

Risk Management for a Construction Project – A Case Study

Sharath Babu Khedagi¹ Aravind Sagar B.² Sowmyashree T.³

^{1,2,3}Assistant Professor

¹VVIT, Bangalore, India ²RASTA – VTU Extension Centre, Bangalore, India ³JAIN Institute of Technology, Davangere, India

Abstract— All categories of any organizations may face few internal and external factors that may make it uncertain to achieve their objectives or goals. This uncertainty is called Risk. A guide to the project management body of knowledge (PMBOK guide) defines project risk management as “The process of conducting risk management planning, identification, analysis, response planning, and monitoring and control on a project”. The main objective of this study is to illustrate application of risk management process in construction project. To achieve this, a case study is chosen in Bangalore which is a residential villa project. A review of literature and experts advice gave opportunity to prepare a risk breakdown structure which has 9 risk categories that result from 39 risk factors which are generally faced in construction projects. Further questionnaire survey played important role in identifying and analysing the risks faced in the case study. And the results of case study conclude with list of risk factors which were majorly affecting the project and their analysis. And a proper recommendation is suggested for the research work carried out.

Key words: Risk Management, Construction

I. INTRODUCTION

Risk management is defined as "Systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing risk".

A typical risk management has the following key steps:

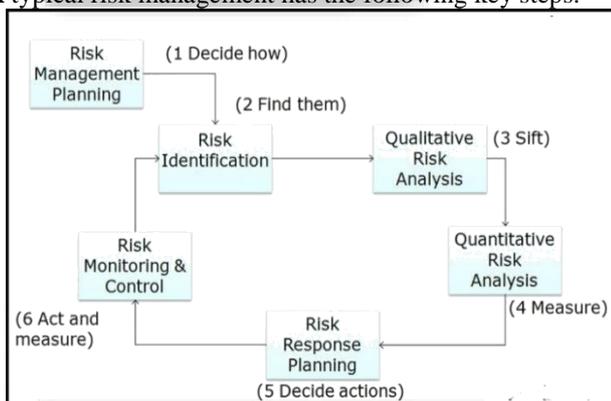


Fig. 1. Risk Management Process

- 1) Risk Management Planning
- 2) Risk Identification
- 3) Risk Analysis – Qualitative and Quantitative Analysis
- 4) Risk Response
- 5) Risk Monitoring and Control

A. Risk Management Planning

This planning describes how an organization conducts risk management activities for a project. Planning meetings and analysis are the techniques which help to prepare a risk management plan. Project scope statement, cost management

plan, schedule management plan etc. may be considered as inputs to prepare risk management plan

B. Risk Identification

The main objective of Risk identification is that, it gives an opportunity to identify potential risks. Hence this is the crucial step in risk management process. Several tools and techniques are there for risk identification. But the project team should use the one that they are familiar with and effective.

The following are the various techniques through which risk identification can be done.

- 1) Documentation Review
- 2) Information Gathering Techniques
 - Brainstorming
 - Delphi Technique
 - Interview
 - Expert Judgement
 - SWOT Analysis
 - Root Cause Analysis
 - Questionnaire Survey
- 3) Checklists
- 4) Diagramming Techniques

C. Risk Analysis or Assessment

Once the risks have been identified or documented, the further question is on how to analyze them. The inputs for this risk assessment process will be risk register and risk management plan.

There two types of risk analysis are as follows:

- 1) Qualitative Risk Analysis
- 2) Quantitative Risk Analysis

Qualitative analysis is done to rate the potential risk on scale of low to high. As the name says the quality or nature of the risks is mentioned here i.e. low risk, moderate risk or high risk.

When it comes to quantitative analysis the value of a risk in terms of impact on project objectives is determined (impact in terms of cost or delay).

Example – A risk ‘x’ causes Rs.y impact on cost and z hour impact on time.

1) Qualitative Risk Analysis

The likelihood of occurrence or say probability of occurrence of a risk and the impact of that risk are the two important terminologies here. The probability and impact are evaluated during the interview or meeting. An explanation to satisfy their answers will also be recovered. There after a probability impact matrix will be prepared

The P-I matrix (probability and impact matrix) combines the probability of occurrence and impact scaling and gives a specific ratings to the risks.

The P-I matrix given in PMBOK is illustrated below

Probability and Impact Matrix										
Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)
Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Fig. 2: P-I Matrix from PMBOK

By multiplying the probability of occurrence and impact scaling we will get a number which are indicated in the matrix. Based on this number a risk can be differentiated as low, moderate or high risk. (Example: probability is 0.5 and impact is 0.2 then the resulting number after multiplication will be 0.10, and this number is checked in the matrix and risk rating can be assigned)

The dark gray area with large numbers will represent high risk (which requires the first response), the light gray represents moderate risks (which require second response) and the medium gray represents low risks (which need third or last response). Based on this ratings risks can be analyzed with the help of P-I matrix.

2) Quantitative Risk Analysis

It emphasizes on finding the impact of risks on project objectives like time, cost and quality. The inputs for quantitative analysis will be risk register, risk management plan, cost management plan and schedule management plan.

1) The following are the techniques used in quantitative analysis Modeling techniques

- Sensitivity analysis using Torondo Diagram
- Expected monetary value analysis (EMV)
- Modelling and simulation using Monte Carlo Analysis

2) Expert Judgement

3) Risk Response

It is an important step to be considered on how the risks shall be treated and what response shall be planned. There are 4 responses for any risk as explained below

a) Risk Mitigate

Decreasing the probability and impact of negative events or uncertainties is called as risk mitigation

b) Risk Transfer

Risk transfer refers to transferring risk from one person to other i.e. from one risk owner to another.

c) Risk Accept

Risk accept is a condition where in a risk shall be accepted and there is less probability to manage that risk.

d) Risk Avoid

A better way to avoid risks is altering the project management plan if any risk source is found in the project management plans like project cost plan, project schedule plan etc. and hence the futuristic risks can be avoided.

4) Risk Monitoring & Control

This is the final step of risk management process. Keeping track of identified risks, discovering new risks and eliminating past risks is possible only by continuous supervision on risk management process.

II. RESEARCH METHODOLOGY & RESEARCH FINDINGS

A proper research methodology is planned to achieve the objectives of the study. The below flow chart explains the research methodology adopted.

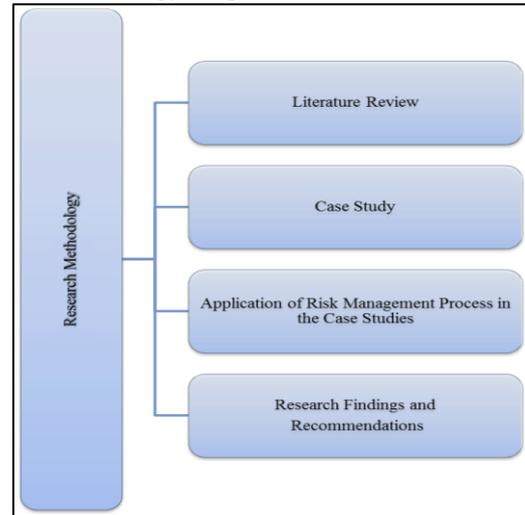


Fig. 3: Research Methodology

A. Literature Review

A thorough literature study shall be taken to understand risk management in detail. Hence the various aspects of project risk management were studied in the literature review and documented.

- Case study

A Residential Villa Project is selected as case study of our research work. The details of the project as follows

- Location: Bangalore
- Development Type: Residential Apartments
- Development Size: 17 Residential Towers + 1 Signature Tower
No of Units: 2368 Apartments.
- Project Duration: 36 Months
- Budgeted Project Construction Cost: Rs. 615 Crores.

B. Risk Identification

From the review of available literatures, discussion with project participants and guidance of industry experts, list of risks generally faced in construction projects were identified and categorized in different aspects. The risk breakdown structure was then prepared including risk categories and risk factors. The 9 risk categories are as follows:

- 1) Organizational Risks
- 2) Legal Risks
- 3) Socio Political Risks
- 4) Financial Risks
- 5) Construction Risks
- 6) Physical Risks
- 7) External Risks
- 8) Design And Technical Risks
- 9) Project Management Risks

The 39 risk factors or risk sources for all the above risk categories are tabulated in the table below

0	Risk Factors	Group
1	Contractual relations	Organizational Risks
2	Contractor experience	
3	Contractual Disputes	

4	Attitude Of Participants	Legal Risks	
5	Conflict Between Different Cultures		
6	Labour Turnover		
7	Industrial Relationships		
8	Intervention By Third Parties		
9	Land Acquisition Risks		
10	Statutory Approvals		
11	Unfamiliar With Local Social Element Scenario		Socio Political Risks
12	Intervention By Social And Political Teams		
13	Bribery/Corruption		
14	Project Funding	Financial Risks	
15	Taxes		
16	Cost Overrun Or Delay		
17	Construction Methodology	Construction Risks	
18	Labour Productivity		
19	Skill And Commitment Of Labours		
20	Unforeseen Extra Work		
21	Omission Of Construction Works		
22	Equipment Or Material Failure		
23	Construction Operations Causing Damage To Local Bodies	Physical Risks	
24	Procurement Risks		
25	Damage To Structure		
26	Damage To Equipment		
27	Labour Injury		
28	Equipment Or Material Theft	External Risks	
29	Weather Risks		

30	Force Major/Act Of God	Design and Technical Risks
31	Marketing	
32	Sales And Customer Commitments	
33	Strikes	
34	Designs (Poor or Moderate)	
35	Quality (Poor or Moderate)	Project Management Risks
36	Project Plan	
37	Project Budgeting	
38	Project Schedule	
39	Project Team	

Table. 1: Designed Risk Breakdown Structure

After preparation of risk breakdown structure, next step is to identify risks in the case studies. Among the several tools and technique used in risk identification, Questionnaire Survey was found to be more appropriate and efficient method to adopt for the research work. A sample of detailed questionnaire survey format is prepared is shown in figure below.

Questionnaire survey is conducted with 5 project management personals i.e. from Vice President of Project to Senior Project Manager. The response of questionnaire survey is illustrated in the table below. The table shows identified risk factors in the questionnaire and out of five how many respondents agreed on these risk occurrences

Si. no	Identified Risk Factors in Case Study	No of Response Out of Five
1	Cost overrun	4
2	Delay	4
3	Labour productivity	5
4	Skills and commitment of labours	4
5	Procurement	4
6	Equipment or material theft	2
7	Weather	4
8	Strikes	3

Table 2: Result of Risk Identification in Case Study

RISK MANAGEMENT QUESTIONNAIRE												
SI. NO	RISK BREAKDOWN STRUCTURE	WHETHER RISK HAS BEEN IDENTIFIED		BRIEF ON IDENTIFIED RISK	PROBABILITY OF OCCURANCE				IMPACT ON			RISK RESPONSE
		YES	NO		LOW	MEDIATE RATE	HIGH		LOW	MEDIATE RATE	HIGH	
	ORGANISATIONAL RISKS											
1)	Contractual relations								COST			
									TIME			
									QUALITY			

									COS T				
2)	Contractor experience								TIM E				
									QUA LITY				
	3) Contractual disputes								COS T				
									TIM E				
										QUA LITY			
	4) Attitude of participants								COS T				
									TIM E				
										QUA LITY			
	5) Conflict between different cultures								COS T				
									TIM E				
										QUA LITY			
	6) Labour turnover								COS T				
									TIM E				
										QUA LITY			
	7) Industrial relationship								COS T				
									TIM E				
										QUA LITY			
	8) Intervention by third party								COS T				
									TIM E				
										QUA LITY			

Fig. 4: Sample of Questionnaire Survey used

Qualitative Analysis of Risks in Case Study -

For doing qualitative analysis the two important factors are probability of occurrence of a risk and its impact factor on the project objectives. For our study we adopted certain selected scales for probability and impact factors from PMBOK as mentioned in below table.

	Low	Moderate	High
Probability	0.30	0.50	0.70
Impact	0.10	0.20	0.40

Table. 3: Designed Probability and Impact Scaling for the Study

With the above selected scalings P-I matrix will be reduced to as shown below.

HIGH PROBABILITY (0.7)	0.07	0.14	0.28
MODERATE PROBABILITY (0.5)	0.05	0.10	0.20
LOW PROBABILITY (0.3)	0.03	0.06	0.12
P – I MATRIX	LOW IMPACT (0.1)	MODERATE IMPACT (0.2)	HIGH IMPACT (0.4)

Fig. 5: Designed P-I Matrix for the study

The dark gray area with large numbers i.e. 0.20 and 0.28 will represent high risk (which requires the first response), the light gray with numbers 0.07,0.14, 0.10, 0.06 and 0.12 will represent moderate risk (which requires second response) and the medium gray with numbers 0.03 and 0.05 will represent low risks (which need third or last response).

The respondents of questionnaire survey were asked to rate the probability and impact scaling for all the risk identified in the case study and the P-I matrix for project objectives like cost, time and quality was prepared. Upon this the risks were summarized as low, medium and high. The below four figures gives out the result of qualitative analysis of case study.

HIGH PROBABILITY (0.7)			
MODERATE PROBABILITY (0.5)	Procurement	Cost overrun	
	Strikes	Equipment or material theft	
LOW PROBABILITY (0.3)	Labour productivity	Delay	
	Weather		
P – I MATRIX	LOW IMPACT (0.1)	MODERATE IMPACT (0.2)	HIGH IMPACT (0.4)

Fig. 6: P – I Matrix for Cost in Case Study

HIGH PROBABILITY (0.7)			
MODERATE PROBABILITY (0.5)	Labour Injury	Procurement	
		Strikes	
LOW PROBABILITY (0.3)	Equipment or material failure.	Delay	
	Weather	Labour productivity	
P – I MATRIX	LOW IMPACT (0.1)	MODERATE IMPACT (0.2)	HIGH IMPACT (0.4)

Fig. 7. P – I Matrix for Cost in Case Study

HIGH PROBABILITY (0.7)			
MODERATE PROBABILITY (0.5)	Labour Injury. Strikes.	Procurement	
	Equipment or material theft.		
LOW PROBABILITY (0.3)	Delay	Labour productivity.	
	Weather	Skills and commitment of labours	
P – I MATRIX	LOW IMPACT (0.1)	MODERATE IMPACT (0.2)	HIGH IMPACT (0.4)

Fig. 8. P – I Matrix for Cost in Case Study Summarised Result of Quantitative Analysis of Case Study Is Given Below

	HIGH RISK	MODERATE RISK	LOW RISK
COST	Nil	Delay	Weather
		Cost Overrun	Strikes
		Equipment or material theft	Procurement
			Labour productivity
TIME	Nil	Delay	Labour Injury
		Labour Productivity	Weather
		Procurement	Equipment or material failure
		Strikes	
QUALITY	Nil	Labour Productivity	Labour Injury
		Skills And Commitment Of Labours	Theft
		Procurement	Delay
			Weather
			Strikes

Fig. 9: Summarised Result of Qualitative Risk Analysis

C. Quantitative Analysis of Case Study

After the Qualitative assessment, now Quantitative assessment should be performed, i.e. impact of identified risk factors on cost. Quantitative analysis is performed using statistical method and representation through Torondo Diagram.

To calculate this, simple statistical approach is adopted and the result of the analysis is illustrated in Torondo diagram or also called Butterfly diagram.

NOTE: Quantitative analysis done here is purely a statistical approach and a probabilistic one too. Due to company policy no cost details have been revealed (other than the budgeted construction cost). And the result of this analysis is just an assumption that the loss or profit may or may not happen if these risks occur. Hence the cost of loss or profit is not the actual loss or profit that this project is undergoing.

From the project we need two important data to conduct quantitative analysis and they are

- Total duration of the project
- Budgeted construction cost of the project

In this analysis, first all the identified risks are well tabulated and they are chosen individually and impact will be calculated. A sample illustration to calculate the cost effect of any risk is shown below

D. Weather Risk

1) Time Factor

The time factor for weather risk can be taken as average of 3 to 4 months i.e. rainy season every year.

Therefore time factor = 3.5 months

2) Probability Scale

The probability scale will be average of probability scale responses of 5 respondents from questionnaire survey that is = $(0.3+0.3+0.3+0.3+0)/5 = 0.24$

3) Cost Factor

- The cost for 36 months will be 615 crores and hence the cost for 3.5 months will be 59.79 crores.

- A equation is adopted based upon literature review to alculate impact of particular risk on cost.

- Therefore, impact of Weather risk on cost = $(\text{probability}/10) \text{ cost} = (0.24/10) 59.79 = 1.43 \text{ crores/year.}$

Impact of weather risk on cost = 1.43 crores

E. Delay Risk

1) Time Factor

The time factor for delay risk can be taken as the project delay period only.

Therefore time factor = 6 month.

2) Probability Scale

The probability scale will be average of probability scale responses of 5 respondents that is = $(0.3+0.3+0.3+0.3+0)/5 = 0.24$

3) Cost Factor

The cost for 36 months will be 615 crores and hence the cost for 6 months it will be 102.5 crores.

Therefore, impact of Delay risk on cost = $(\text{probability}/10) \text{ cost} = (0.24/10) 102.5$

= 2.46 crores

Impact of delay risk on cost = 2.46 crores

The below figure gives summary of quantitative analysis through Torondo diagram tool.

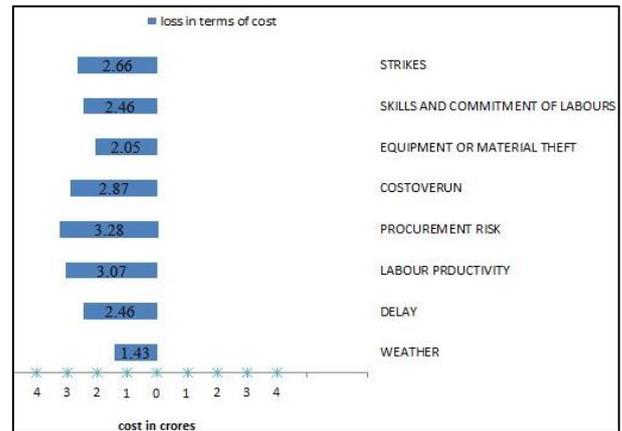


Fig. 10: Result of Quantitative Analysis in the Form of Torondo Diagram

F. Risk Response

The identified risks from the qualitative analysis were studied thoroughly and the risk responses were suggested. The sample of the risk response suggested for respective risks are shown in below figure.

RISKS FACED IN THE SITE	RISK RESPONSE
1) Labour Productivity <ul style="list-style-type: none"> • No 100% efficiency or productivity in the site • Non availability of labours • There are several labour governments schemes which provide good facilities to labours in their natives; hence due to this the migration of labours is a concern • Non availability of skilled labours • No complete commitment of labours due to several factors like personal or professional problems 	Risk Mitigated <ul style="list-style-type: none"> • Conducting training to labours • Transformation of unskilled labours to skilled once through repetitive trainings • Giving incentives and supporting good workers
2) Procurement Risks <ul style="list-style-type: none"> • Delay in procurements • When consignment of materials is made the supplier even then tends to neglect the consignment and sells his material to other projects and this may delay the procurement • At the time of revision of rates there may be stop of supply example : revision of rates of cement • Non availability criteria - major problem observed in sand procurement due to strikes and scarcity 	Risk Mitigated <ul style="list-style-type: none"> • Excess procurement without affecting the inventory • Foresight and knowledge on future developments in market. Proper consignment given after studying the supplier profiles

Fig. 11: Risk Response Sample

III. CONCLUSION & RECOMMENDATIONS

This research works gives out a proper procedure to adopt risk management to a construction project so as to identify, analyse, mitigate and control the risks in a the project. A check list of the risk identified in a project can be prepared and before starting of the new project the check listed risks can be reviewed and taken care that those risks doesn't repeat in the upcoming project and hence the project objectives like Cost, Time and Quality will not be affected.

The proper following recommendations were given out to carry out risk management process to any project –

A. Recommendation 1: Application of Project Risk Management

1) Step 1: Formation of Risk Management Team

Risk management is important and sensitive process. A team can be prepared by taking project participants or any external member who has proficiency in risk management. As risk management planning is the first step in risk management process, the team shall plan on how to proceed on managing and controlling the risks.

2) Step 2: Risk Identification

Risk identification is the second step in risk management process. In order to identify risks there are several tools and techniques but better recommended techniques are Brainstorming and questionnaire survey.

3) Step 3: Preparation of Risk Register

A purpose of risk register is to record and manage risks effectively. The risk management team shall now prepare a risk register and enter the identified risks into it. No standard risk register is given in PMBOK and any organization can prepare their own risk register according to their requirement. The risk register shall be kept in site or office and all the project participants will have the opportunity to enter the data in it.

A typical risk register will have details like Identified risk name, Risk identified by whom and date of identification, Risk type i.e. whether it is opportunity or threat, Status of risk i.e. whether it is open or close or proposed and Probability impact scaling. The risk register shall be updated by weekly meetings and discussions.

4) Step 4: Risk Analysis

As seen in the case studies the better served technique for qualitative analysis is probability and impact assessment using probability and impact matrix. Hence for qualitative analysis probability and impact assessment technique is recommended.

For quantitative analysis, sensitivity analysis using Torondo diagram is the recommended technique. The team shall calculate the impact of each risk individually and draw Torondo diagram.

5) Step 5: Risk Control

The risk management team shall now decide on how to react to the identified risks and manage them. The team can select any risk response like risk avoid, risk mitigate, risk accept and risk transfer.

B. Recommendation 2 - Application of Project Risk Management using Primavera

Risk management team can use Primavera software (web version) to apply risk management in any project. To use primavera following steps shall be followed:

1) Step 1: Creating Project Risks

Risks can be identified and added in the primavera. This option is provided in the projects bar and risk can be added in add risk option. Following entries can be made in this step such as Risk I.D, Risk Name, Risk type, Risk status and Risk category.

2) Step 2: Risk Analysis & Risk Scoring

For risk analysis the software give slots to make entries in the fields like probability, schedule and cost impact. The scaling for these fields may be from very low to very high. The appropriate ratings shall be given for the probability of

occurrence and impact on schedule and cost. The risk score is calculated by the selection of probability, schedule and cost. By using these three fields score can be calculated. The relative severity of different risks score can be viewed by clicking the probability and impact diagram detail window and viewing the values derived from the risk scoring matrix assigned to the project.

3) Step 3: Risk Response

Risk response type can be selected from risk response window where 4 types of risk responses are given and they are risk accept, risk avoid, risk reduce and risk transfer. There is also window to make entry for the cause and effect of any risk. And in the description window details of the risk can be given.

REFERENCES

- [1] Alberto De Marco and Muhammad Jamaluddin Thakeem (2004). "Risk Analysis in Construction Projects: A Practical Selection Methodology", American Journal of Applied Sciences, AJAS.
- [2] Ana I. Irimia - Dieguez (2014). "Risk Management in Mega Projects", Procedia – Social and Behavioural Sciences, ELSEVIER.
- [3] Pauline Corbett and Warren Grigg "Risk Registers in Construction: Theory with Practice".
- [4] Dr. M. J. Kolhatkar and Er. Amit Bijon Dutta (September 2013). "Study of Risk in Construction Projects", Global Research Analysis, GRA, Vol. 2, Issue 9.
- [5] "Risk Management – Concept and Guidelines", By Carl L. Pritchard.
- [6] "Risk Management – Principles and Guidelines", IS/ISO 31000:2009.
- [7] "Risk Management – Risk Assessment Techniques", IES/FOIS 31030.
- [8] "A Guide to the Project Management Body of Knowledge", (PMBOK), ANSI/PMI99-001-2008