technology. The initial investment is high to set up plant and machinery. Transportation of large components is a challenge. Huge lifting equipments are required to connect pre cast members at heights. Project management must be at its best for better coordination of the technical team.

- Monolithic Construction

Cast-in-Site Monolithic reinforced concrete construction system is used in recent times. The industry cannot keep up with pace of housing segment. The industry must increase the speed of deliverables. Monolithic construction is most practical and cost effective way of providing mass housing at a good pace.

Fig 4.8 shows foundation of monolithic construction

Fig 4.8 Foundation of monolithic construction (Source: Buildpedia-Concrete Reinforcing)

The monolithic construction uses formwork manufactured from light weight materials like aluminum. The process is highly repetitive to achieve optimum efficiency. The number of activities is drastically reduced as walls, slabs and most of the components of a floor are laid in a single pour of concrete. The product achieved is excellent. It requires minimum amount of plastering and painting. As the structure is monolithic the earthquake resistance and strength in general is very high. Brickwork and plastering which is time consuming is avoided. Quality standards are maintained as high performance ready mix concrete is used. The manpower requirements decrease considerably. Due to achievement of thin dimension of structure more space is available than buildings with conventional technology. The walls are mostly 10-20cm thick. Work progresses at a faster pace as most panels conduits and plumbing is done at the same time as floor construction. The deshuttering speed is very high. It is 12 hours for wall panels and 72 hours for slabs after leaving the mid supports in place. The shuttering is used repeatedly to increase the pace of construction.

Fig 4.9 shows the aluminum panel monolithic construction

Fig 4.9 Aluminum panel monolithic construction (Source: Directindustry-Monolithic formwork)

The step by step procedure for monolithic construction is followed for efficiency. Design plays an important role in monolithic construction. All the components are designed and ready at the start of construction specially the formwork. The concrete pouring plan is available. A lean concrete is laid before laying the foundation. The reinforcement is

prepared and the piping is done. The foundation is laid and the wall bars connected to the foundation. The wall formwork is placed after the conduits with door frames are installed. The concrete is poured monolithically. After removing the wall forms the ceiling formwork is placed. Electrical and other conduits are laid before concrete monolithically. The concreted floor is then prepared for laying the walls of the next floor and this process is repeated for all.

The advantage of monolithic construction over pre cast construction is monolithic construction requires less investment, can be used for lower number of units, semi skilled labour is sufficient and it does not require heavy equipments.

Fig 4.10 Shows monolithic construction cast at site

Fig 4.10 Monolithic construction cast at site(Source: DurhaInfracon- Durha Monolithic construction technology)

- Glass fibre reinforced gypsum (GFRG) Panels

Construction industry is seeing a lot of technology advancements, the latest being gypsum based panels. Gypsum has been used as a plastering material earlier. It is also used for interior partition walls. Gypsum is a natural choice due to its availability. It is manufactured from industrial wastes especially from fertilizer industry. GFRG is the latest product especially used in rapid mass housing in recent times.

GFRG wall panels are manufactured to be used readily in construction. It is the world's largest load bearing, light weight and pre fabricated building panel. The commercial name is rapid wall. Its dimensions are 12m long, 3m high and 124mm thick. It has modular

cavities and is manufactured by combining glass fibre strands with gypsum plaster. It produced in an energy efficient fluidized bed calcining process.

Fig 4.11 shows GFRG panel construction

Fig 4.11 GFRG panel construction (Source: Commonfloor-Panels to replace brick walls, reduce construction time)

The cavities are cellular. They are filled with concrete and reinforced with steel for windows and doors. They are used for load bearing structures and high rise structures. They are used as floor and roof slabs and in staircases, after embedding reinforced concrete in cavities and using a thin layer of screed concrete on the top. They are also used in reinforced cement concrete framed structures.

Fig 4.12 Shows GFRG slab construction

Fig 4.12 GFRG slab construction (Source: GFRG demo you tube- IITMadras)

The structures built using them are also earthquake resistant. They are used not only as load bearing walls but also as shear walls. The services cables, electrical and plumbing cables can be laid in the cavities easily. GFRG panels used in construction are cost efficient greener way of concrete. The materials bring down the cost of buildings making it affordable. The only disadvantage is the panels are not available everywhere and have

to be transported to construction sites which posses a challenge when sites are in remote regions. The costs of transportation negate the cost saved by these buildings. Awareness among public to use these buildings is most important for its success. Being a new material it may not be accepted easily.

Fig 4.13 shows GFRG model house

Fig 4.13 GFRG model house (Source: Crazyengineers-IIT Madras model house)

f) Central government schemes to assist affordable housing

Central government started a lot of initiatives for providing affordable housing. Some of them are listed below

- National Urban Housing and Habitat Policy (NUHHP) 2007 is a policy that recognizes affordable housing. It promotes partnerships between various public, private, cooperative and institutional stakeholders in housing. The policy aims at providing suitable land for development of housing to all sections of the population. It encourages land assembly, development and disposal. It pioneers in providing rental as well as ownership housing stock and encourages sustainable development.
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was formed in 2005 by the government to expedite urban reforms. It is currently applicable to 63 cities. The scheme provides additional central assistance to the cities to be developed with an

equal investment from state government and local bodies. It encourages in earmarking 20-25% space in all developments for economically weaker sections and low income groups. It is a novel scheme that provides for slum development programs and schemes of basic services for urban poor integrated development is given importance. The scheme aims to develop the infrastructure with the housing to provide for better quality of living. For slum development in some cases 80% of the cost is borne by the central government. It provides for interest subvention for affordable housing up to 1% for a loan up to Rs.10lakhs and house cost not exceeding Rs.20lakhs. The scheme provides for a partnership for development of housing. It caters economically weaker and low income group sections of the society with the help of public and private housing providers. Providing loans with interest subvention, developing infrastructure, providing land, having stake in projects through subsidiary organizations are the methods adopted in JNNURM.

- Rajiv Awas Yojna is a novel scheme to provide legal rights of land to the slum dwellers. The slum dwellers are taken into confidence for slum development. Large lands are available for providing housing. The area is well developed to provide all basic amenities and the right of land provided to the slum dwellers. This increases their sense of security and participation. The sanitation and living conditions of the people in the cities improves considerably.
- The modification of rent control act is done to provide for rental housing, for people who cannot afford their own houses. It solves the problems of both parties involved. Urban land ceiling and regulation Act (ULCRA) that was passed in 1976 is a revolution in the equal distribution of land holdings. It facilitated availability and affordability of urban land. It had a ceiling on land ownership. The law enabled government to acquire, redistribute and use land for the improvement of the citizens at large.

g) State government schemes to assist affordable housing

Many state governments have taken steps for affordable housing and have also collaborated with central government and its schemes for providing housing for the economically weaker sections and low income groups.

Fig 4.14 shows housing shortage in India

Fig 4.14 Housing shortage in India (Source: Indiabulls-Realty sector demand reduction in cost borrowing)

- The Andhra Pradesh government made provisions in the master plan for providing space for affordable housing. The same applies for group housing. They have constructed 1,75,000 units of housing project under the "Rajiv Swagraha" scheme. The housing units are provided at a price 25% less than the prevailing market price.
- The Gujarat government repealed urban land ceiling and regulation act. This freed up surplus land. It is transferred to urban local bodies for developing affordable housing. The government gives special provisions to developers who concentrate on low cost housing.
- Haryana government has provides 20% area for housing which is affordable. Similar provisions have been made for group housing and apartment developments.
- Madhya Pradesh government provides additional FSI for housing provided to economically weaker sections and low income groups. The state government provides land at concessional rates and 30% of the development is for affordable housing. When land is bought by the developers they have to provide 15% of developed area for affordable housing.
- The Maharashtra government is at the forefront of providing low cost and affordable housing. They executed successful slum development programs which are a model to other states. FSI upto 2.5 is provided for such type of housing. The metropolitan development authority is pushing for private public partnership (PPP) model for development of affordable housing. An FSI of 4 is provided for such projects. This also

promotes rental housing. The Maharashtra government has also developed mass housing schemes on their own.

- Chennai metropolitan authorities provide 50% additional FSI for housing the economically weaker sections and 30% additional FSI for housing the low income groups.
- The Karnataka government announced the digitization of land records and giving property card to property holders. This increases revenue by giving a clear indication of the land held by the government. It is utilized for low cost housing. It frees up land encroached upon illegally. Karnataka housing board developed homes on its own and in partnership with private agencies for benefit of weaker sections.

h) Risks in affordable housing

The risks that are associated with regular projects are also accompanied by affordable housing. Some of the risks that are specific to affordable and low cost housing in Mangalore region are discussed to understand the challenges in affordable housing.

- There is a lack of availability of urban land. Land prices have increased due to limited availability. It becomes unviable for developers to take up affordable housing. Land is locked up with government agencies like railways, government offices and others that are strategically located which is not utilized optimally. There are local political issues hindering slum development. State governments have exercised excessive control on land development and have created on artificial shortage. New regulations designed lands for housing away from the city. This is an unviable housing option.
- There is lack of access to home finance for low income groups. The middle and high income groups are serviced easily by financial institutions. The low income housing owners cannot provide for security. Their incomes are not steady. Traditional banking financers shy away from providing them finance. Hence the developers also face problems of finance. The long standing demand for special status by the government is delayed. As a result the banks minimized their exposure to real estate which is a termed a risky asset by reserve bank. The developers are constrained to use costly finance from non banking financial corporations and private equity investors.
- The taxation of real estate has been a debatable subject for long time. Taxes are levied by central, state and local agencies. This coupled with transaction costs and other levied taxes make real estate development a costly proposition. It is estimated that about

30% of the cost in a development are taxes. This is a major risk if managed well it leads to affordable housing.

4.3.3 Recent Regulation – Real Estate Bill

The real estate bill introduced in India is a breakthrough for fair practices in the housing development market of India. The salient features of the bill are

- The developer who develops land and constructs more than 1000sq.m or more than 12 dwelling units has to register with the real estate authority. It is set up in accordance with this regulatory act. The registration is for every project individually. Registration is mandatory before the developer starts marketing the project. The authority verifies the documents pertaining to various clearances and legal matters for the benefit of the customers and investors. The project is advertised for booking only after clearance. After obtaining permission from the authority, the license may be withdrawn at any point by issuing prior notice. The developer is given a proper hearing before it is done.
- According to the bill the person involved in marketing the project, the real estate agents needs to register with the real estate regulatory authority before starting to sell the project on behalf of the developers.
- The promoter after obtaining the license from the real estate regulatory authority receives a log in id and password to the website of the authority. The developer uploads all the details regarding the project on the website. It includes the clearance licenses obtained together with land documents and registration numbers. The agreement types to be entered between the developer and allotee with the advertisements released by the developer are exhibited in detail.

Fig 4.15 shows the features of real estate bill

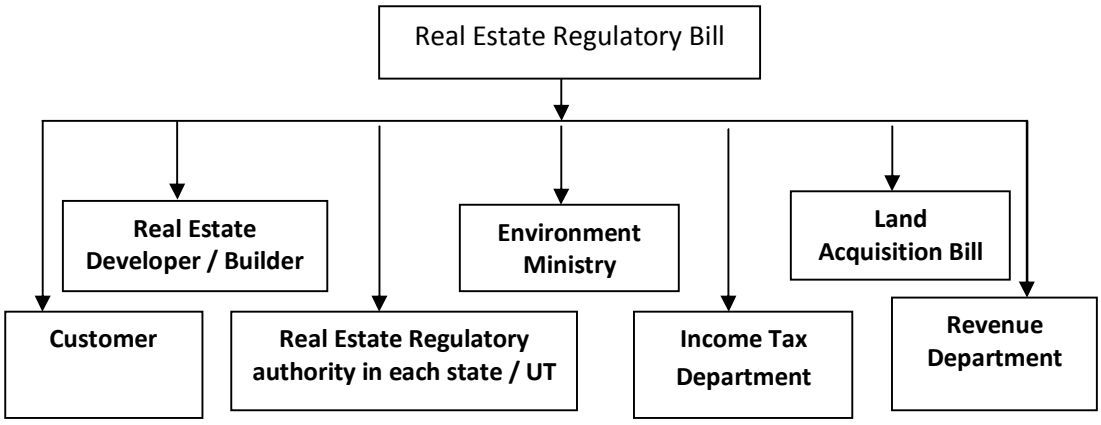

Fig 4.15 Features of real estate bill

- The developer gives a detailed plan of execution with structural details, technology and time schedule that is been planned for the project.
- The promoter is not entitled more than 10 percent of the value of the transaction as booking fees or advance before the agreement. The agreement includes all the terms and conditions in detail. In case there is a cancellation of agreement by the allotee then his compensation follows the terms and conditions of the agreement. In case a cancellation occurs due to wrong doings of the developer or false promises made due to misleading advertisements then the developer returns full amount of the allotee with a compensation amount.
- The responsibility of providing completion certificate and all other documents is on the developer. The promoter after executing the project is responsible for rectification, if brought to notice by the allotee within 2 years of completion of the project.
- The agent who sell a project of the promoter on behalf of the promoter, have the responsibility of right interpretation of facts to the customers. If found to be not abiding by the ethics and codes of the authority their license is revoked. Action is taken against the developer in such cases of non compliance. According to law a registered agent sells the projects that are registered with the authority only.
- The allotee's right is to obtain entitled information. It includes information regarding licenses, plans, structural design, sub division of areas, payment plan, schedule of construction and all other relevant details. The allotee pays from time to time the installment towards his flat. On non receipt of payment the promoter charges interest as agreed upon. On handing over the property the allotee is responsible to adhere to the provisions of setting up a society in the condominium.
- The appropriate government sets up a real estate regulatory authority. Experienced people are involved in the management of the authority who have handled projects for 15 to 20 years and served in government departments. This gives an edge of technical and beaurocratic knowledge. The people involved must not have business interests in the realty market. They are to keep records, fix regulations and ensure compliance. The authority must ban activities of monopoly and promote environmental friendly housing which is affordable.
- The government sets up a central advisory council. It consists of representatives and ministers of government departments both central and state that deal with different components that lead to a successful housing project. The council advices the authority on

implementation of act. It protects consumer interest and fastens growth of the real estate sector.

- The government is responsible to have a fair system. A provision is made for setting up of a Real Estate Appellate Tribunal. The tribunal listens to any person aggrieved by any direction or decision order made by the authority. The judicial members of the tribunal understand the fairness and give judgment with consultation of its technical members.
- Penalties are levied on the fraudulent people involved in real estate development. If a promoter is found not to be abiding by the rules of the authority then the promoter is fined upto 10 percent the cost of the project. Furthermore if the order of the authority is not followed the promoter is imprisoned for a term of 3 years. Fraudulent real estate agents are fined ten thousand rupees a day until show cause or a maximum of 5 percent the cost of the project. When a company is involved all the persons in the company liable to take decisions are held responsible for the act of non compliance.
- A real estate fund is set up to manage the finances of the authority. The grants given by the government are included here. The income of the authority by registrations and fines levied is credited to this account. It takes care of the regular running of the authority and payment of salary to its members and employees. It is liable to be probed by controller and auditor general (CAG) the premier auditing authority of the government of India.
- No civil court has jurisdiction to entertain any suit regarding the authority. In respect of matters relating to real estate development the procedures of the authority are followed. The decision of the authority is not be overruled by getting an injunction from civil court. The decisions made by the government are final with respect to any misunderstanding or misinterpretations between the government and the authority. Every rule proposed by the government is cleared with the council of ministers and then the house of representative. This ensures fairness. If the authority is not delegating its authority in the right manner then the government overrules the authority and its powers for a period of 6 months. After this a fresh governing council is set up as real estate regulatory authority.

a) Risks due to real estate bill

The objective of introducing the real estate regulatory bill and setting up of real estate regulatory authority is to implement transparency and accountability in the real estate

sector. This ensures the development of the sector by increase in the capital flows and transforms it into an organized sector. The real estate regulatory bill enforces a few risks that are additional to prevailing risks in the construction industry of Mangalore region. The bill has a few errors that lead to the following risk.

- The bill is concentrated on the residential realty market. It neglects the commercial realty market. People realizing tight regulation in residential market increase projects in commercial real estate and escalate cost of residential development. The bill does not mention farm lands which are invested and also sold by developers as farm houses.
- The bill increases work of developers. In turn the customers pay extra cost of liaison for statutory authority registration. It is believed that 40% of the cost of the project is contribution of liaison and other statutory license fees. A group of liaison agents crops up to obtain the clearance of project by the authority.
- The bill treats the authority as another agency the developer needs to obtain a license to commence business. It does not cater to the problems and hurdles the developer's face in getting clearance. An ideal authority is a watchdog that implements best practices in the real estate market.
- The cost of the project increases for the developer and renders the project incompetent due to the extra cost of listing the project with the authority. The reason for this is that, at the time the bill is passed all other previous projects ongoing and that have obtained licenses are not under the purview of this act. This is a major risk for developers launching new projects. The authority not having an investigative agency is a lacuna as it is unable to verify correctly the claims made against developers.
- The bill lacks in setting up the educational qualifications of real estate agents. It only provides for registration of agents. Certification must be mandatory as it filters the agents. This inhibits people with inadequate qualification and prevents the use of unethical means to get into the mainstream business. Hence improving the quality of people working in the market
- The regulatory authority must bring under it the agreements drawn between the developer and allotee. The disadvantage of the bill is negated by an agreement that favors the promoter. Therefore this risk is to be dealt by the authority, by drawing up sample documents and checking random agreements in vogue.

- The promoter due to the bill faces lot of risks that add up as cost. The major hurdle is crossed only when the permissions to be obtained by the developer are brought down to a minimum.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Results of the survey

The survey results are interpreted according to their grouping to get a better understanding of the prevailing risks in Mangalore region.

5.1.1 Results of the survey for management risk

The types of management risk with its risk percentage and rank is shown in table 5.1.

Table 5.1 Risk percentage and ranks of management risk

Management risk	**Mean risk percentage**	**Rank**
Improper allocation of job	41.07	1.65
Delay in decision making	44.62	2.52
Short tendering time	44.36	2.84
Defective management decision	39.55	3.35
Change of management	30.69	5.00
Generalization changes in ownership	25.63	5.63

The ranks are the weights which suggest that improper allocation of job is the most important management risk. Generalization changes in ownership are ranked as the least important management risk. The highest risk percentage of 44.62 percent is given to delay in decision making with a ranking of 2.52. Short tendering time and improper allocation of job are the next important risks with risk percentage of 44.36 and 41.07 subsequently.

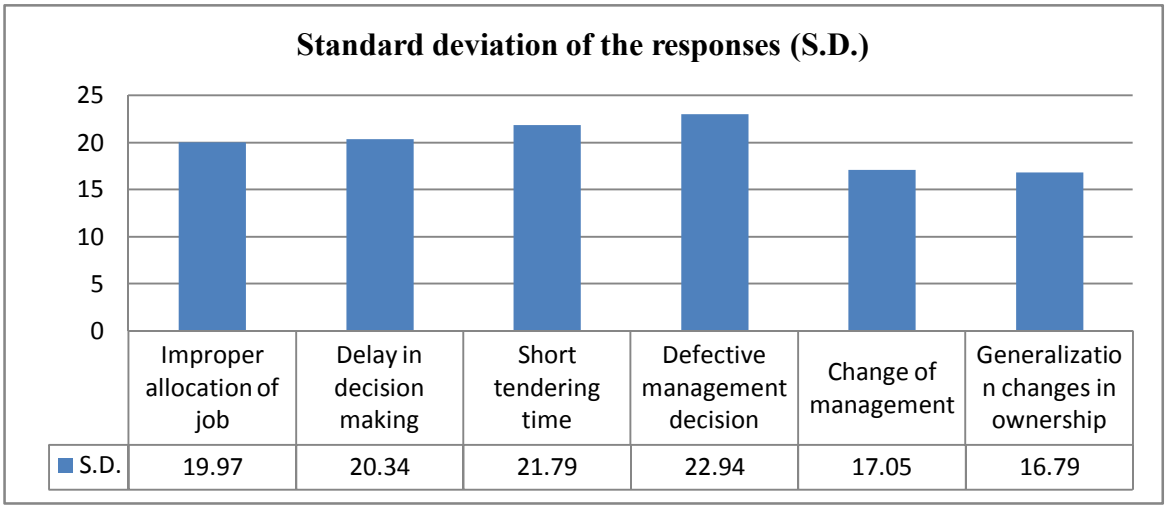

Fig. 5.1 Standard deviation for management risk

Fig 5.1 shows the standard deviation of the responses for management risk. It is evident that all the standard deviation is almost similar and it is best suited to use an average to estimate weighted data. It also shows the consistency of the respondents.

5.1.2 Results of the survey for policy & political risk

The types of policy & political risk with its risk percentage and rank is shown in table 5.2

Table 5.2 Risk percentage and ranks of policy & political risk

Policy & Political risk	**Mean risk percentage**	**Rank**
Changes in government law	39.30	1.24
Legal issues related to project	40.56	2.24
Inability to gain access for key personnel	29.17	4.00
Incomplete approval of documents	34.74	4.20
Refusal of issue of project license	38.79	4.37
Political changes	29.43	4.96

The ranks are the weights which suggest that changes in government law are the most important policy & political risk. Political changes are ranked as the least important policy & political risk. The highest risk percentage of 40.56 percent is given to legal issues related to project with a ranking of 2.24. Changes in government law and refusal of issue of project license are the next important risks with risk percentage of 39.30 and 38.79 subsequently.

Fig 5.2 shows the standard deviation of the responses for policy & political risk. It is evident that all the standard deviation is almost similar. In such a case it is best suited to use an average to estimate weighted data. Sometimes values may be ranged. When standard deviation of the whole survey is considered an average is best suited. It shows the consistency of the respondents.

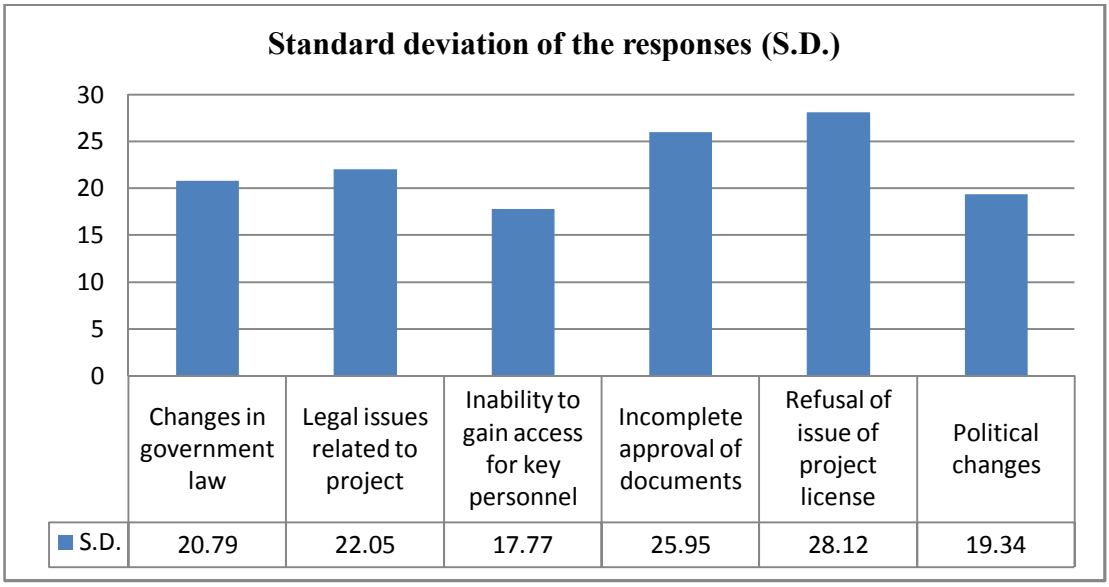

Fig 5.2 Standard deviation for policy and political risk

5.1.3 Results of the survey for financial risk

The types of financial risk with its risk percentage and rank is shown in table 5.3

Table 5.3 Risk percentage and ranks of financial risk

Financial Risk	**Mean Risk percentage**	**Rank**
Escalation in materials and labour charges	46.39	1.39
Project funding	59.05	2.45
Defective sequence of payment towards contractors and suppliers	48.67	2.76
Changes in bank formalities and regulations	29.68	3.82
Client penalty	23.60	5.18
Fluctuation of interest rate	24.36	5.39

The ranks are the weights which suggest that escalation in materials and labour charges is the most important financial risk. Fluctuation of interest rate is ranked as the least important financial risk. The highest risk percentage of 59.05 percent is given to project funding with a ranking of 2.45. Defective sequence of payment towards contractors and suppliers and escalation in materials and labour charges are the next important risks with risk percentage of 48.67 and 46.39 subsequently.

Fig 5.3 shows the standard deviation of the responses for financial risk.

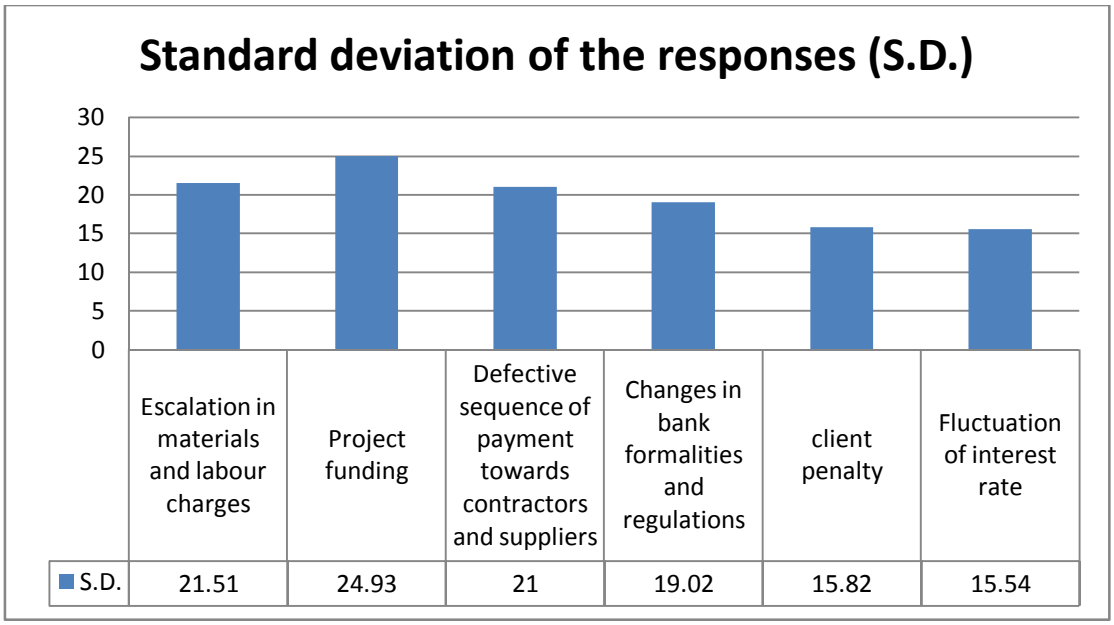

Fig 5.3 Standard deviation for financial risk

5.1.4 Results of the survey for planning & selection Risk

The types of planning & selection risk with its risk percentage and rank is shown in table 5.4

Table 5.4 Risk percentage and ranks of planning & selection risk

Planning & Selection Risk	**Mean Risk percentage**	**Rank**
Inadequate project planning	47.91	1.22
Inappropriate contractor selection process	48.16	2.88
Inadequate pricing	46.64	3.43
Architectural modifications	31.96	4.35
Non estimated extra work	39.55	4.49
Defective resource selection (Labour, Material, Plant & Machineries)	48.41	4.63

The ranks are the weights which suggest that inadequate project planning is the most important planning & selection risk. The highest risk percentage of 48.41 percent is given to defective resource selection (Labour, Material, Plant & Machineries). Inappropriate

contractor selection process and inadequate project planning are the next important risks with risk percentage of 48.16 and 47.91 subsequently.

Fig 5.4 shows the standard deviation of the responses for planning and selection risk.

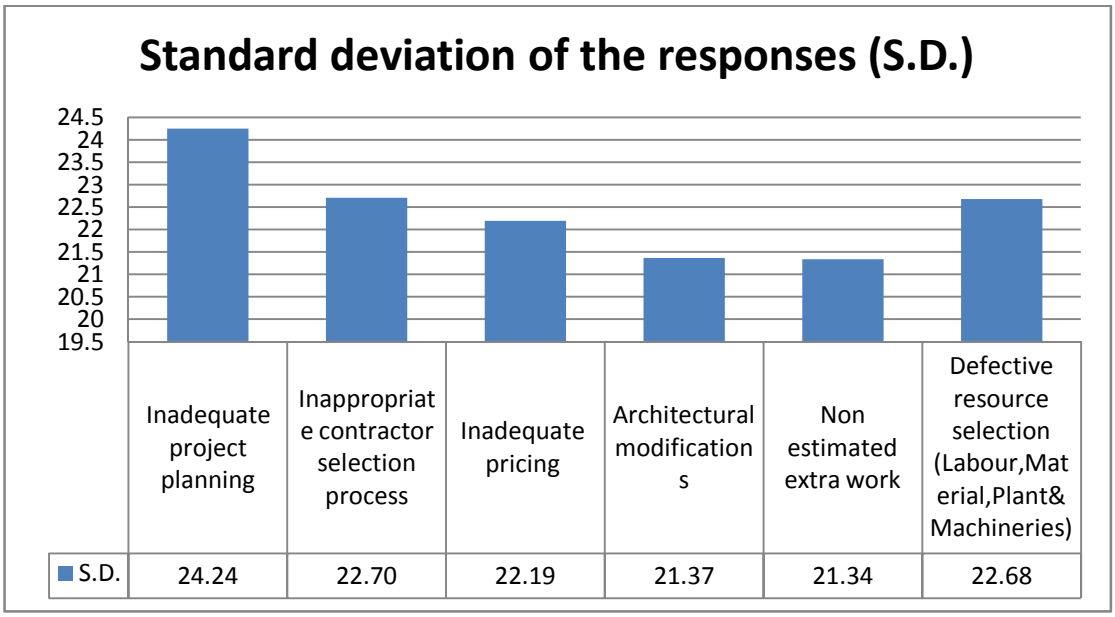

Fig 5.4 Standard deviation for planning and selection risk

5.1.5 Results of the survey for risk related to quality & safety

The types of risk related to quality& safety with its risk percentage and rank is shown in table 5.5

Table 5.5 Risk percentage and ranks of risk related to quality& safety

Risk related to quality & safety	**Mean Risk percentage**	**Rank**
Negligence of safety (Accidents)	40.82	1.45
Insufficient quality control	51.7	2
Changes in client requirement	38.54	3.37
Snagging, chipping, touchup work	32.97	4.67
Defective materials	43.6	4.71
Unrealistic schedule	41.58	4.82

The ranks are the weights which suggest that negligence of safety (Accidents) is the most important risk related to quality& safety. Unrealistic schedule are ranked as the least important risk related to quality& safety. The highest risk percentage of 51.7 percent is

given to insufficient quality control with a ranking of 2. Defective materials and unrealistic schedule are the next important risks with risk percentage of 43.6 and 41.58 subsequently.

Fig 5.5 shows the standard deviation of the responses for risk related to quality& safety.

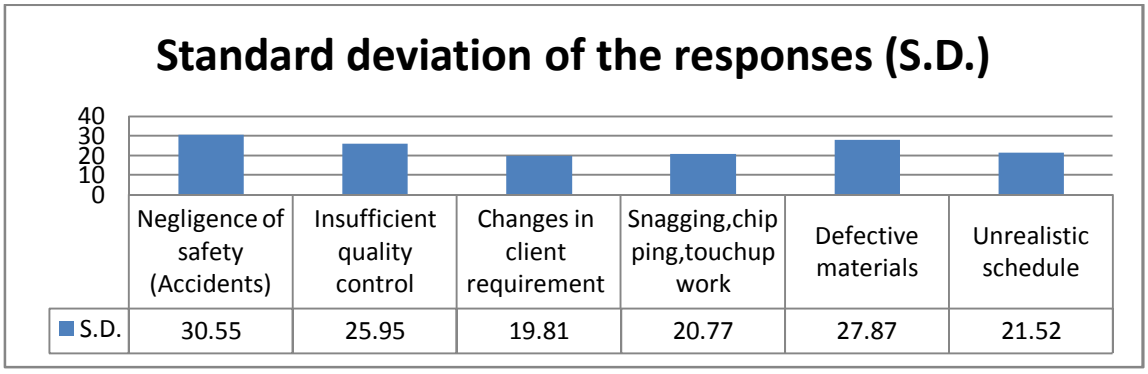

Fig 5.5 Standard deviation for risk related to quality and safety

5.1.6 Results of the survey for organizational risk

The types of organizational risk with its risk percentage and rank is shown in table 5.6

Table 5.6 Risk percentage and ranks of organizational risk

Organizational Risk	**Mean Risk percentage**	**Rank**
Change in quantities of work actually carried out at site	36.26	2.18
Defective work inspection	43.10	2.88
Improper sequencing of activities	36.51	3.27
Changes made in project program	33.73	3.39
Defective design	39.55	4.49
Insufficient site access to engineers	37.27	4.84

The ranks are the weights which suggest that change in quantities of work actually carried out at site is the most important organizational risk. Insufficient site access to engineers is ranked as the least important organizational risk. The highest risk percentage of 43.10 percent is given to defective work inspection with a ranking of 2.88. Defective design and insufficient site access to engineers are the next important risks with risk percentage of 39.55 and 37.27 subsequently.

Fig 5.6 shows the standard deviation of the responses for organizational risk.

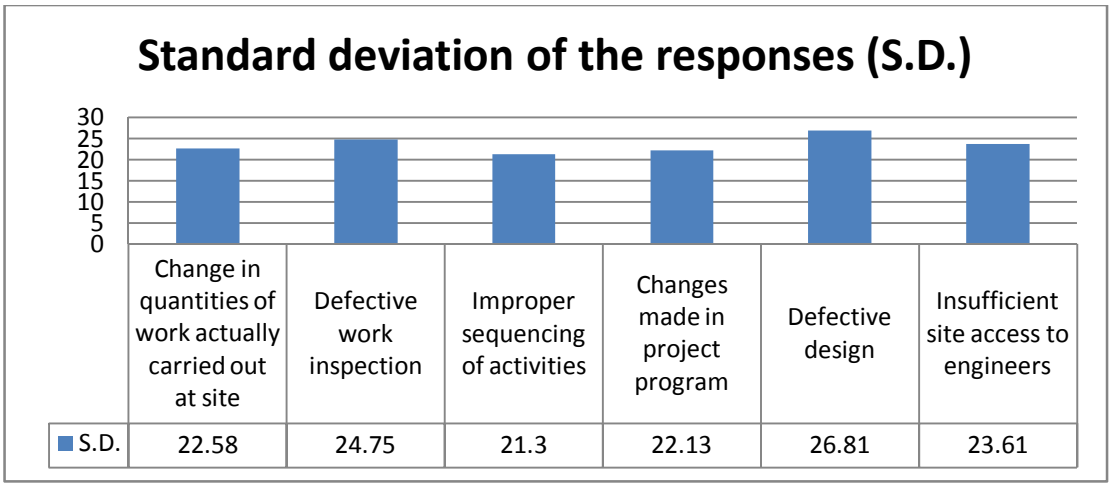

Fig 5.6 Standard deviation for organizational risk

5.1.7 Results of the survey for labour risk

The types of labour risk with its risk percentage and rank is shown in table 5.7

Table 5.7 Risk percentage and ranks of labour risk

Labour Risk	**Mean risk percentage**	**Rank**
Scarcity of sufficient number of skilled labours	55.50	1.84
Due to poor workmanship	56.01	2.02
Defective work inspection	47.15	3.94
Holidays due to festivals	37.78	4.00
Sudden change of labour	41.83	4.00
Labour disputes & labour strikes	35.00	5.20

The ranks are the weights which suggest that scarcity of sufficient number of skilled labours is the most important labour risk. Labour disputes & labour strikes are ranked as the least important labour risk. The highest risk percentage of 56.01 percent is given to due to poor workmanship with a ranking of 2.02. Scarcity of sufficient number of skilled labours and defective work inspection are the next important risks with risk percentage of 55.50 and 47.15 subsequently.

Fig 5.7 shows the standard deviation of the responses for labour risk.

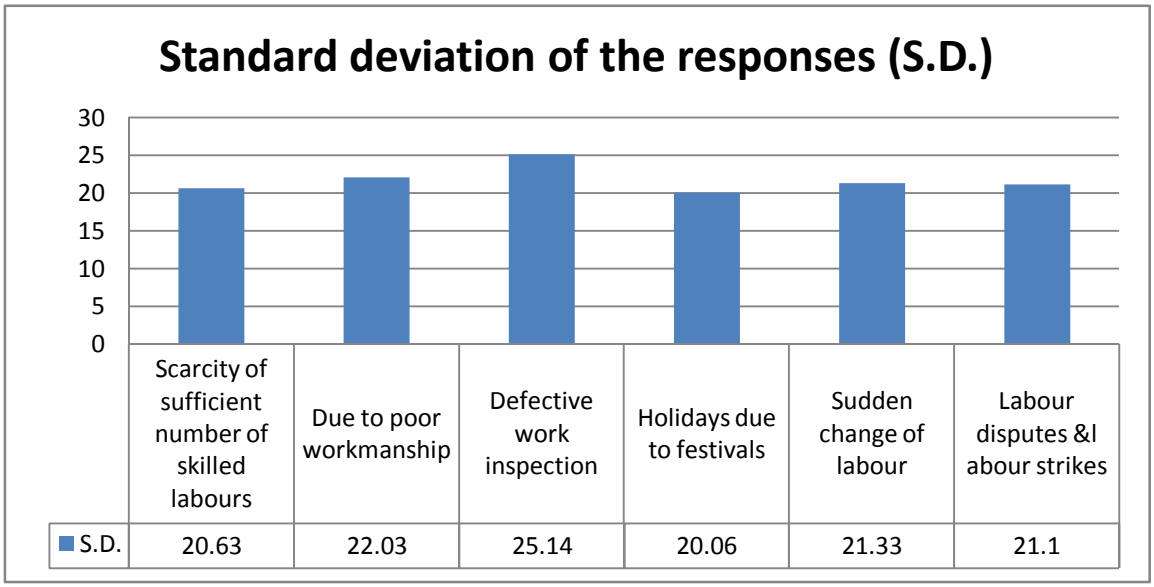

Fig 5.7 Standard deviation for labour risk

5.1.8 Results of the survey for market risk

The types of market risk with its risk percentage and rank is shown in table 5.8

Table 5.8 Risk percentage and ranks of market risk

Market Risk	**Mean risk percentage**	**Rank**
Rise in the labour and material cost	51.20	1.14
Sudden shortage of resources in the market	43.86	2.24
Exceptional increase in tender prices	41.07	3.18
Changes in the exchange rate due to economic instability	31.20	4.16
Marketing commission in the company	27.91	4.22

The ranks are the weights which suggest that rise in the labour and material cost is the most important market risk. Marketing commission in the company is ranked as the least important market risk. The highest risk percentage of 51.20 percent is given to rise in the labour and material cost with a ranking of 1.14. Sudden shortage of resources in the market and exceptional increase in tender prices are the next important risks with risk percentage of 43.86 and 41.07 subsequently.

Fig 5.8 shows the standard deviation of the responses for market risk.

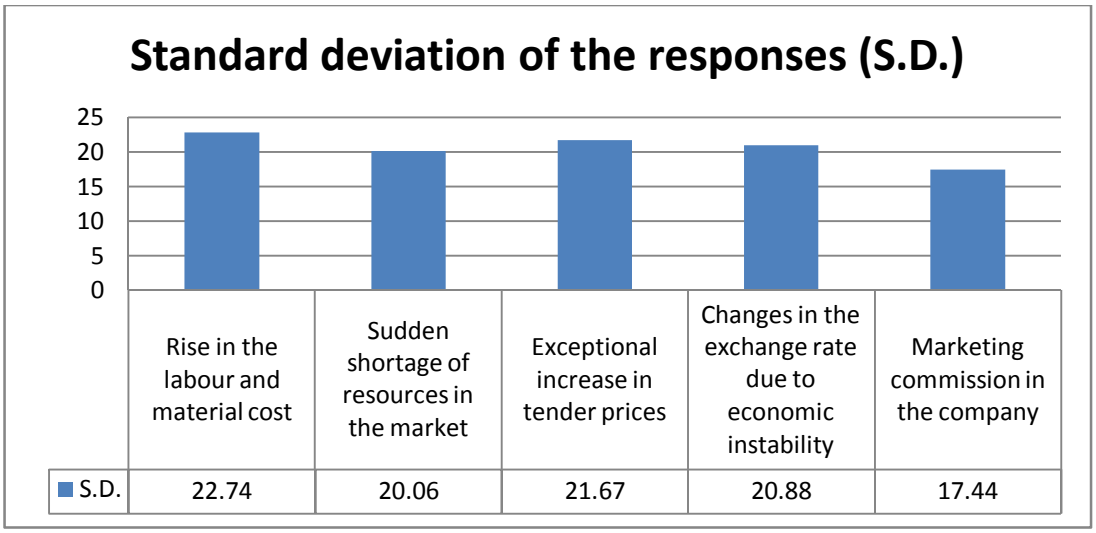

Fig 5.8 Standard deviation for market risk

5.1.9 Results of the survey for technical & environmental risk

The types of technical & environmental risk with its risk percentage and rank is shown in table 5.9

Table 5.9 Risk percentage and ranks of technical & environmental risk

Technical & Environmental Risk	**Mean risk percentage**	**Rank**
Complicated site conditions	44.62	1.96
Severe weather (rain, heat, snow etc)condition	40.06	2.41
Delay in the design	37.78	2.71
Specification changes	32.72	3.63
Modification cost	36.26	4.65
Inappropriate technology	35.75	5.67

The ranks are the weights which suggest that complicated site conditions are the most important technical & environmental risk. Inappropriate technology is ranked as the least important technical & environmental risk. The highest risk percentage of 44.62 percent is given to complicated site conditions with a ranking of 1.96. Severe weather (rain, heat, snow etc) condition and delay in the design are the next important risks with risk percentage of 40.06 and 37.78 subsequently.

Fig 5.9 shows the standard deviation of the responses for technical & environmental risk.

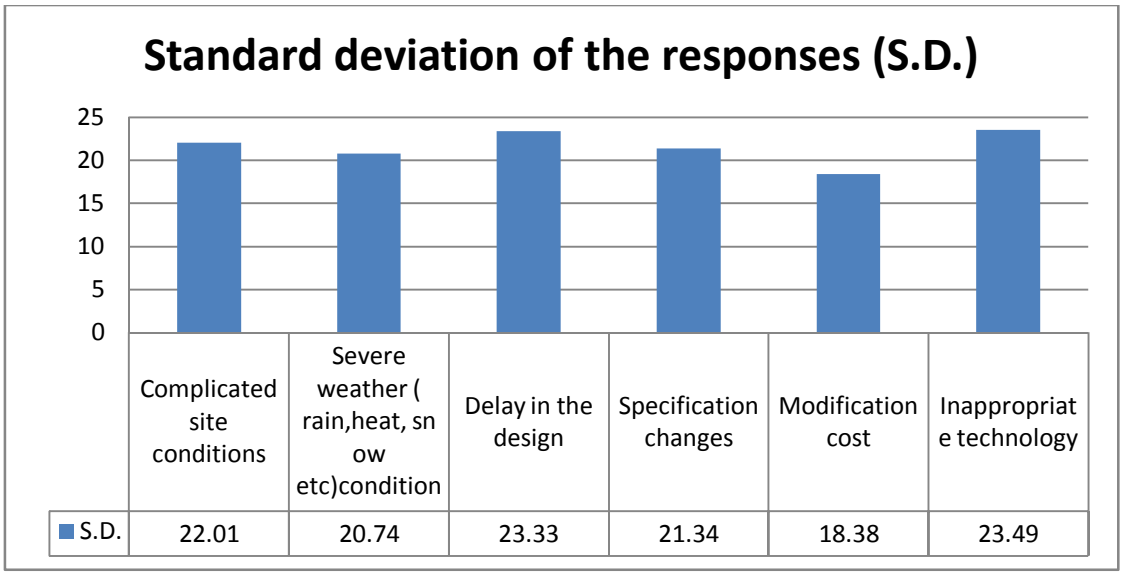

Fig 5.9 Standard deviation for technical and environmental risk

5.1.10 Results of the survey for resource risk

The types of resource risk with its risk percentage and rank is shown in table 5.10

Table 5.10 Risk percentage and ranks of resource risk

Resource Risk	**Mean risk percentage**	**Rank**
Inadequate material stock at the site	37.78	2.16
Resource constraints (Non Availability)	41.32	2.67
Excess wastage of materials	28.67	2.75
Inadequate knowledge of materials	37.53	3.35
Machine break down	29.43	4.45
Equipment shortage	33.22	5.63

The ranks are the weights which suggest that inadequate material stock at the site is the most important resource risk. Equipment shortage is ranked as the least important resource risk. The highest risk percentage of 41.32 percent is given to Resource constraints (Non Availability) with a ranking of 2.67. Inadequate material stock at the site and inadequate knowledge of materials are the next important risks with risk percentage of 37.78 and 37.53subsequently.

Fig 5.10 shows the standard deviation of the responses for resource risk.

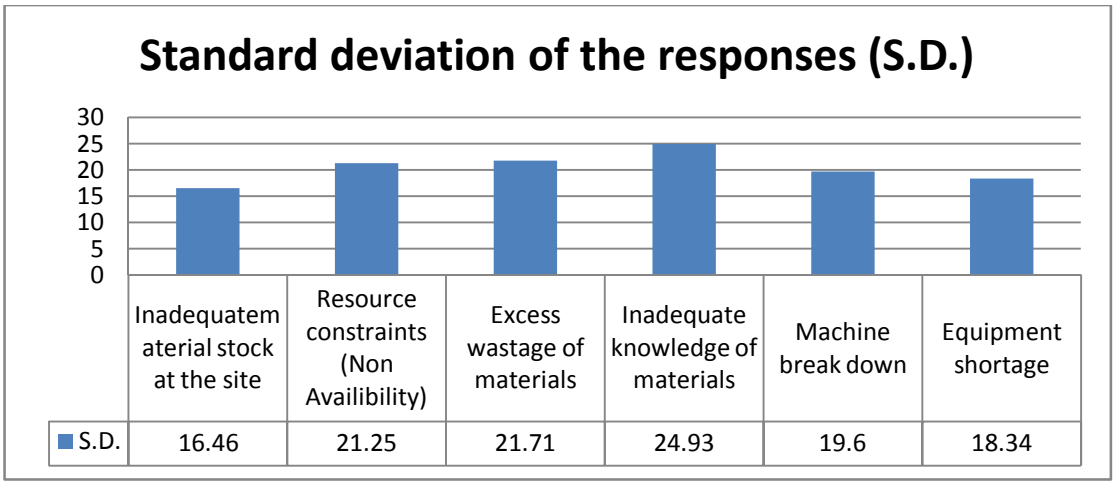

Fig. 5.10 Standard deviation for resource risk

5.1.11 Results of the survey for all types of risk groups

Table 5.11 shows the types of risks and its risk percentage and their ranks

Table 5.11 Types of risks and its risk percentage with ranks

Type of Risks	**Simple Mean risk percentage**	**Weighted Mean risk percentage**	**Rank**
Labour Risk	45.55	48.16	2.98
Financial Risks	38.63	43.42	3.43
Market Risk	39.05	42.44	4.69
Management Risk	37.65	40.14	4.86
Risk related to Quality& Safety	41.54	42.49	4.96
Planning& Selection Risk	43.77	44.79	5.75
Resource Risk	34.66	35.29	6.04
Technical& Environmental Risk	37.87	38.76	7.15
Policy and political Risks	35.33	37.29	7.51
Organisational Risk	37.74	37.62	7.67

From the table it is observed that labour risk is the most predominant risk with a weighted mean risk percentage of 48.16 and the highest rank of 2.98. The financial risk and market

risk are ranked after labour risk with a weighted mean risk percentage of 43.42 and 42.44 subsequently. The simple mean risk percentage is the average of the risk percentages under each group. The higher rank has a higher risk percentage. The ranks are the weights that are used to calculate the weighted risk from the risk percentages chosen by the respondents.

Fig 5.11 shows the standard deviation of the responses for all types of risks. It is evident that all the standard deviation is almost similar. In such a case it is best suited to use an average to estimate weighted data.

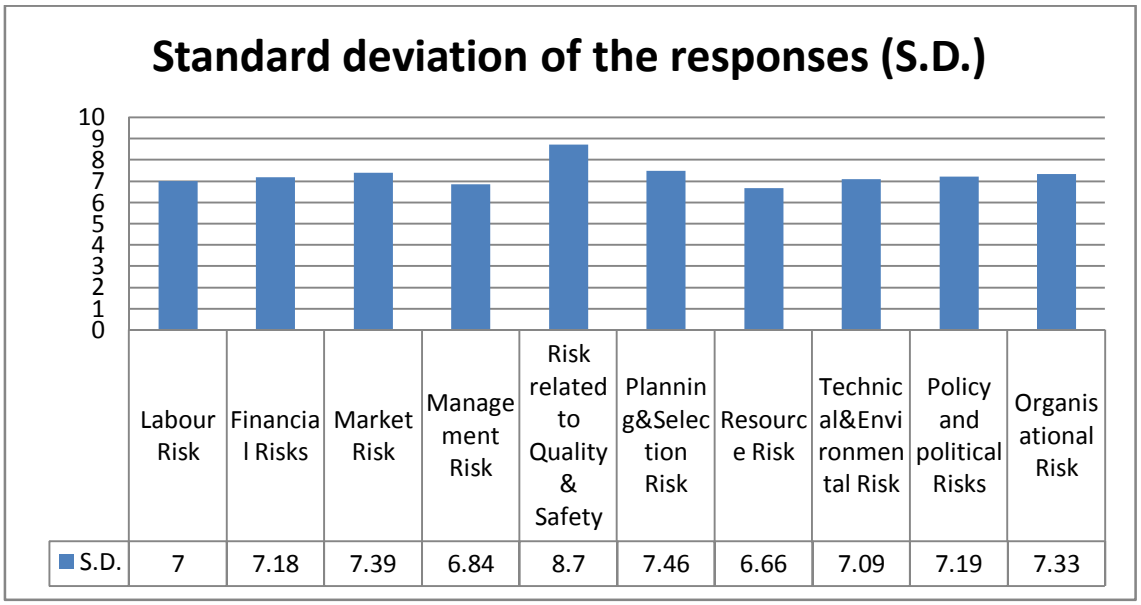

Fig 5.11 Standard deviation for different types of major risk

5.2 Results of case study–Application to Building

From the table 5.12 it is evident that the developer, contractor and investor have to make a choice for the best possible path to be followed by them. The schedule of work is followed month wise for all calculations. The present value that guides decision making for the case study of a residential construction is given in the table. The stake holders of the project generate a number of alternatives for different risk percentages. The profit margin can be altered easily by using these alternatives

The tabulated final results of the case study in Mangalore region as suggested by the risk mitigation method in this research work are given in table 5.12.

.

Table 5.12 Actual cost and risk cost for different risk percentages.

Types of Problems	Actual Expense (Rs.)	Risk Cost (Rs.) for different risk percentages				
		50%	75%	90%	95%	99%
Apartment Building 15,500 Square Feet Area (Present Value)						
Developer Problem	27176239	32311692	32783541	33360096	33767097	34636081
Contractor Problem	25395954	30112475	30568056	31124726	31517691	32356697

5.3 Results associated with recent developments in construction

5.3.1 Risks in green buildings

In Mangalore region when surveyed very few green buildings are found under construction. Only a couple of them are completed. By large due to non availability of ample samples only a qualitative approach towards risks in green buildings of Mangalore region is possible. The feedback through discussion is formulated and is helpful in understanding the status and the following risks of green buildings in Mangalore region.

- Mangalore not being a metropolitan, there is a dearth of knowledgeable green building technical specialists. The consultants in Mangalore who advices on green buildings are not able to meet the stipulations due to lack of experience in green buildings.
- Green materials like high performance glass, gypsum plaster, high quality country material brick and specification like automation technology are not easily available in Mangalore region. This drives the cost upwards due to procurement cost.
- The execution of green building requires skilled workers. In Mangalore region workers are experienced in executing by conventional methods. They do not adopt to newer methods due to decrease in daily work productivity. Gypsum plaster and self locking country blocks need high precision and skilled masons which are difficult to find.

- The saleable price of a green building is more due to the challenges in execution that a developer encounters. This is a deterrent to the buyer and developer to embrace green building in an unstable economic condition. The customer is price sensitive and wary of downward risks to real estate market. Hence is averse to risk.
- There are multiple rating agencies. Developers are pressurized to rate the building with these agencies. The rating is not feasible due to individualistic nature of Mangalore region. Rating is used as a marketing stratergy. Green buildings without rating are seldom encouraged even though they are innovative. No rating agency has a centre in this region. There is competition for superiority between agencies. Hence it is a deterrent to the developer to develop green buildings.
- Ignorance by the customers in understanding green buildings is a hindrance. People have little or no knowledge of the long term benefits of green buildings. They are ignorant about the features of green buildings. Builders use this loophole to market projects by giving non functional green products or very few green features to charge a premium over normal construction. The green building is used as a unique selling point and limited to lip service.
- The cost of certification is a deterrent for the developers to construct green buildings. The builders have to enroll and submit the building designs to conform to rating agencies. It requires dedicated technical professionals. This increases cost of final product. Certification is not feasible for smaller projects.
- Due to budget constraints the customers is not able to maintain buildings. The builders who have installed the green features are not in charge of them. This makes the green features non functional as there are no dedicated maintenance companies and cost of maintenance is high.
- The audit of green building on a longer run is not possible. There are not many green buildings in Mangalore. Long term results are very important for people to adapt to newer technologies like green buildings.

5.3.2 Risks in affordable housing

In the Mangalore region affordable housing is the latest buzzword. The newer developers are offering affordable housing. The older seasoned developers are tapping this new opportunity. The risks in affordable housing of Mangalore region are

- The main risk for affordable housing in Mangalore region is non availability of urban land. Prices of land have increased. Costly land makes affordable housing non viable.
- A lot of land is locked with government agencies like railways, government offices and others in the heart of the city.
- There is lot of political pressure for not undertaking slum development programs. Rehabilitation of slum dwellers at the construction time is a large problem in a dense city.
- The delay in obtaining clearances make a project non viable to the developer as the cost advantage of timely land development is lost.
- The clients of affordable housing in Mangalore do not have stable income. They do not get loans from banks. They have to depend on private institution, borrow from lenders and mortgage their valuables. This arises uncertainty for the developer due to discontinuity in timely payments.
- Developers have to use costly finance which increases their cost of developing affordable housing.
- There are a lot of regulatory taxes. These add upto 30% cost of the project. This drives up the cost of the project.
- Latest technology is not adopted by low cost housing developers in Mangalore. The construction progresses at a slow pace, driving up inflation related cost.
- Margins are lower in affordable housing. Mass construction in quick pace with maximum sale aids affordable housing. In a weak economic situation sales are low and hence discourage affordable housing.
- The new developers suffer losses due to lack of experience in handling big projects. Smaller affordable housing projects are not viable which deters the developers from undertaking future projects in Mangalore region.
- The newer technologies are not easily accepted by Mangalore region which poses as an important risk to affordable housing in Mangalore region.

5.3.3 Risks due to real estate bill

The real estate bill is still not into practice. In Mangalore region the bill will change the dynamics of business in the real estate market. There are lots of risks that arise due to the bill in Mangalore region.

- According to the bill pre booking of projects is not possible. Mangalore being a small market in real estate there are very few big companies in the real estate segment. Most builders work through joint ventures or accumulate land for project through pre booking. The builder pays a token advance to land owner, designs projects and takes pre booking to complete his commitment to land owner. The construction is also commenced by advance paid by the clients at the time of agreement signing. This arrangement does not work once the bill is enforced. The builders won't be able to sell projects until all licenses are procured. This effects Mangalore real estate market adversely.
- The bill concentrates on residential realty market. The commercial constructions gain momentum neglecting residential development. This drives up cost of residential real estate due to increase in demand.
- Around Mangalore region plantations and farms are developed as real estate. These are sold to high net worth clients. The bill does not include these developments. This leads to unfavourable development of realty market.
- The developers have additional financial burden which they pass on to customers. The extra cost includes registration costs, liaison fees and other license fees.
- The real estate market is specific to a region. The same is true for Mangalore. As the bill is another agency to obtain license and has no region specific rules to address the problem of this region its success is difficult to gauge.
- There may be a rush of developers from this region to sanction projects before the bill is enforced. This is a disadvantage to developers who launch their projects according to regulations of the bill. The cost of new projects in the region due to the bill is non viable.
- Mangalore real estate has lot of agents dependent on selling real estate. They have to obtain registration to conduct business as real estate agents. They are not impacted as certification is not mandatory. But nevertheless more knowledgeable agents are first movers to grab business.
- Agreements are not drawn as sample documents in the bill. The developers of the region may draw up agreements that negate the effect of the bill. The agreement may favour the promoter.
- There is no single window clearance. The developers of the region are burdened with multiple agencies for obtaining license. Now they have to obtain clearance from an

additional authority. This drives up liaison cost and cost due to delays in obtaining permission. This is a deterrent especially to affordable housing.

CHAPTER 6

CONCLUSIONS

The model suggested takes care of risk, risk cost, time elapse and inflationary cost increases of all the activities involved in the construction project. The model reveals the true cost of the stakeholders due to risk and facilitates better planning and costing.

The application of the model is worked meticulously for real life projects. The risks through questionnaire survey are applied to a project and give the true picture of cost breakup for different risk percentages. The charts drawn help in efficient project planning and management. This is helpful to project stakeholders in setting up the right price of project. Delays due to litigation are averted when there is transparency. The method is flexible and gives a chance for experimenting with different possibilities for a better result. It stresses the importance of employing project management experts in risk mitigation as inexperienced managers do not have the precision.

From the study the following conclusions are made

- There exists a considerable risk in construction industry of Mangalore region. In an attempt to mitigate these risks it is found that its relationship with cost gives a better understanding of risks.
- The total risk percentage in construction industry of Mangalore is 41.83%.
- The labour risk is the most predominant risk with risk percentage48.16%.
- Scarcity of sufficient number of skilled labours is the most important labour risk with the risk percentage of 55.50%. Labour disputes and strikes with a risk percentage of 35% is the least among labour risk. The risk due to poor workmanship, defective work inspection, holidays due to festival and sudden change of labour are ranked between the most important and least important labour risks respectively.
- The financial risk and market risk are ranked as second and third predominant risks with a risk percentage of 43.42% and 42.44% respectively.
- Escalation in materials and labour charges is the most important financial risk with the risk percentage of 46.39%. Fluctuation in interest rate with a risk percentage of 24.36% is the least among financial risk. The risk due to project funding, defective sequence of payment towards contractors and suppliers, changes in bank formalities and

regulations and client penalty are ranked between the most important and least important financial risks respectively.

- Rise in the labour and material cost is the most important market risk with the risk percentage of 51.20%. Marketing commission in the company with a risk percentage of 27.91% is the least among market risk. The risk due to sudden shortage of resources in the market, exceptional increase in tender prices and changes in the exchange rate due to economic instability are ranked between the most important and least important market risks respectively.
- The relationship and interdependence of risks is established from the survey. The risks that are dependent have similar risk percentages.
- Scarcity of sufficient number of skilled labours is the predominant labour risk with risk percentage of 55.50%. Due to scarcity of labours there is an escalation in their charges and their cost rises. From the survey it is evident escalation in materials and labours is the predominant financial risk with risk percentage 46.39% and rise in the labour and material cost is the predominant market risk with risk percentage 51.20%. All the three predominant risks are interdependent and ranked as the most important risks in their respective grouping having similar risk percentages.
- In the questionnaire the ranks are collected independent of the risk percentages. It is observed that higher the risk percentage more predominant is its rank. The labour risk is given a rank of 2.98 having a risk percentage of 48.16%. Financial risk is ranked 3.43 with a risk percentage of 43.42% and market risk is ranked 4.69 with a risk percentage of 42.44%. .
- The model is replicable to any region and project type.

Limitations of the study and scope for further research

- The study is limited to the private projects in Mangalore region.
- Expert opinion is collected from experienced engineers only among the stakeholders.
- Further study in the field of construction risks can be applied to technological advancements like green technologies, monolithic constructions and latest trends like affordable housing.
- The risks in construction due to the introduction of real estate regulatory bill in the near future that promises to change the market dynamics makes for an interesting study

APPENDIX I

QUESTIONNAIRE SURVEY
RISKS IN CONSTRUCTION INDUSTRY

Note : Please Tick the appropriate Box(Fill in personal information on the last page) ✓

RISKS	PERCENTAGE OCCURANCE				
Management risk	**15%**	**35%**	**55%**	**75%**	**95%**
Defective management decision?					
Change of management?					
Delay in decision making?					
Improper allocation of job?					
Short tendering time?					
Generalization changes in ownership?					
Policy and political risks	**15%**	**35%**	**55%**	**75%**	**95%**
Political changes?					
Changes in Government law?					
Legal issues related to project?					
Refusal of issue of project license ?					
Incomplete approval of documents?					
Inability to gain access for key personnel?					
Financial risks	**15%**	**35%**	**55%**	**75%**	**95%**
Project funding?					
Changes in the bank formalities and regulations?					
Escalation in materials and labour charges ?					
Defective sequence of payment towards Contractors and suppliers ?					
Fluctuation of interest rate?					
Client penalty?					

Planning&Selection Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Inadequate project planning?					
Inappropriate contractor selection process?					
Inadequate pricing ?					
Defective resource Selection (Labour, Material, Plant & Machineries)?					
Architectural modifications?					
Non estimated extra work?					
Risk related to Quality & Safety	**15%**	**35%**	**55%**	**75%**	**95%**
Defective materials?					
Insufficient Quality control?					
Changes in client requirement ?					
Unrealistic schedule?					
Snagging, Chipping, Touchup work?					
Negligence of safety (Accidents)?					
Organisational Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Change in quantities of work actually carried out at site?					
Changes made in project program?					
Insufficient Site access to engineers?					
Defective design?					
Improper Sequencing of activities?					
Defective work inspection?					
Labour Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Sudden change of labour?					
Labour disputes&labour strikes?					

Labour Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Scarcity of sufficient number of skilled labours?					
Due to poor workmanship?					
Defective work inspection?					
Holidays due to festivals?					
Market Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Changes in the exchange rate due to economic instability?					
Marketing commission in the company?					
Sudden shortage of resources in the market?					
Rise in the Labour and material cost?					
Exceptional increase in tender prices?					
Technical & Environmental Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Complicated site conditions?					
Delay in the design?					
Specification changes?					
Severe weather (rain, heat, snow etc)condition?					
Modification cost?					
Inappropriate Technology?					
Resource Risk	**15%**	**35%**	**55%**	**75%**	**95%**
Inadequate material stock at the site?					
Excess wastage of materials?					
Inadequate knowledge of materials?					
Resource constraints?					
Machine break down?					
Equipment shortage?					

Personal Information :-

Name :

Company Name :

Designation :

Place :

Date :

E- Mail ID :

Mobile No :

Signature

Acknowledgement

Thank you for the Positive Response It is Humbly appreciated

Rohan Maxwel Colaco (PhD Scholar, NITK Surathkal)

Guided by:-

Prof. Dr.M.K.Nagaraj,HOD Dept of Applied Mechanics & Hydraulics NITK Surathkal.

APPENDIX II

QUESTIONNAIRE SURVEY
RISKS IN CONSTRUCTION INDUSTRY

Note : Please Tick the appropriate Box(Fill in personal information on the last page) ✓

RANKS	RISKS	PERCENTAGE OCCURANCE				
Rank 1-6	**Management risk**	15%	35%	55%	75%	95%
	Defective management decision?					
	Change of management?					
	Delay in decision making?					
	Improper allocation of job?					
	Short tendering time?					
	Generalization changes in ownership?					
Rank 1-6	**Policy and political risks**	15%	35%	55%	75%	95%
	Political changes?					
	Changes in Government law?					
	Legal issues related to project?					
	Refusal of issue of project license ?					
	Incomplete approval of documents?					
	Inability to gain access for key personnel?					
Rank 1-6	**Financial risks**	15%	35%	55%	75%	95%
	Project funding?					
	Changes in the bank formalities and regulations?					
	Escalation in materials and labourcharges ?					
	Defective sequence of payment towards Contractors and suppliers ?					
	Fluctuation of interest rate?					
	Client penalty?					

Rank 1-6	**Planning&Selection Risk**	**15%**	**35%**	**55%**	**75%**	**95%**
	Inadequate project planning?					
	Inappropriate contractor selection process?					
	Inadequate pricing ?					
	Defective resource Selection (Labour,Material,Plant&Machineries)?					
	Architectural modifications?					
	Non estimated extra work?					
Rank 1-6	**Risk related to Quality&Safety**	**15%**	**35%**	**55%**	**75%**	**95%**
	Defective materials?					
	Insufficient Quality control?					
	Changes in client requirement ?					
	Unrealistic schedule?					
	Snagging,Chipping,Touchup work?					
	Negligence of safety (Accidents)?					
Rank 1-6	**Organisational Risk**	**15%**	**35%**	**55%**	**75%**	**95%**
	Change in quantities of work actually carried out at site?					
	Changes made in project program?					
	Insufficient Site access to engineers?					
	Defective design?					
	Improper Sequencing of activities?					
	Defective work inspection?					
Rank 1-6	**Labour Risk**	**15%**	**35%**	**55%**	**75%**	**95%**
	Sudden change of labour?					
	Labourdisputes&labour strikes?					

	Scarcity of sufficient number of skilled labours?					
	Due to poor workmanship?					
	Defective work inspection?					
	Holidays due to festivals?					
Rank 1-5	**<u>Market Risk</u>**	**15%**	**35%**	**55%**	**75%**	**95%**
	Changes in the exchange rate due to economic instability?					
	Marketing commission in the company?					
	Sudden shortage of resources in the market?					
	Rise in the Labour and material cost?					
	Exceptional increase in tender prices?					
Rank 1-6	**<u>Technical&Environmental Risk</u>**	**15%**	**35%**	**55%**	**75%**	**95%**
	Complicated site conditions?					
	Delay in the design?					
	Specification changes?					
	Severe weather (rain,heat, snow etc)condition?					
	Modification cost?					
	Inappropriate Technology?					
Rank 1-6	**<u>Resource Risk</u>**	**15%**	**35%**	**55%**	**75%**	**95%**
	Inadequatematerial stock at the site?					
	Excess wastage of materials?					
	Inadequate knowledge of materials?					
	Resource constraints?(Non Availibility)					
	Machine break down?					
	Equipment shortage?					

Rank 1-10	Type of Risks
	Management risk
	Policy and political risks
	Financial risks
	Planning&Selection Risk
	Risk related to Quality&Safety
	Organisational Risk
	Labour Risk
	Market Risk
	Technical&Environmental Risk
	Resource Risk

Personal Information :-

Name**:**

Company Name **:**

Designation **:**

Place **:**

Date **:**

E- Mail ID **:**

Mobile No **:**

Signature

Acknowledgement

Thank youfor the Positive Response It is Humbly appreciated

RohanMaxwelColaco(PhD Scholar, NITK Surathkal)

Guided by:-

Prof. Dr.M.K.Nagaraj,HODDept ofApplied Mechanics & Hydraulics NITK Surathkal.

APPENDIX III

QUESTIONNAIRE SURVEY
RISKS IN CONSTRUCTION INDUSTRY

Note : Please Tick the appropriate Box(Fill in personal information on the last page) ✓

RANKS	RISKS	PERCENTAGE OCCURANCE				
Rank 1-6	Management risk	15%	35%	55%	75%	95%
3.35	Defective management decision?	27	23	15	12	2
5	Change of management?	36	27	13	3	
2.52	Delay in decision making?	13	30	24	9	3
1.65	Improper allocation of job?	13	43	13	6	4
2.84	Short tendering time?	17	23	29	5	5
5.63	Generalization changes in ownership?	52	15	9	3	
Rank 1-6	Policy and political risks	15%	35%	55%	75%	95%
4.96	Political changes?	44	20	8	7	
1.24	Changes in Government law?	22	31	14	11	1
2.24	Legal issues related to project?	19	34	17	3	6
4.37	Refusal of issue of project license?	40	9	12	11	7
4.20	Incomplete approval of documents?	42	15	9	7	6
4	Inability to gain access for key personnel?	40	27	8	3	1
Rank 1-6	Financial risks	15%	35%	55%	75%	95%
2.45	Project funding?	7	22	10	28	12
3.82	Changes in the bank formalities and regulations?	45	14	16	4	
1.39	Escalation in materials and labour charges ?	13	28	21	14	3
2.76	Defective sequence of payment towards Contractors and suppliers?	7	34	20	13	5
5.39	Fluctuation of interest rate?	54	15	8	2	
5.18	Client penalty?	57	13	6	3	

Rank 1-6	Planning & Selection Risk	15%	35%	55%	75%	95%
1.22	Inadequate project planning?	13	31	13	15	7
2.88	Inappropriate contractor selection process?	9	34	19	9	8
3.43	Inadequate pricing?	19	12	34	11	3
4.63	Defective resource Selection (Labour, Material, Plant & Machineries)?	14	20	29	10	6
4.35	Architectural modifications?	42	16	13	7	1
4.49	Non estimated extra work?	19	37	14	4	5
Rank 1-6	Risk related to Quality & Safety	15%	35%	55%	75%	95%
4.71	Defective materials?	29	16	14	11	9
2	Insufficient Quality control?	10	31	13	12	13
3.37	Changes in client requirement?	20	36	14	7	2
4.82	Unrealistic schedule?	19	30	18	9	3
4.67	Snagging, Chipping, Touchup work?	37	21	15	4	2
1.45	Negligence of safety (Accidents)?	37	15	8	5	14
Rank 1-6	Organizational Risk	15%	35%	55%	75%	95%
2.18	Change in quantities of work actually carried out at site?	33	21	14	9	2
3.39	Changes made in project program?	40	13	19	5	2
4.84	Insufficient Site access to engineers?	33	20	12	12	2
4.49	Defective design?	35	15	10	14	5
3.27	Improper Sequencing of activities?	33	15	24	6	1
2.88	Defective work inspection?	19	33	11	8	8
Rank 1-6	Labour Risk	15%	35%	55%	75%	95%
4	Sudden change of labour?	13	42	15	2	7
5.20	Labour disputes & labour strikes?	31	27	14	4	3

1.84	Scarcity of sufficient number of skilled labours?	2	29	19	23	6
2.02	Due to poor workmanship?	5	21	28	15	10
3.94	Defective work inspection?	16	29	11	16	7
4	Holidays due to festivals?	24	29	19	5	2
Rank 1-5	Market Risk	15%	35%	55%	75%	95%
4.16	Changes in the exchange rate due to economic instability?	43	17	10	9	
4.22	Marketing commission in the company?	45	21	9	4	
2.24	Sudden shortage of resources in the market?	12	35	20	9	3
1.14	Rise in the Labour and material cost?	7	31	19	14	8
3.18	Exceptional increase in tender prices?	18	35	14	8	4
Rank 1-6	Technical & Environmental Risk	15%	35%	55%	75%	95%
1.96	Complicated site conditions?	14	34	13	15	3
2.71	Delay in the design?	34	15	15	15	
3.63	Specification changes?	40	18	11	10	
2.41	Severe weather (rain, heat, snow etc)condition?	17	39	13	6	4
4.65	Modification cost?	23	35	15	5	1
5.67	Inappropriate Technology?	33	25	11	5	5
Rank 1-6	Resource Risk	15%	35%	55%	75%	95%
2.16	Inadequate material stock at the site?	15	45	12	7	
2.75	Excess wastage of materials?	49	17	5	5	3
3.35	Inadequate knowledge of materials?	34	20	10	11	4
2.67	Resource constraints?(Non Availability)	17	37	10	13	2
4.45	Machine break down?	43	22	9	3	2
5.63	Equipment shortage?	27	39	9	1	3

Rank 1-10	Type of Risks
4.86	Management risk
7.51	Policy and political risks
3.43	Financial risks
5.75	Planning & Selection Risk
4.96	Risk related to Quality & Safety
7.67	Organizational Risk
2.98	Labour Risk
4.69	Market Risk
7.15	Technical & Environmental Risk
6.04	Resource Risk

REFERENCES

Abdullah et.al (2010). "Potential effects on large mara construction projects due to construction delay." *Int. J. Integrated Eng.*, 1, 53-62.

Ahmet Oztas and Onder Okmen (2005)."Judgmental risk analysis process development in construction projects." *Building and Environment*, 40(1), 1244-1254.

Akintola S Akintoye and Malcolm J MacLeod (1997). "Risk analysis and management in construction." *International Journal of Project Management*, 15(1), 31-38.

Alberto Jamaluddin De Marco and Muhammad Thaheem (2014). "Risk Analysis in Construction Projects: APractical Selection Methodology." *American Journal of Applied Sciences*, 11 (1), 74-84.

Alexander Laufer and Dora Cohenca (1990). "Factors affecting construction planning outcomes." *Journal of Construction Engineering and Management*, 116(1), 135-156.

Alfred E. Thal Jr. et.al (2010). "Estimation of Cost Contingency for Air Force Construction Projects." *Journal of Construction Engineering and Management*, 136(11), 1181-1188.

Alfredo del Can and M. Pilar de la Cruz (2002). "Integrated Methodology for Project Risk Management." *Journal of Construction Engineering and Management*, ASCE. 473-485.

Alfredo Federico Serpella (2014). "Risk management in construction projects: a knowledge-based approach." *Procedia - Social and Behavioral Sciences*, 119, 653 – 662

Alin Veronika et.al (2006). "Corrective Action Recommendation for Project Cost Variance in Construction Material Management." *The Tenth East Asia-Pacific Conference on Structural Engineering and Construction, Bangkok, Thailand.*

Amani Suliman BU-Qammaz (2007). "Risk Assessment of International Construction Projects Using the Analytic Network Process."1-188.

Amir Reza Karimi Azari et.al (2011). "Risk assessment model selection in construction industry." *Expert Systems with Applications*, 38(1), 9105-9111.

Amiruddin Ismail et.al (2009). "Literature Review in Resource-Constrain Critical Path Method Techniques." *European Journal of Scientific Research*, 29(2), 222-236.

Anna Klemetti (2006). “Risk Management in Construction Project Networks.” *Laboratory of Industrial Management*, 1-115.

Arazi Idrus et.al (2011). “Development of project cost contingency estimation model using risk analysis and fuzzy expert system.” *Expert Systems with Applications*, 38, 1501-1508.

Artem Aleshin (2001). “Risk management of international projects in Russia." *International Journal of Project Management*. 1(19), 207-222.

Artto K and Kahkonen K (2000). “Management of Uncertainty.” *Project Management Association,* Finland, Helsinki, 147.

Ashley D and Bonner J. (1987). “Political Risks in International Construction,” *Journal of Construction Engineering and Management*, 113(3), 447-467.

Axelsson B (1994). “Corporate strategy models and networks – diverging perspectives.” *Industrial Networks: A new View of Reality*, Axelsson B and Easton G (eds), Rout ledge, London. 265.

Baccarini D and Archer R (2001). “The risk ranking of projects: a methodology.” *International Journal of Project Management*, 19, 139-145.

Baloi D and Price A.D.F. (2003). “Modeling global risk factors affecting construction cost performance.” *International Journal of Project Management*. 21, 261-269.

Bayu Aditya Firmansyah et.al (2006). “Risk Analysis in Feasibility Study of Building Construction Project: Case Study - PT. Perusahaan Gas Negara Indonesia.” 145-150.

Beach R et.al (2005). “An evaluation of partnership development in the construction industry.” *International Journal of Project Management*, 23(8), 611.

Bert Bielefeld (2008). “Basics Construction Scheduling.” *Birkhauser Architecture; 1st edition*.

Bon-Gang Hwang et.al (2014). “Risk management in small construction projects in Singapore: Status, barriers and impact.” *International Journal of Project Management*, 32, 116-124.

C. G. Hoskins (2006). "Benefit-Cost Ratios Versus Net Present Value: Revisited." *Journal of Business Finance & Accounting*, 1(2), 249–264.

C. William Ibbs and Young Hoon Kwak (2000). "Assessing Project Management Maturity." *Project Management Institute*, 31(1), 32–43.

Chapman C (1997). "Project risk analysis and management- PRAM the generic process." *International Journal of Project Management*, 15(5), 273-281.

Chiang Y et.al (2010). "Employing the Net Present Value-Consistent IRR Methods for EPFI Contracts." *Journal of Construction Engineering and Management*, 136(7), 811-814.

Chidambaram Ramanathan et.al (2012). "Construction Delays Causing Risks on Time and Cost –a Critical Review." *Australasian Journal of Construction Economics and Building*, 12(1), 37-57.

Chien-Ho Ko and Min-Yuan Cheng (2003). "Hybrid use of AI techniques in developing construction management tools." *Automation in Construction*, 12, 271-281.

Chitkara K.K. (1998). "Construction project management – planning, scheduling and controlling." *Tata McGraw-Hill Publishing Company Limited*, New Delhi

Choudhry R. and Iqbal K. (2013). "Identification of Risk Management System in Construction Industry in Pakistan." *Journal Management Engineering*, 29(1), 42-49.

Christian Gollier (2010). "Expected net present value, expected net future value, and the Ramsey rule." *Journal of Environmental Economics and Management*, 59(2), 142-148.

Daniel Castro-Lacouture et.al (2009). "Construction Project Scheduling with Time, Cost and Material Restrictions Using Fuzzy Mathematical Models and Critical Path Method." *Journal of Construction Engineering and Management*, 135(10), 1096-1104.

Darrin and Mervyn K Lewis (2002). "Evaluating the risks of public private partnerships for infrastructure projects." *International Journal of Project Management*, 107-118.

Daud Nasir et.al (2003). "Evaluating Risk in Construction–Schedule Model (ERIC–S) Construction Schedule Risk Model." *Journal of Construction Engineering and Management*, ASCE. 129(5), 518-527.

Dezhi Jin et.al (2010). “Construction Project Schedule Risk Analysis and Assessment Using Monte Carlo Simulation Method.” *IEEE*, 597-601.

Diane Kelly et.al (2008). “Questionnaire mode effects in interactive information retrieval experiments.” *Information Processing and Management*, 44, 122-141.

Dikmen et.al (2008). “Learning from risks: A tool for post-project risk assessment.” *Automation in Construction*, 18(1), 42-50.

Edem O. P. Akpan et.al (2008). “Integrated Time and Cost Management System for Project Monitoring, Evaluation and Control.” *First International Conference on Construction in Developing Countries*, 11-21.

Ekaterina Osipova (2008). “Risk management in construction projects: a comparative study of the different procurement options in Sweden.” *Lulea University of Technology*, 1-43.

El-Diraby.T. A and Gill S. M. (March 2006). "A taxonomy for construction terms in privatized infrastructure finance: supporting semantic exchange of project risk information." *Construction Management and Economics*, 271–285.

Ewelina Gajewska and Mikaela Ropel (2011). “Risk Management Practices in a Construction Project – a case study.” *Chalmers University of Technology,* 11-56.

Florence Yean Yng Ling and Linda Hoi (2006). “Risks faced by Singapore firms when undertaking construction projects in India.” *International Journal of Project Management*, 24(3), 261–270

Fortunato B. et.al (2012). “Identification of Safety Risks for High-Performance Sustainable Construction Projects.” *J. Constr. Eng. Manage*., 138(4), 499–508.

Francis K. Adams (2008). “Construction Contract Risk Management: A Study of Practices in the United Kingdom.” *Cost Engineering*, 50(1), 22-33.

G. Emre Gurcanli and Ugur Mungen (2009). “An occupational safety risk analysis method at construction sites using fuzzy sets.” *International Journal of Industrial Ergonomics*, 39, 371-387.

Gabriel A Barraza (2007). “Cost Contingency Management.” Journal of Management and Engineering, 23(3), 140-146.

Garg.A.K.(2005). “Risk management in construction contacts.” *Construction Materials Purchase*, 14-16.

Gary Mitchell (2010) “On Calculating Activity Slack in Stochastic Project Networks.” *American Journal of Economics and Business Administration*, 2(1), 78-85.

Goh Cheng Siew and Hamzah Abdul-Rahman (2013). “The Identification and Management of Major Risks in the Malaysian Construction Industry.” *Journal of Construction in Developing Countries*.

Harisaweni (2007). “The Framework for Minimizing Construction
Time and Cost overruns in Padang and Pekanbaru, Indonesia.” *Universiti Teknologi Malaysia*, 1-189.

Hashemi H et.al (2011). “Bootstrap Technique for Risk Analysis with Interval Numbers in Bridge Construction Projects.” *Journal of Construction Engineering and Management*, 137(8), 600-608.

Hastak and Shaked (2000). "ICRAM-1: Model for international construction risk assessment." *Journal of Management in Engineering,* ASCE. 16(1), 59-69

Himadri Guha and Partha Pratim Biswas (2008). “Monsoon Risks for Construction Sites in India.” *IEEE*, 1724-1727.

Hisham Said S. and Khaled El-Rayes (2011). “Optimizing Material Procurement and Storage on Construction Sites.” *Journal of Construction Engineering and Management*, 137(6), 421-431.

Hong Xian Li et.al (2013). “Risk identification and assessment of modular construction utilizing fuzzy analytic hierarchy process (AHP) and simulation.” *Canadian Journal of Civil Engineering*, 40(12), 1184-1195.

HUANG Jian-Wen and WANG Xing-Xia (2009). “Risk Analysis of Construction Schedule Based on PERT and MC Simulation.” *International Conference on Information Management, Innovation Management and Industrial Engineering*, 150-153.

Hyun-Ho Choi et.al (April 2004). "Risk Assessment Methodology for Underground Construction Projects." *Journal of Construction Engineering and Management*, (12), 258-272.

Ivan W.H. Fung et.al (2012). "Development of a qualitative & quantitative risk evaluation model (Q2REM) for different trades of construction works in Hong Kong." *Accident Analysis and Prevention*, 48, 167-184.

Ivana Burcar Dunovic et.al (2013). "Risk register developement and implementation for construction projects." *Gradevinar*, 1, 23-35.

Jaafari A. (2001). "Management of risks, uncertainties and opportunities on projects: time for a fundamental shift." *International Journal of Project Management*, (19), 89-101.

Jamal F. Al-Bahar and Keith C. Crandall (2007). "Systematic Risk Management Approach for Construction Projects." *J. Constr. Eng. Manage*, 116(3), 533–546.

Jaser Hmaid and Abu Mousa (2005). "Risk Management in Construction Projects from Contractors and Owners perspectives." 1-125.

Jay S. Newitt (2008). "Construction Scheduling: Principles and Practices." *Prentice Hall; 2 edition*.

Jeong Wook Son and Eddy M. Rojas (2011). "Impact of Optimism Bias Regarding Organizational Dynamics on Project Planning and Control." *Journal of Construction Engineering and Management*, 137, 147-157.

Joe Wong and Eddie C. M. Hui (April 2006). "Construction project risks: further considerations for constructors pricing in Hong Kong." *Construction Management and Economic*. 13, 425-438.

John G. Zhao (2007). "Significance of Risk Quantification." *Palisade RISK Conference*, 1-11.

John Walewski and Edward Gibson.G, Jr (2003). "International Project Risk Assessment." *A Report of the Centre Construction Industry Studies, University of Texas*, Austin. 11-15.

Jolanta Tamosaitiene et.al (2013). "Multi-criteria risk assessment of a construction project." *Procedia Computer Science*, 17, 129-133.

Khalid Johara et.al (2010). "A Study of Correlation Aspects in Probabilistic NPV Analysis." The Engineering Economist: *A Journal Devoted to the Problems of Capital Investment*, 55(2), 181-199.

Kyoo-Jin Yi and David Langford (2006). "Scheduling Based Risk Estimation and safety planning for construction projects." *Journal of Construction Engineering and Management*, 132(6), 626-635.

Le Roy F. Simmons (2002). "PROJECT MANAGEMENT – Critical Path Method (cpm) and Pert Simulated with Process Model." *Winter Simulation Conference*, 1786-1788.

Lee Chun Siang and Azlan Shah Ali (2012). "Implementation of Risk Management in the Malaysian Construction Industry." *Journal of Surveying, Construction & Property*, 3(1), 1-15.

Li Bing et.al (1999). "Risk Management Model for International Construction Joint Ventures." *Journal of Construction Engineering and Management*, ASCE. 125(5), 377-384.

Liisa Lehtiranta (2011). "Relational Risk Management in Construction Projects: Modeling the Complexity." *Leadership and Management in Engineering*, 141-154.

Liisa Lehtiranta (2014). "Collaborative risk management in complex construction projects." *Aalto University School of Engineering, Helsinki*.

Lisa R. Goldberg et.al (2005). "statistics for weighted means in credit risk modeling." *The Journal of Risk Finance*, The Emerald Group Publishing Limited, 6(4), 349-365.

Luka G (2008). "Productivity Scheduling method Compared to Linear and Respective Project Scheduling Methods." *Journal of Construction Engineering and Management*, 134(9), 711-720.

Luka Goji Tipili and Muhammad Sa'adiya Ilyasu (2014). "Evaluating the impact of risk factors on construction projects cost in Nigeria." *The International Journal of Engineering and Science*, 3(6), 10-15.

Luis F. Alarcon et.al (2011). "Risk Planning and Management for the Panama Canal Expansion Program." *Journal of Construction Engineering and Management*, 137, 762-771.

M. J. Kolhatkar and Amit Bijon Dutta (2013). "Study of Risk in Construction Projects." *International Global Research Analysis*, 2(9), 104-107.

M. Angeline Swarna and R. Venkatakrishnaiah (2014). "Fault Tree Analysis in Construction Industry for Risk Management." *International Journal of Advanced Research in Civil, Structural, Environmental and Infrastructure Engineering and Developing*, 2(1), 15-21.

Mariana gerber and rossouw von solms (2005). "Management of risk in the information age." *journal of computers and security*, (24), 16-30.

Marques R. and Berg S. (2011). "Risks, Contracts, and Private-Sector Participation in Infrastructure." *J. Constr. Eng. Manage.*,137(11), 925–932.

Martin Schieg (2006). "Risk management in construction project Management." *Journal of Business Economics and Management*, 7(2), 77-83.

Mehdizadeh Rasool (2012). "Dynamic risk management of construction projects using tailor-made risk breakdown structures." *Prix Jeunes Chercheurs, Rene Houpert, Chambery*, 2-8.

Michael A. Law (2004). "Using net present value as a decision-making tool." *Air Medical Journal*, 23(6), 28-33.

Miller R and Lessard D. (2001). "Understanding and managing risks in large engineering projects." *International Journal of Project Management*, 19, 437-443.

Mills A. (2001). "A systematic approach to risk management for construction." *Structural Survey*, 19(5), 245-252.

Ming Lu and Heng Li (2003). "Resource-Activity Critical-Path Method for Construction Planning." *Journal of Construction Engineering and Management*, 129(4), 412-420.

Ming Teh Wang and Hui-Yu Chou (2003). "Risk Allocation and Risk Handling of Highway Projects in Taiwan." *Journal of management in engineering*, ASCE. (19), 60-68.

Motiarrahman M and Mohan. M. Kumaraswamy(2002). "Joint risk management through transactionally efficient relational contracting", *Construction Management and Economics*. 45–54.

Mulholland.B and Christian.J (1999). "Risk assessment in construction schedules." *Journal of Construction Engineering and Management*. 125(1), 8-15.

N.B. Kasim et.al (2005). "Improving Materials Management Practices on Fast-Track Construction Projects." *Association of Researchers in Construction Management*, l2, 793-802.

Nabil A.Kartam and Saied A. Kartam (2001). "Risk and its management in the Kuwaiti construction industry a contractor's perspective." *International journal of project management*. (19), 325-335.

Naoum S. (2003). "An overview into the concept of partnering." *International Journal of Project Management*, 21(1), 71-76.

Nassimbeni G. (1998). "Network structures and co-ordination mechanisms, A taxonomy." *International Journal of Operations & Production Management*, 18(6), 538-554.

Nicholas Chileshe and Geraldine John Kikwasi (2013). "Perception of Barriers to Implementing Risk Assessment and Management Practices by Construction Professionals in Tanzania." *Procs 29Th Annual ARCOM Conference*, 1137-1146.

Nigel J. Smith et.al (2006). "Managing Risk in Construction Projects." *Blackwell Publishing, 2nd Edition*, 1-256.

O.A. Adedokun et.al (2013) "Evaluation of quantitative risk analysis techniques in selected large construction companies in Nigeria." *Journal of Facilities Management*, 11(4), 354-368.

O.N.Aneziris et.al (2012). "Occupational risk of building construction." *Reliability Engineering and System Safety*, 105, 36-46.

O. O. Odimabo and C. F. Oduoza (2013). "Risk Assessment Framework for Building Construction Projects in Developing Countries." *International Journal of Construction Engineering and Management*, 2(5), 143-154.

Onder Okamen and Ahmet Oztas (2008). "Construction Project Network Evaluation with Correlated Schedule Risk Analysis Model." *Journal of Construction Engineering and Management*, 134(1), 49-63.

Odeh A.M and Battaineh H.T. (2002). "Causes of construction delay: traditional contracts". *International Journal of Project Management*, 20(1), 67-73.

Ofer Zwikael and Arik Sadeh (2007). "planning effort as an effective risk management tool." *Journal of operation management*. (25), 755-767.

Osama Ahmed Jannadi and Salman Almishari (2003). "Risk Assessment in Construction." *Journal of Construction Engineering and Management*, ASCE. 129(5), 492-500.

P. Jaskowski and S. Biruk (2011). "The Conceptual Framework for Construction Project Risk Assessment." *Framework for Construction Project Risk Assessment*, 2, 27-35.

P.K. Marhavilas et.al (2013). "Harmonic analysis of occupational-accident time-series as a part of the quantified risk evaluation in worksites: Application on electric power industry and construction sector." *Reliability Engineering and System Safety*, 112, 8-25.

Palaneeswaran E et.al (2003). "Curing congenital construction industry disorders through relationally integrated supply chains." *Building and Environment*, 38, 571-582.

Pankaj Vijay Naphade and Pankaj P. Bhangale (2013). "To Study on the Risk Management, Risk Treatment Strategies and Insurance in Construction Industries." *International Journal of Innovative Technology and Exploring Engineering*, 3(4), 68-74.

Patel Ankit Mahendra et.al (2013). "A Study of Risk Management Techniques for Construction Projects in Developing Countries." *International Journal of Innovative Technology and Exploring Engineering*, 3(5), 139-142.

Patrick. X.W. Zou et.al (2013). "Identifying Key Risks in Construction Projects: Life Cycle and Stakeholder Perspectives." 1-14.

Phua F.T.T and Rowlinson S (2004). "How important is cooperation to construction project success?." *A grounded empirical quantification*, 11(1), 45-54.

Piotr Jaśkowski and Anna Sobotka (2006). "Scheduling Construction Projects Using Evolutionary Algorithm." *Journal of Construction Engineering and Management*, 132(8), 861-870.

Prasanta kumardey (2000). "Managing projects in fast track -A case of public sector organization in India." *International journal of public sector management*. 13(9), 588-609.

Prashant Kapila and Chris Hendrickson 2001). "Exchange rate risk management in international construction ventures." *Journal of Management in Engineering*, ASCE. 17(4), 186-191.

Praveen Sukumaran et.al (2006). "Model for Analysis of Factors Affecting Construction Schedule in Highway Work Zones." *Journal of Transportation Engineering*, 132(6), 508-517.

Project Management Institute (2000). "*PMBOK:* A Guide to the Project Management Book of Knowledge." *Project Management Institute.*

Pryke S.D. (2004). "Analyzing construction project coalitions: exploring the application of social network analysis." *Construction Management and Economics*, 22, 787-797.

Qing-Fu Li et.al (2013). "Risk Identification for the Construction Phases of the Large Bridge Based on WBS-RBS." *Research Journal of Applied Sciences, Engineering and Technology*, 6(9), 1523-1530.

R. C. Walke (2011). "An Approach to risk quantification in construction projects using EMV analysis." *International Journal of Engineering Science and Technology*, 3(9), 6847-6855.

R. K. Kansal and Manoj Sharma (2012). "Risk Assessment Methods and Application in the Construction Projects." *International Journal of Modern Engineering Research (IJMER)*, 2(3), 1081-1085

Rahman et.al (2004). “Potential for Implementing Relational Contracting and Joint Risk Management.” *Journal of Management in Engineering*, 20(4), 178-189.

Risk Management (2008). “All stakeholders must do their part.” *Journal of loss prevention in the process industries*. (21).

Rita L. Sousa and Herbert H. Einstein (2012). “Risk analysis during tunnel construction using Bayesian Networks: Porto Metro case study.” *Tunnelling and Underground Space Technology*, 27, 86-100.

Roozbehkangari (1995). “Risk management perceptions and trends of U.S construction.” *Journal of Construction Engineering and Management*, 121(4), 422-429.

Rowley T.J. (1997). “Moving beyond dyadic ties: a network theory of stakeholder influences.” The Academy of Management Review, 22(4), 887-910

Royer P.S. (2000). “Risk Management: The Undiscovered Dimension of Project Management.” *Project Management Journal*, 31(1), 6-13.

Saari H-L (2004). “Risk management in Drug Development Projects.” *Helsinki university of Technology*, *Laboratory of Industrial Management*, Espoo, 153.

Saleh A. Mubarak (2010). “Construction Project Scheduling and Control.” *Construction Project Scheduling and Control, 2nd Edition*.

Salminen J. (2005). “Measuring Performance and Determining Success Factors of Construction Sites.” *Helsinki University of Technology*, Espoo, 175.

Satyendra Kumar Sharma (2014). “Risk Management in Construction Projects Using Combined Analytic Hierarchy Process and Risk Map Framework.” *The IUP Journal of Operations Management*, 12(4), 23-53.

Seung H. Han et.al (2004). "Multi criteria Financial Portfolio Risk Management for International Projects." *Journal of Construction Engineering and Management*, ASCE. 346-356.

Seyed Hossein Hashemi Doulabi et.al (2011). “Efficient Hybrid Genetic Algorithm for Resource Leveling via Activity Splitting.” *Journal of Construction Engineering and Management,* 137(2), 137-146.

Shen L Y(1997). “Project risk management in Hong Kong.” *International Journal of Project Management* 15(2), 101-105.

Shen L Y et.al (2001). “Risk Assessment for Construction joint ventures in China.” *Journal of Construction Engineering and Management*, ASCE. 127(1), 76-81.

Shou Qing Wang et.al (2004). "Risk management framework for construction projects in developing countries." *Construction Management and Economics*. (22), 237–252.

Simaan Abou Rizk (2010). “Role of Simulation in Construction Engineering and Management.” *Journal of Construction Engineering and Management*, 136(10), 1140-1153.

Smith Ring P and Van de Ven A.H. (1994). “Developmental processes of cooperative inter organizational relationships.” *The Academy of Management Review*, 19(1), 90-117.

Tarek Hegazy and Wail Menesi (2010). “Critical Path Segments Scheduling Technique.” *Journal of Construction Engineering and Management*, 136(10), 1078-1085.

Taroun A Yang J.B. and Lowe D. (2011). “Construction Risk Modeling and Assessment: Insights from a Literature Review.” *The Built & Human Environment Review*, 4(1), 87-97.

Terry Lyons and Martin Skitmore (2004). "Project risk management in the Queensland engineering construction industry: a survey." *International Journal of Project Management*, 22(36), 51–61.

Thomas A. Carbone and Donald D. Tippett (2004). “Project Risk Management Using the Project Risk FMEA.” *Engineering Management Journal*, 16(4), 28-35.

Thomas.A.V. et.al (2003). “Risk perception analysis in India.” *Construction Management and Economics*. (21), 393–407

Thompson Jr. R. and Lucko G. (2012). "Modeling Measures of Float Monetization for Quantitative Risk Management of Construction Projects." *Construction Research Congress 2012*, 485-494.

Tyrone T. Liny (2013). "Applying the maximum net present value rule in valuing real options." *Journal of Interdisciplinary Mathematics*, 7(3), 279-295.

Uher T.E. and Toakley A.R. (1999). "Risk management in the conceptual phase of a project." *International Journal of Project Management*, 17(3), 161-169.

Uzzi B. (1997). "Social Structure and Competition in Inter firm Networks: The Paradox of Embeddedness." *Administrative Science Quarterly*, 42(1), 35-67.

Wayne A. Haga and Tim O'keefe (2001). "Crashing Pert Networks: A Simulation Approach." *4th International conference of the Academy of Business and Administrative Sciences Conference*, 1-15.

Wenzhe Tang et.al (2007). "Risk management in the Chinese construction industry." *Journal of construction engineering and management ASCE*.

Wong J.T.Y. and Hui E.C.M (2006). "Construction project risks: further considerations for constructor-s pricing in Hong Kong." *Construction Management and Economics*, 24, 425-438.

Xiang. P. et.al (2012). "Construction Project Risk Management Based on the View of Asymmetric Information." *J. Constr. Eng. Manage.*, 138(11), 1303–1311.

Young Hoon Kwak and Lisa Ingall (2007). "Exploring Monte Carlo Simulation Applications for Project Management." *Palgrave Macmillan Ltd*, 9, 44-57.

Zaghloul R and Hartman F. (2003). "Construction contracts: the cost of mistrust." *International Journal of Project Management*, 21(6), 419-424.

Zeynalian et.al (2013). "Modification of advanced programmatic risk analysis and management model for the whole project life cycle's risks." *Journal of Construction Engineering and Management*, 139(1), 51-59.

PUBLICATION BASED ON PRESENT RESEARCH WORK

Rohan Maxwel Colaco, M.K. Nagaraj, T.P.M. Pakkala, (2013). "Risks in Construction Industry of Mangalore." *Journal of Construction Engineering, Technology and Management, 3(2), 11-20.*

CURRICULUM VITAE

Rohan Maxwel Colaco was born on 5th May 1980 in Mangalore City, Karnataka State, India. After completing Pre Degree Course at St. Aloysius College in Mangalore, he joined Manipal Institute of Technology, Manipal for first year Civil Engineering in 1998.

Obtained B.E. (Civil) degree from Manipal Academy of Higher Education (Deemed University).

Obtained M. Tech. (Construction Engineering and Management) degree in 2004 from Manipal Academy of Higher Education (Deemed University) securing First Class with Distinction and was recognized with Gold Medal for outstanding academic performance.

Later he joined Bearys group Bangalore as Project Planner and Dharmaraj Associates as Project Coordinator.

In 2006 he started his own Project management consulting firm and has continued in the same stream of work to date.

In 2010, he started his Ph.D. research at National Institute of Technology, Surathkal.

He is a Member of Association of Consulting Civil Engineers (INDIA), Mangalore Chapter and Kanara Chamber of Commerce and Industry, Mangalore.

Contact Address: 101/102, Royal Residency
Vaslane, Balmatta
Mangalore-2

Contact Number: 0824-2438084
09448123047
07204655347
E-mail: colaco.rohan@gmail.com