HBRP PUBLICATION

Journal of Research in Infrastructure Designing
Volume 4 Issue 3

Applicability of Risk Assessment Tools and Techniques for a Construction Project

Souvik Das[1], Abhijit Rastogi[2]*, Kuldeep Kumar[3]
[1]Student, Department of Building Engineering and Management,
School of Planning and Architecture, New Delhi, India.
[2]Assistant Professor, Department of Building Engineering and Management,
School of Planning and Architecture, New Delhi, India.
[3]Research Scholar, Department of Building Engineering and Management,
School of Planning and Architecture, New Delhi, India.
****Corresponding Author***
E-mail Id:*-arabhijit@spa.ac.in*

ABSTRACT

The construction projects are prone to several risk variables that will affect their key features such as precise goals, time limits, financial restrictions, special organizational and legal requirements, etc. However, there are varying severity of effects due to the different risk factors on these projects' key features and if these risk factors are not taken into consideration or overlooked during various project phases, then the construction project is probable to exhibit the issues of time and cost overruns. This main paper aims to identify risk management tools, techniques, and their applicability on a construction project. Risk factors are identified through literature and case studies. Simultaneously critical activities are identified and the impact of risk factors on those critical activities are loaded. After identification, stage qualitative and quantitative analysis of risk factors and simulation is performed to compare the scheduled duration, deterministic duration, and actual duration. This analysis is required to identify the applicability of the risk management process applied. The findings confirm the existence of gaps in the process of risk management in case study projects. Accordingly, mitigation strategies are proposed to make the current risk management process robust.

Keywords:*-Risk management, qualitative and quantitative analysis, simulation, critical activities.*

INTRODUCTION

According to PMBOK (Project Management Body of Knowledge), risk is defined as an uncertain event that has the potential to impose a remarkable impact on the project's goal. This impact may have positive as well as a negative effects in terms of the project's schedule and cost.

However, often a risk can be a threat to the project's objectives. Risk exists when a decision is expressed in terms of the range of possible outcomes and unknown possibilities can be attached to those outcomes.

For successful risk management, the identification and analysis of project risks are needed. If one does not categorize and classify them to know what they are, how likely they occur, and what their effect may be, one cannot handle risks.

To reduce and handle these project risks, risk management is performed. With the aid of different instruments and techniques, additional efforts are required to establish and implement risk management strategies. The risk identification and evaluation process is intended to convert unknown unknowns (uncertainty) into known threats for a better project management process.

Risk analysis is the risk evaluation method, while risk management uses risk analysis to formulate risk reduction or mitigation management techniques. These approaches are used in project management to answer the questions "how long will this project eventually take?" (Schedule risk), "how much will it finally cost?" (Cost risk), and "will its product perform according to specifications?" (Performance risk) Thus, risk management is the systematic method of controlling the risk exposures of an enterprise to achieve its goals in a manner compatible with its objectives.

The essence of managing a project lies to create a balance between time, cost, and quality to achieve desired objective i.e. scope. Hence, the risk management starts right from the inception stage, schedule preparation to assess the delivery time, i.e. project duration, mobilizing resources to project cash flows till the project completion [2–4]. There exists lots of uncertainties at each stage and managing these uncertainties is a complex process [5]. Poor management of uncertainties often leads to overruns of time and expense [6,7].

Thus, a project manager must have a stochastic approach, defining uncertainties in values, such as durations of scheduling tasks and components of costs, and incorporating risk into them that can provide potential results on quantification that are more practical[1,3]. The objectives of this paper are:

1) To identify risks in various activities during the construction phase of a project.
2) To apply risk management techniques on case projects and compare percentage completion of works (planned, deterministic and actual durations).
3) To identify challenges during the application of Risk management tools and techniques (if any) and propose mitigation strategies.

LITERATURE REVIEW

Risks and Uncertainties

The distinction and link between uncertainty and risk can be defined as risk is observable uncertainty, while uncertainty is an unmeasurable risk [1]. The risk is created by the relationship between uncertainty and objectives, which means that risks can only become relevant uncertainties that have the potential to affect project goals. In other words, the risk is the uncertainty that counts and the importance is determined to the particular objectives in question. The term risk, however, is commonly used in several applications, but the most common application of risk management is in projects, where project risks are described as uncertainties that could affect project goals [8].

Fundamentals of Risk Management

Risks in construction have historically been overlooked or arbitrarily dealt with, yet today risk management is an important part of project management [9,10]. The definition of effective risk management was defined as a continuously controlled, integrated formal process for defining priorities, identifying sources of uncertainty, evaluating them, and formulating management responses to create an inappropriate balance between risk and opportunity [11].

This includes optimizing the probability and effects of positive events and minimizing the likelihood and effect on project objectives of adverse events [1]. Ultimately, risk management implementation can act as a tool to help facilitate the decision-making process to prevent, reduce and decrease risks.

Risk Management Process

For risk management, there are several methodologies or models, but the main risk management mechanism is comprised of four phases in the construction industry. Identification and classification of risk sources, analysis of risk assessment, production of risk management responses, control and monitoring of risk sources [8]. The risk management approach helps to observe and define all the risks to which the project is exposed in the hope of making a deliberate decision to use resources in a planned and cost-effective manner to monitor and minimize the impact and overall likelihood of events deemed undesirable [2], [12].

Risk Identification

Risk detection is arguably regarded as the most important step in the process of risk management [13]. The aim is not to obtain perfect predictions of future events, but rather to recognize potential sources of risk that have a high effect on and may occur on a particular project. It is not possible to identify all possible hazards and the intent should not be to do so. The goal of risk assessment and risk management is therefore to ensure that potential risks are measured and managed in a way that allows the overall objectives to be achieved.

Owing to the constantly changing nature of hazards across the life cycle of projects, risk management must be an ongoing practice [8,9,14,15]. They must be established before risks can be handled, and information from previous experiences can relate to the current project [16].

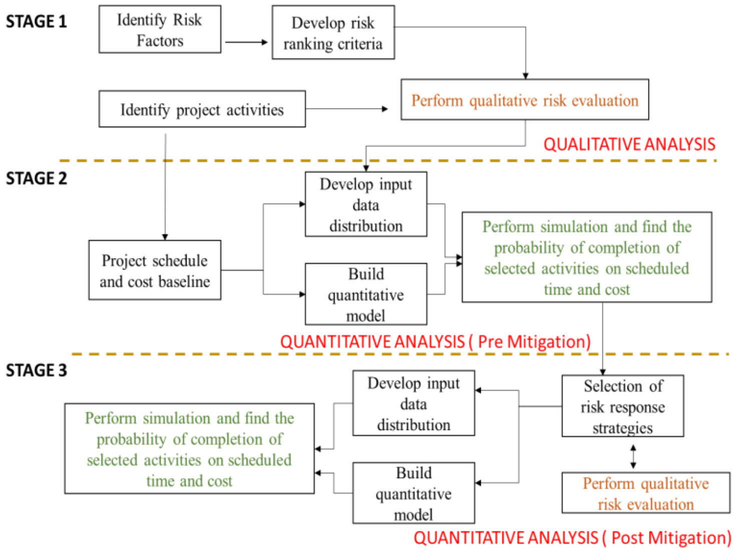


***Fig.1:**-Risk Management Process (adapted from [8])*

Qualitative Risk Analysis

The qualitative risk evaluation includes defining a risk hierarchy, its scale, the factors that cause it to occur, and possible dependencies. The hierarchy is based on the likelihood of the occurrence and the effect on the strategy. PMBOK includes an effect matrix of probability that helps to build this risk hierarchy [1]. Qualitative risk analysis assesses the value of the identified risks and, for further analysis or direct reduction, creates prioritized lists of these risks. Each defined risk is evaluated by the management team for its likelihood of occurring and its effect on project goals. PMBOK also provides a definition of the impact scale as shown in the probability impact matrix on the four objectives of a project; cost, time, scope, and quality [1].

Quantitative Risk Analysis

Quantitative risk analysis is a way of measuring the likelihood of a project achieving its cost and time targets numerically. The quantitative analysis is based on a concurrent assessment of the effects of all threats detected and quantified. The outcome is a probability distribution of the cost and completion date of the project based on the project's risks. Quantitative methods are focused on risk-sharing probability and can provide more objective results than qualitative methods, assuming that adequate current data is available. Qualitative approaches, on the other hand, rely on the analyst's personal opinion and past experiences, and the findings can differ from person to person.

Risk Responses

Several risk response strategies are available. The strategy or mix of strategies most likely to be effective should be selected for each risk. PMBOK suggests four ways of responding to risk in projects, which are as follows:

a) **Avoid:** eliminating a specific threat, usually by eliminating the cause. The project management team can never eliminate all risks, but specific risk events can often be eliminated.

b) **Transfer:** Risk transfer requires shifting some or all of the negative impact of a threat, along with ownership of the response, to a third party. Transferring the risk simply gives another party responsible for its management-it does not eliminate it.

c) **Mitigation:** Reducing the expected monetary value at risk events by reducing the probability of occurrence (e.g., using new technology), reducing the risk event value (e.g, buying insurance), or both.

d) **Acceptance:** Accepting the consequences. Acceptance can be active by developing a contingency plan to execute should the risk event occur or passive by accepting a lower profit if some activities are overrun.

Qualitative Tools for Risk management-

Table 1:-*Qualitative Tools for Risk Assessment (Source: Author)*

Tools	Benefits	Weakness
Brainstorming • Everyone is invited to present their review • Encourages new ideas	• Almost all stakeholders contribute to analyzing risks with their knowledge.	• Lack of quantitative results on occurrence probability and impact • Results often need to be verified • Lots of variations
Delphi Method A group of experts reaches a consensus on the best solution for a particular problem	• Particular solution for a particular problem	• May take a longer time for sending letters, waiting for everyone's responses, etc.
Final Project Report Lesson learned from final project reports of previous works.	• Prevents the repetition of the same mistakes.	• Limited to those risks that have previously occurred
Probability and impact matrix- Evaluate the importance and prioritization of each risk based on occurrence probability and impact	• Allows the prioritization of risks for further use in a process • Reflects the level of risk tolerance.	• Does not directly deal with other factors like urgency • Sometimes does not match with the predicted range
AHP (Analytic Hierarchy Process)- Comparison between the relative importance of elements.	• Determine the relative weight of project objectives.	• An individual may not agree with project objectives.
Root Cause analysis of risk- Deals with the main cause behind the risk.	• Identify additional and subsidiary risks	• Most risk management techniques deal with each risk individually, not suitable for establishing the cause of risk

Quantitative Tools for Risk Assessment-

***Table 2:**-Quantitative Tools for Risk Assessment (Source: Author)*

Tools	Benefits	Weakness
Sensitivity Analysis- • Establish value in case any alteration is related to an individual variable and analyze the impact of these alterations.	• Provide numerous possible outcomes	• Dealing with each variable individually from numerous outcomes.
PERT • Estimate uncertainty from 3 aspects.	• Increase the probability of meeting milestone	• Extra effort and time are needed in the collection of valid input data for PERT.
Monte Carlo • Simulates the intensity of the impact of identified risks and the range of possible outcomes for several scenarios.	• It is primarily used in the analysis of risks related to the schedule and cost of the project to assist strategic decision-making. • It allows simultaneous change of all identified risks • It makes a quantitative assessment of the overall risk of the project	• It provides unrealistic results when the input data simultaneously contain threats and opportunities • The quality of the input data is highly dependent on expert judgment and the efforts and expertise of the person acting as the risk analyst
Decision tree analysis- • The Decision tree analysis helps in the calculation of the expected value of the project, in identifying alternative solutions on the project, and in choosing a better direction for emerging actions	• The decision-maker associates profit and costs to individual alternatives, which points to their attitude towards risk.	• It can be difficult to quantify the probability of the risk event if there is no information on similar experiences from previous projects.

***Table 3:**-Summarized Characteristics of Case examples (Source: Author)*

S No	Project	Year	Author	Reference	Type
CS 1	Flyover in Pune	2015	(Patil, 2015)[17]	Risk Management in Infrastructure Projects in India	Infrastructure
CS 2	Padmabhooshan Vasantdada Patil Institute of Technology, Extension, Pune	2017	(Konde, 2017)[10]	Identification and Assessment of Risks in Construction Projects: A Case of Pune City	Institutional
CS 3	Metro Corridor MC 1B (Delhi Metro Rail)		(Sarkar, 2011)[18]	Project Risk Assessor Model for Underground Corridor Construction	Infrastructure
CS 4	Baramati Phaltan Road, Pune	2016	(Vishambar, 2016)[19]	Risk Planning in Construction of Highway Project: Case Study	Infrastructure
CS 5	IIT Guwahati, Academic Block	2009	Ankit Bhatia,may 2010, IIT Guwahati	IIT Guwahati	institutional
CS 6	Bishop Heber college campus	2017	C. Vignesh, 2018, Manipal University	Risk assessment - a Case Study	institutional
CS 7	The Metrozone Project, Nasik	2012	Prof. Mohan M. Dusane1, Prof. Pankaj P. Bhangale, SSGB College of Engineering, Nashik	Assessment of Risk and Its Application for Residential Construction Projects: A Case Study	Residential
CS 8	17 story Residential Building	2010	Vishal Porwal, Principal at InteloBuild Project Solutions	InteloBuild Project Solutions	Residential
CS 9	Blossom Green, Noida	2015	xxxxx	Synergy Property Development Ltd	Residential

***Table 4**:-Risk factors identified in case examples (Source: Author)*

Risk Category	Risk Type	Risk Description	Reference
TECHNICAL	REQUIREMENTS	Change is design, Design Error	CS1,CS2,CS4,CS7,CS8
		Delay in Issue of drawings	CS1,CS2,CS5,CS6
		Inappropriate specifications	CS3,CS4,CS7,CS8,CS9
		Un-coordinated Design	CS5,CS6,CS7,CS3
		Incomplete Design	CS1,CS2,CS4,CS7,CS8
		Delay in Approval of drawings	CS1,CS2,CS4,CS7,CS8
	TECHNOLOGY	New/inadequate technical requirement	CS2,CS4,CS5,CS7,CS8
		Ill-equipped with new technology	CS1.CS5,CS6,CS7
		Insufficient technological support	CS1,CS5,CS6
	COMPLEXITY AND INTERFACE	Site Location	CS5,CS6,CS7,CS3
		Geopolitical Issue	CS8,CS1,
		Excessive approval procedure	CS2,CS4,CS5,CS7,CS8
		Excessive of requirements	CS4,CS5,CS6,CS7
		Tight project schedule	CS3,CS4,CS7,CS8
		Project Constraints	CS1,CS2,CS4,CS7,CS8
		Complex Design Details	CS3,CS4,CS7,CS8
		Nonstandard design specification	CS6,CS8,CS5,CS9
	PERFORMANCE AND RELIABILITY	Failure of equipment	CS1,CS5,CS6,CS7
		Site investigation error	CS1,CS3,CS6,CS9
		Labour unrest/ Strike	CS6,CS7,CS8
	QUALITY	Poor Workmanship	CS1,CS2.CS3,CS6,CS7,CS8
		Schedule change	CS1,CS2,CS4,CS7,CS8
		Inadequate resources	CS3,CS4,CS7,CS8
		Improper design	CS2,CS4,CS5,CS7,CS8,CS9
		Substandard quality of resources	CS6,CS8,CS5

Summarized Case examples-

Nine case examples have been studied in the Indian context and their characteristics, risk factors identified by those case examples, and challenges faced by those case examples during the implementation of risk management tools and techniques are identified.

METHODOLOGY

The main objective of this research is to study and define instruments and techniques for risk management and their applicability to a building project. Concerning their previous experience and historical records, risk factors were identified through site staff on respective case studies. Critical activities are then identified and the effect of risk factors on those critical activities have loaded.

A qualitative and quantitative review of risk factors is carried out according to PMBOK guidelines and NIST standards after the identification point. The length of the scheduled time, deterministic time, and actual-time were compared after qualitative and quantitative research simulation. To identify the applicability of the risk management process applied to this construction project, this review is essential. There are no loopholes in this risk management mechanism if the deterministic time suits the actual job, but if not, there are some gaps in this process and those gaps need to be found and mitigated. Fig.2 illustrates the steps involved in the metholdogy process.

Table 5*:-Gaps identified in case examples (Source: Author)*

Category	Description	Stage 1	Stage 2	Stage 3
MANAGEMENT	Unsupportive culture		CS1,CS3,CS5,CS6, CS7	CS1,CS2,CS4,CS7,CS8
	Lack of knowledge	CS3, CS6	CS2,CS4,CS5,CS7, CS8	
	Lack of practical experience		CS4,CS5,CS6,CS7	CS4,CS5,CS6,CS7
	Lack of policy and procedures			CS3,CS4,CS7,CS8
	Lack of expertise of PM team	CS8	CS1,CS2.CS3,CS6, CS7,CS8	
	Lack of organizational support		CS1,CS2,CS4,CS7, CS8	CS3,CS6,CS7,CS8
	Lack of money		CS1,CS2,CS7	CS1,CS3,CS5,CS6,CS7
	Difficulties in interpreting the results			CS1,CS2.CS3,CS6,CS7,CS8
	Unavailability of resources	CS1,CS2		
STAKEHOLDERS	Communication and transparency with project stakeholders	CS1,CS2,CS4,CS7, CS8		
	Lack of experience of similar type of projects	CS1,CS2,CS5,CS6		CS1,CS3,CS6
HISTORICAL DATA	Not enough similar historical data	CS1,CS2,CS4,CS7, CS8		
	Insufficient ongoing project information for decision making		CS6,CS7	
MULTIPLICITY	lots of variation in decisions	CS6,CS8,CS5		
	an individual may not agree with one project objectives		CS2,CS7	
	no validation of collected data	CS1,CS2.CS3,CS6, CS7,CS8		CS1,CS3,CS5,CS6,CS7
	lack of similarities on experts opinions	CS1,CS5,CS6		
SITE CONDITION	Unexpected events occur	CS2,CS4,CS5,CS7, CS8		CS1,CS2,CS4,CS7,CS8
	Accidents	CS1,CS2,CS4,CS7, CS8		
	Equipment failure	CS1,CS3,CS6		

Journal of Research in Infrastructure Designing
Volume 4 Issue 3

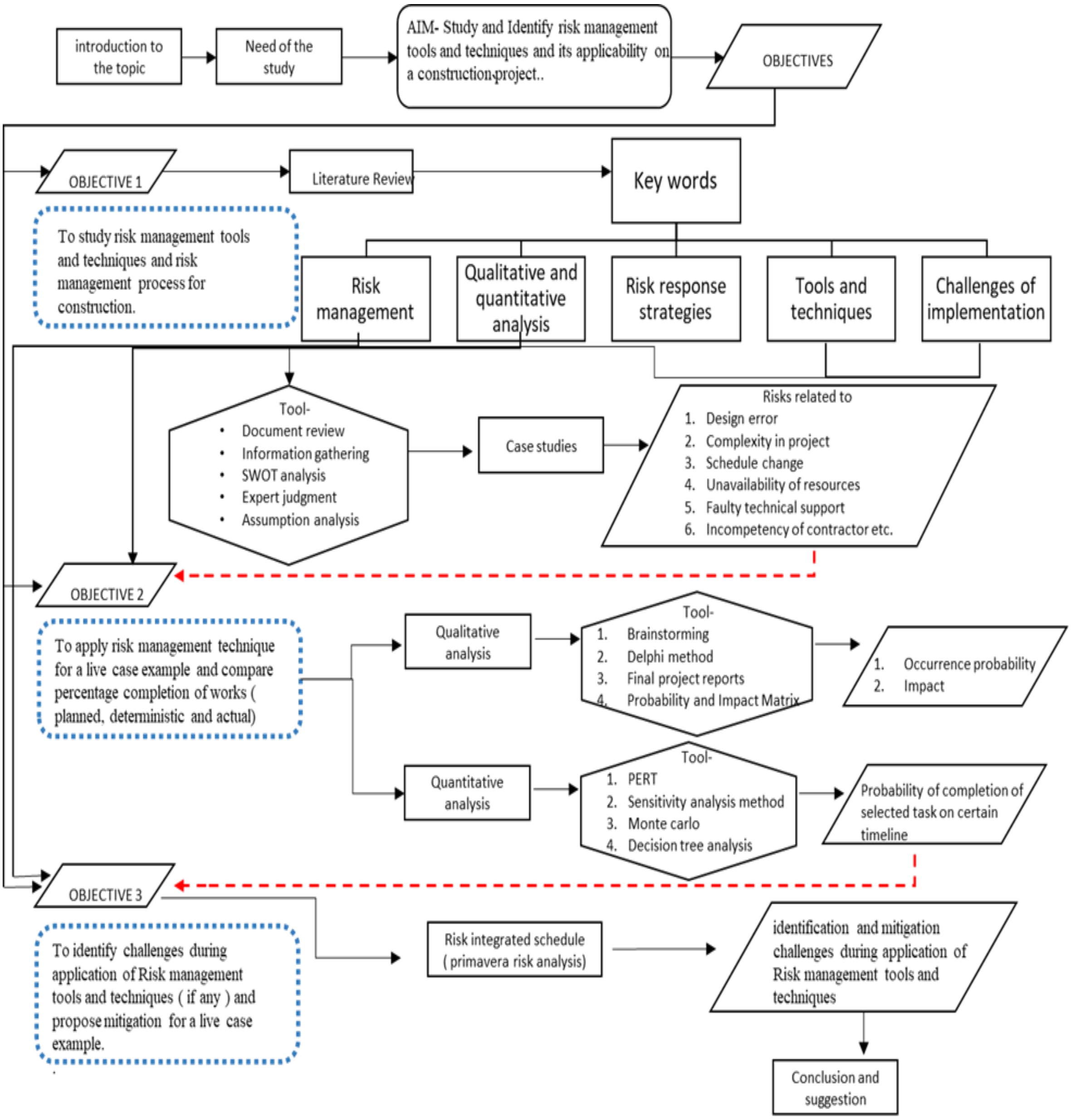


***Fig.2:-**Methodology Flowchart (Source: Author)*

CASE STUDY

Project Description

The site for the construction of this experiment is a 100-bedded hospital, with 1 basement, Faridabad. Total site area 5058.57 Sqm, Total Built-up area 8268 sqm.

The current status of work-

- Excavation is done, Raft casting is continuing, Concreting of Phase 1 of the basement slab is ongoing
- Shuttering of Phase 2 basement slab is ongoing
- Retaining wall is ongoing

Framework for risk assessment

Methodology for conducting risk management for a case study is broadly divided into 4 categories and illustrated in Fig.3.

- Risk identification
- Qualitative risk analysis
- Quantitative risk analysis
- Comparison

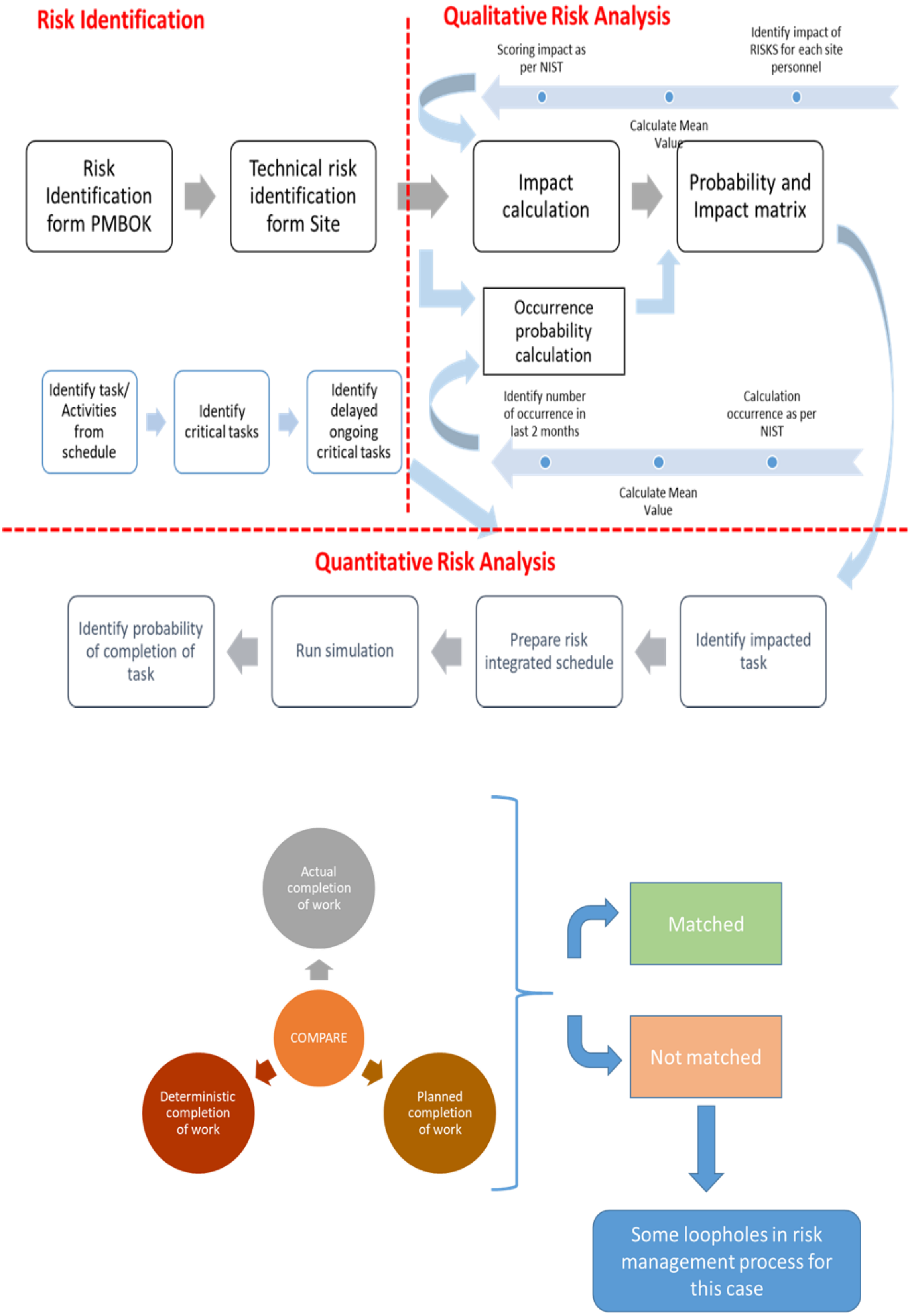


Fig.3:-*Risk Assessment Framework*

Risk Identification and Impacted Critical Tasks

Table 6:-Risk Identification and Impacted Critical Tasks

Risk Category	Risk Type	Risk ID	Risk Description	Root Cause	Impacted CRITICAL task (No)																Responsible person
					Footing Excavation	Soil stabilization	Footing PCC	Raft Reinforcement	Raft Casting	Shuttering and reinforcement of retaining wall	Casting of retaining wall	Column Casting Part B	Shuttering Part B	Reinforcement Part B	Casting	Column Casting (Ground-6th)	Shuttering (Ground-6th)	Reinforcement (Ground-6th)	Casting (Ground-6th)	External Plastering	
TECHNICAL	REQUIREMENTS	R1	Change is design, Design Error	position of sump and water tank, STP, Ramp				✓	✓	✓	✓										Client
		R2	Delay in Issue of drawings	due to incompetence of design team			✓					✓	✓	✓			✓		✓		Design Team
		R3	Inappropriate specifications	x																	
		R4	Un-coordinated Design	due to imcompetence of Project management team						✓	✓					✓					Management Team
		R5	Imcomplete Design	position of sump and water tank, STP, Ramp				✓	✓	✓	✓						✓	✓			Client
		R6	Delay in Approvqal of drawings	position of sump and water tank, STP, Ramp- delay in approval			✓	✓	✓	✓	✓	✓	✓	✓		✓					Client
	TECHNOLOGY	R7	New inadequate technical requirement	x																	
		R8	ill equiped with new technology	x																	
		R9	insufficient technological support	failure of soil retaining structure, sheet pile (accident)		✓				✓	✓										Contractor
TECHNICAL	COMPLEXITY AND INTERFACE	R10	Site Location	very less setbacks	✓					✓	✓										x
		R11	Geopolitical Issue	x																	
		R12	excessive approval procedure	x																	
		R13	excessive of requirements	x																	
		R14	tight project schedule	x																	
		R15	Project Constraints	very less setbacks, less working space (accident occurs)	✓	✓				✓	✓									✓	x
		R16	Complex Design Details	x																	
		R17	non standard design specification	x																	
	PERFORMANCE AND RELIABILITY	R18	Failure of equipement	incompetence of contractor	✓																contractor
		R19	site investigation error	failure of soil retaining structure, sheet pile		✓				✓	✓										contarctore, management team
		R20	labour unrest/ Strike	x																	
	QUALITY	R21	Poor Workmanship	incompetence of contractor								✓	✓	✓			✓		✓	✓	Contractor
		R22	Schedule change	x																	
		R23	inadequate resources	incompetence of contractor								✓	✓	✓			✓		✓		Contractor
		R24	improper design	x																	
		R25	substandard quality of resources	x																	

Qualitative Risk Assessment

Probability & impact assessment can be used to determine the likelihood of a specific risk occurring. The risk impact on project priorities is assessed in terms of opportunities and positive results, as well as threats and negative effects. It is important to adapt to the specific project and define the possibility and effect.

In the hope of recognizing areas with the greatest exposure to these hazards, risk categorization is used as a way to systemize the threats according to their origins. The use of this technique breaks down operations into small units and generates a hierarchical sequence of operations, and the strategy may also include risk dependencies and prioritize them based on how quickly they need a response.

Total risks and probability of occurrence of risks on construction tendering and procurement, the formulae proposed by the National Institute of Standards and Technology [20] as described below were used:

- Total Risk = likelihood of occurrence (L) X degree of impact (I)
- Probability of occurrence (P) = (Total risk/ cumulative total risk)

likelihood of occurrence

Qualitative Value	Score	Occurrence in Last 2 Months
Very High	95--100	more than 16
High	80--95	8--16
Moderate	21--79	3--7
Low	5--20	1--2
Very Low	0-4	less than 1

Degree of impact

Qualitative Value	Score	Impact in Days
Very High	95--100	more 40
High	80--95	20--40
Moderate	21--79	10--20
Low	5--20	5--10
Very Low	0-4	0--5

To calculate the likelihood of occurrence and impact factor of risk factors for the last 2 months a survey has been conducted from site personnel.

***Fig.4:**-Probability and Impact Matrix of Risks*

***Table 7:**-Likelihood of Occurrence*

Risk Category	Risk Type	Risk ID	Risk Description	Root Cause	Responsible person	Site Personal (Occurance)							Mean	Likelihood Of Occurance	Qualitative Value
						Mr Sharma	Kripal Singh	Sunil Tripathi	Nishant Singh	Mr Nirala	Mr Das	Mr. Dubey			
TECHNICAL	REQUIREMENTS	R1	Change is design, Design Error	position of sump and water tank, STP, Ramp	Client	9	11	6	8	10	9	6	8.4286	80.75	H
		R2	Delay in Issue of drawings	due to incompetence of design team	Design Team	5	4	8	6	5	7	2	5.2857	52.8	M
		R3	Inappropiate specifications	×		0	0	0	0	0	0	0	0		x
		R4	Un-coordinated Design	due to imcompetence of Project management team	Management Team	2	1	3	2	3	1	1	1.8571	17.75	L
		R5	Imcompltete Design	position of sump and water tank, STP, Ramp	Client	3	2	3	3	4	3	2	2.8571	28	M
		R6	Delay in Approvqal of drawings	position of sump and water tank, STP, Ramp-delay in approval	Client	2	2	1	1	3	2	2	1.8571	17.75	L
	TECHNOLOGY	R7	New/inadequate technical requirement	×		0	0	0	0	0	0	0	0		x
		R8	ill equiped with new technology	×		0	0	0	0	0	0	0	0		x
		R9	insufficient technological support	failure of soil retaining structure, sheet pile (accident)	Contractor	2	2	2	1	2	2	2	1.8571	17.75	L
TECHNICAL	COMPLEXITY AND INTERFACE	R10	Site Location	very less setbacks	×	2	2	2	2	2	2	2	2	20	L
		R11	Geopolitical Issue	×		0	0	0	0	0	0	0	0		x
		R12	excessive approval procedure	×		0	0	0	0	0	0	0	0		x
		R13	excessive of requirements	×		0	0	0	0	0	0	0	0		x
		R14	tight project schedule	×		0	0	0	0	0	0	0	0		x
		R15	Project Constraints	very less setbacks, less working space (accident occurs)	×	3	4	4	6	3	7	3	4.2857	43	M
		R16	Complex Design Details	×		0	0	0	0	0	0	0	0		x
		R17	non standard design specification	×		0	0	0	0	0	0	0	0		x
	PERFORMANCE AND RELIABILITY	R18	Failure of equipement	×		2	2	4	1	2	2	2	2.1429	22	x
		R19	site investigation error	failure of soil retaining structure, sheet pile	contarctore, management team	2	3	3	2	5	2	2	2.7143	27	M
		R20	labour unrest/ Strike	×		0	0	0	0	0	0	0	0		x
	QUALITY	R21	Poor Workmanship	incompetence of contractor	Contractor	3	3	2	2	3	3	3	2.7143	27	M
		R22	Schedule change	×		0	0	0	0	0	0	0	0		x
		R23	inadequate resources	incompetence of contractor	Contractor	3	3	2	2	3	3	2	2.5714	25	M
		R24	improper design	×		0	0	0	0	0	0	0	0		x
		R25	substandard quality of resources	×		0	0	0	0	0	0	0	0		x

HBRP PUBLICATION

Journal of Research in Infrastructure Designing
Volume 4 Issue 3

***Table 8:-** Impact Factor*

Risk Category	Risk Type	Risk ID	Risk Description	Root Cause	Responsible person	Site Personal (Impact in days)							Mean	Impact factor	Qualitative Value
						Mr Sharma	Kripal Singh	Sunil Tripathi	Nishant Singh	Mr Nirala	Mr Das	Mr. Dubey			
TECHNICAL	REQUIREMENTS	R1	Change is design, Design Error	position of sump and water tank, STP, Ramp	Client	6	7	6	6	8	10	6	7	11	L
		R2	Delay in Issue of drawings	due to incompetence of design team	Design Team	12	15	10	15	18	12	15	13.857	42.8	M
		R3	Inappropiate specifications	×		0	0	0	0	0	0	0	0		X
		R4	Un-coordinated Design	due to imcompetence of Project management team	Management Team	18	20	20	22	18	22	20	20	80	M
		R5	Imcompltete Design	position of sump and water tank, STP, Ramp	Client	5	8	5	7	5	5	8	6.1429	8.42	L
		R6	Delay in Approvqal of drawings	position of sump and water tank, STP, Ramp-delay in approval	Client	10	8	12	8	10	10	12	10	20	L
	TECHNOLOGY	R7	New/inadequate technical requirement	×		0	0	0	0	0	0	0	0		X
		R8	ill equiped with new technology	×		0	0	0	0	0	0	0	0		X
		R9	insufficient technological support	failure of soil retaining structure, sheet pile (accident)	Contractor	20	22	24	20	21	24	22	21.857	81.38	H
TECHNICAL	COMPLEXITY AND INTERFACE	R10	Site Location	very less setbacks	×	6	6	5	4	6	5	5	5.2857	5.48	L
		R11	Geopolitical Issue	×		0	0	0	0	0	0	0	0		X
		R12	excessive approval procedure	×		0	0	0	0	0	0	0	0		X
		R13	excessive of requirements	×		0	0	0	0	0	0	0	0		X
		R14	tight project schedule	×		0	0	0	0	0	0	0	0		X
		R15	Project Constraints	very less setbacks, less working space (accident occurs)	×	6	6	5	4	4	5	6	5.1429	5.42	L
		R16	Complex Design Details	×		0	0	0	0	0	0	0	0		X
		R17	non standard design specification	×		0	0	0	0	0	0	0	0		X
	PERFORMANCE AND RELIABILITY	R18	Failure of equipement	×		0	0	0	0	0	0	0	0		X
		R19	site investigation error	failure of soil retaining structure, sheet pile	contarctore, management team	10	12	14	13	14	15	15	13.286	39.68	M
		R20	labour unrest/ Strike	×		0	0	0	0	0	0	0	0		X
	QUALITY	R21	Poor Workmanship	incompetence of contractor	Contractor	10	8	12	10	8	12	12	10.286	21.2	M
		R22	Schedule change	×		0	0	0	0	0	0	0	0		X
		R23	inadequate resources	incompetence of contractor	Contractor	13	15	18	12	12	14	18	14.571	47.42	M
		R24	improper design	×		0	0	0	0	0	0	0	0		X
		R25	substandard quality of resources	×		0	0	0	0	0	0	0	0		X

After identification of likelihood of occurrence, impact factor, and occurrence probability of each risk factors risk scoring is has been done in primavera.

Quantitative Risk Assessment

It has a quantifiable schedule and/or cost effect on the project if a risk arises. By mapping threats to activities, the effect can be modeled. It is then possible to calculate the total cost and schedule effect of all the uncertainties on the project.

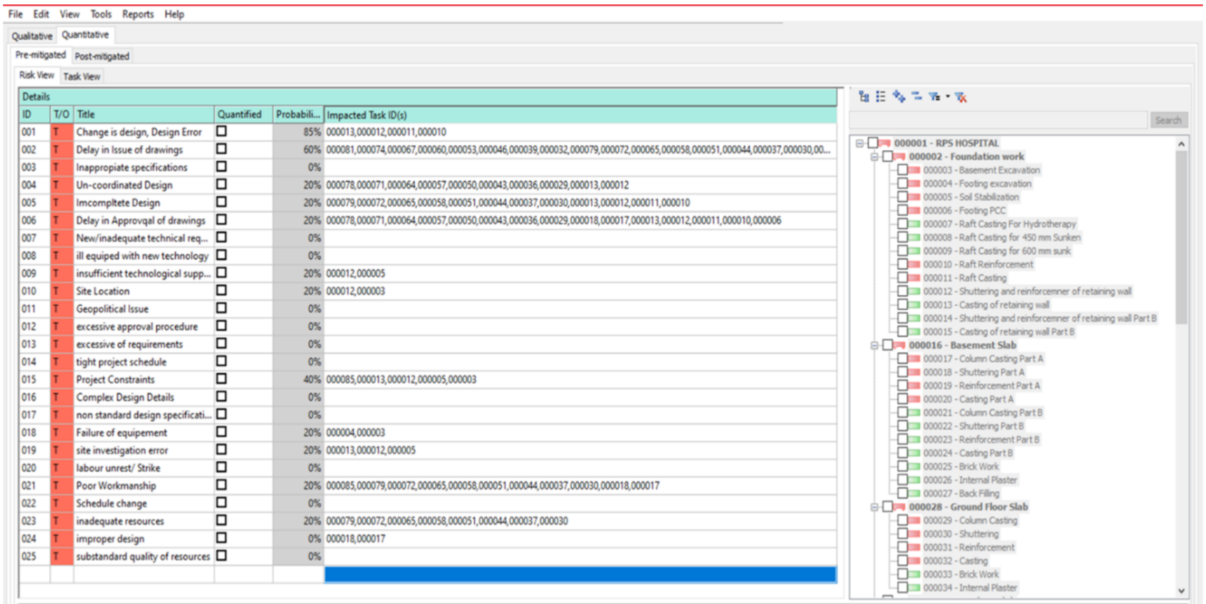
After the activities were listed their deterministic duration, start, and finish date was added. As soon as these data were added the Gantt chart was created. Then for three-time estimates- optimistic, being minimum, most likely, and pessimistic being maximum of each activity were added based on 5 % variation.

After adding the data of three-time estimated risks are liked with every activity from the pre-prepared risk register and a risk integrated schedule is made based on experience or historical data from the site.

After loading all the quantified risk factors to schedule risk analysis or simulation was done with 1000 iteration which produced the following data (as illustrated in Fig.4-Fig.***6***).

Table 9:-Probability of Occurrence

Risk Category	Risk Type	Risk ID	Risk Description	Root Cause	Likelihood of Occurrence	Impact factor	Total Risk	Occurrence Probability
TECHNICAL	**REQUIREMENTS**	**R1**	Change is design, Design Error	position of sump and water tank, STP, Ramp	80.75	11	888.25	9%
		R2	Delay in Issue of drawings	due to the incompetence of the design team	52.8	42.8	2259.84	23%
		R3	Inappropriate specifications	x	0	0	0	0%
		R4	Un-coordinated Design	due to the incompetence of the Project management team	17.75	80	1420	15%
		R5	Incomplete Design	position of sump and water tank, STP, Ramp	28	8.42	235.76	2%
		R6	Delay in Approval of drawings	position of sump and water tank, STP, Ramp- delay in approval	17.75	20	355	4%
	TECHNOLOGY	**R7**	New/inadequate technical requirement	x	0	0	0	0%
		R8	ill equipped with new technology	x	0	0	0	0%
		R9	insufficient technological support	failure of soil retaining structure, sheet pile (accident)	17.75	81.38	1444.5	15%
TECHNICAL	**COMPLEXITY AND INTERFACE**	**R10**	Site Location	very less setbacks	20	5.48	109.6	1%
		R11	Geopolitical Issue	x	0	0	0	0%
		R12	excessive approval procedure	x	0	0	0	0%
		R13	excessive of requirements	x	0	0	0	0%
		R14	tight project schedule	x	0	0	0	0%
		R15	Project Constraints	very less setbacks, less working space (accident occurs)	43	5.42	233.06	2%
		R16	Complex Design Details	x	0	0	0	0%
		R17	nonstandard design specification	x	0	0	0	0%
	PERFORMANCE AND RELIABILITY	**R18**	Failure of equipment	x	22	0	0	0%
		R19	site investigation error	failure of soil retaining structure, sheet pile	27	39.68	1071.36	11%
		R20	labour unrest/ Strike	x	0	0	0	0%
	QUALITY	**R21**	Poor Workmanship	incompetence of contractor	27	21.2	572.4	6%
		R22	Schedule change	x	0	0	0	0%
		R23	inadequate resources	incompetence of contractor	25	47.42	1185.5	12%
		R24	improper design	x	0	0	0	0%
		R25	substandard quality of resources	x	0	0	0	0%



ID	T/O	Title	Quantified	Probabili...	Impacted Task ID(s)
001	T	Change is design, Design Error	☐	85%	000013,000012,000011,000010
002	T	Delay in Issue of drawings	☐	60%	000081,000074,000067,000060,000053,000046,000039,000032,000079,000072,000065,000058,000051,000044,000037,000030,00...
003	T	Inappropiate specifications	☐	0%	
004	T	Un-coordinated Design	☐	20%	000078,000071,000064,000057,000050,000043,000036,000029,000013,000012
005	T	Imcompltete Design	☐	20%	000079,000072,000065,000058,000051,000044,000037,000030,000013,000012,000011,000010
006	T	Delay in Approvqal of drawings	☐	20%	000078,000071,000064,000057,000050,000043,000036,000029,000018,000017,000013,000012,000011,000010,000006
007	T	New/inadequate technical req...	☐	0%	
008	T	ill equiped with new technology	☐	0%	
009	T	insufficient technological supp...	☐	20%	000012,000005
010	T	Site Location	☐	20%	000012,000003
011	T	Geopolitical Issue	☐	0%	
012	T	excessive approval procedure	☐	0%	
013	T	excessive of requirements	☐	0%	
014	T	tight project schedule	☐	0%	
015	T	Project Constraints	☐	40%	000085,000013,000012,000005,000003
016	T	Complex Design Details	☐	0%	
017	T	non standard design specificati...	☐	0%	
018	T	Failure of equipement	☐	20%	000004,000003
019	T	site investigation error	☐	20%	000013,000012,000005
020	T	labour unrest/ Strike	☐	0%	
021	T	Poor Workmanship	☐	20%	000085,000079,000072,000065,000058,000051,000044,000037,000030,000018,000017
022	T	Schedule change	☐	0%	
023	T	inadequate resources	☐	20%	000079,000072,000065,000058,000051,000044,000037,000030
024	T	improper design	☐	0%	000018,000017
025	T	substandard quality of resources	☐	0%	

Fig.4:-*Risk Register (Quantitative)*

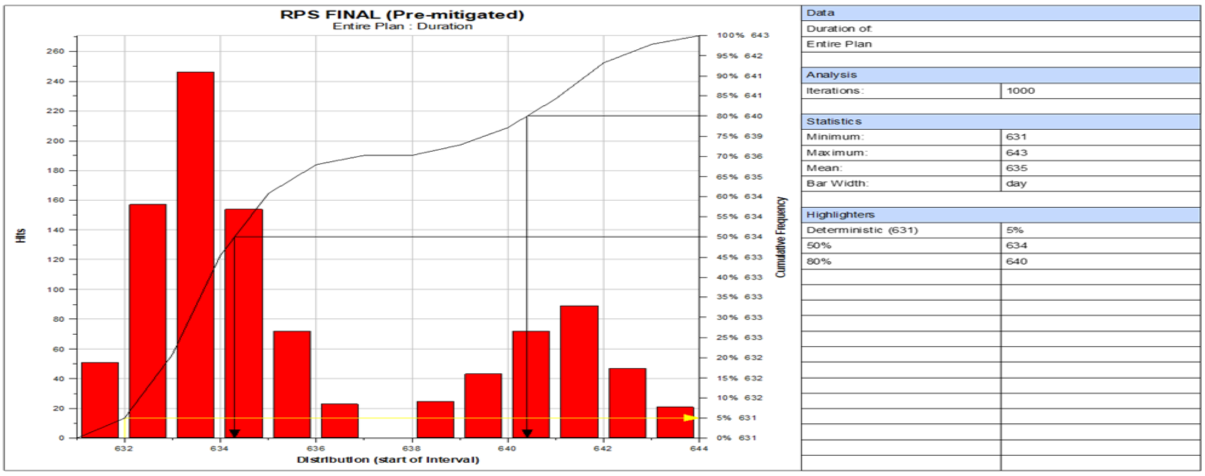


Fig.5:-*Probability Distribution (Duration)*

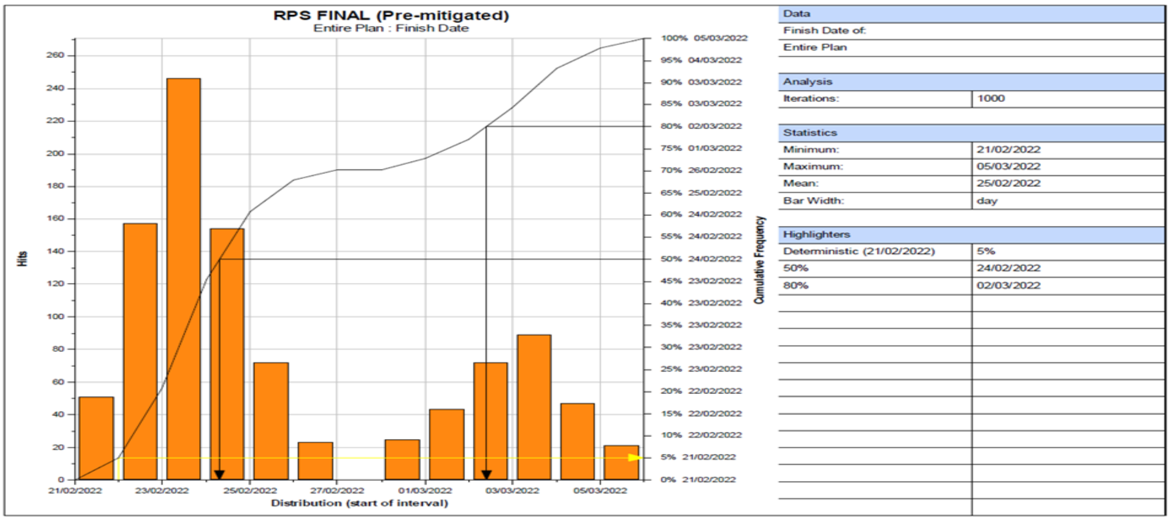


Fig.6:-*Probability Distribution (End Date)*

The following results are obtained in the pre mitigation stage after risk analysis with 1000 iteration.

- Scheduled duration 541 days
- Min 631 days (incorporating risk factors)
- Max 643 days (incorporating risk factors)

Table ***10***.

This analysis is required to identify the applicability of the risk management process applied in this construction project. If the deterministic time matches with the actual work then there are no loopholes in this risk management process

Table ***10***.

Lots of variation is noticed in the duration of the planned schedule, deterministic schedule and actual schedule it implies that the risk management process.

- Deterministic (80%) - 640 days.

After getting the results from risk analysis in the pre mitigation stage analysis was done by comparing the percentage of completion of work as of date 1/12/2020, between planned, deterministic and actual timeline. The comparison chart is attached below in

but if not then there are some gaps in this process and those gaps need to be identified and mitigated.

FINDINGS

After qualitative analysis and quantitative analysis of technical risk based on historical data from the site, for the project during the time of construction, the findings are tabulated below in

Also if we consider the percentage of completion of work of ongoing activities as of the date of 1/12/2020, there exists some variation between planned, actual, and deterministic. It implies that the risk management process that applied in this project, has some gaps.

Table 10:-*Comparison of percentage completion of works as on date 1/12/2020*

Ongoing Tasks	**Scheduled (%)**	**Deterministic- 80%**	**Actual**
Raft Reinforcement	76	71	70
Raft Casting	68	58	60
Shuttering and Reinforcement of Retaining	87	77	53
The casting of Retaining Wall	44	33	7
Shuttering and reinforcement of Retaining	48	31	7
Shuttering Part A	89	70	53
Reinforcement Part A	62	47	34
Casting Part A	88	68	79

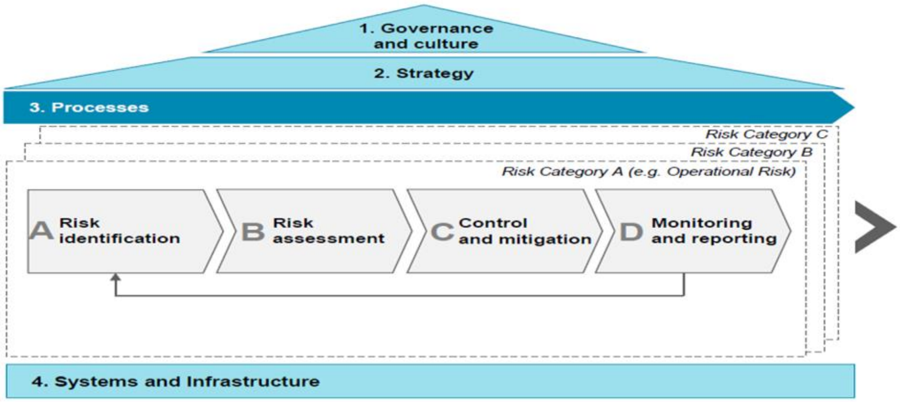


Fig.7:-Key components of a risk management framework (Source: PMBoK[1])

CONCLUSIONS AND RECOMMENDATIONS

Based on findings, the risk mitigation strategies in a form of recommendations are suggested based on key components of the risk management framework as illustrated in Fig.7.

The gaps are identified with respect to the processes mentioned in Fig.7 and accordingly, recommendations are presented in Table 11

Table 11:-Gap identification and recommendation of risk assessment

		RISK MANAGEMENT OPERATIONS	GAPS/RECOMMENDATION
2		**STRATEGY**	
2A	**Incorporation of risks into strategic planning**	•Describes how risk and opportunities are linked due to the organization operating in vulnerable and high-risk areas	•There is no direct link between risk outcomes and strategy •No link into strategic plan including information of how risks could impact the plan
3		**PROCESSES**	
3A	**Risk Identification**	•A total of 5 categories are assessed through a risk self-assessment template •The operational risk template assesses 25 risks, which form a subset of the Risk Matrix, filled in by the project management team. •PM Team can identify and make suggestions for new risks to be added	• Results often need to be verified • Lots of variations • limited to those risks that have previously occurred • Individual may not agree with project objectives.
3B	**Risk Assessment**	Qualitative Risk assessment- 1. Identification of impact 2. Calculation of likelihood of occurrence 3. Calculation of occurrence probability.	Limited to those risks that have previously occurred Does not directly deal with other factors like urgency Sometimes does not match with the predicted range Lack of similarity No validation of collected data.

		RISK MANAGEMENT OPERATIONS	GAPS/RECOMMENDATION
		Qualitative Risk assessment- 1. Identification of impacted task 2. Preparation of risk integrated schedule 3. Run simulation 4. Identification of probability of completion of the task	It provides unrealistic results when the input data simultaneously contain threats and opportunities The quality of the input data is highly dependent on expert judgment and the efforts and expertise of the person acting as the risk analyst It can be difficult to quantify the probability of the risk event if there is no information on similar experiences from previous projects. Based on historical data
3C/D	**Monitoring and controlling**	•All risk reports currently provide a view of the current risk level across •All levels of reporting.	Controls/mitigations are not linked to Key Control Indicators (KCIs) to monitor how well the control is implemented; also no assessment of the effectiveness of controls, which creates a risk of time and resources wasted on ineffective controls.

REFERENCES

1. Project Management Institute, Ed., *The standard for project management and a guide to the project management body of knowledge (PMBOK guide)*, Seventh Edition. Newtown Square, Pennsylvania: Project Management Institute, Inc, 2021.
2. Sawhney, A., Agnihotri, R., & Paul, V. K. (2014). Grand challenges for the Indian construction industry. *Built Environment Project and Asset Management*.
3. Paul, V. K., & Basu, C. (2018). *A Handbook for Construction Project Planning and Scheduling*. Copal Publishing Group.
4. Yadav, P.S., Paul, V.K (2020). Complexities of Cost Overrun in Construction Projects. 5(2):4.
5. Kukreja, B., Paul, V.K., Bawaniya, V(2020). Analysis of Key Factors Influencing Labour Productivity in Construction Projects.8(7):9.
6. Mittal, Y. K., Paul, V. K., Rostami, A., Riley, M., & Sawhney, A. (2020). Delay factors in construction of healthcare infrastructure projects: a comparison amongst developing countries. *Asian Journal of Civil Engineering*, 1-13..
7. Mittal, Y. K., & Paul, K. (2018). Identification of critical factors for delay in metro rail projects in India. *IJSRTM*, *6*(1), 30-39.
8. Raz, T., & Hillson, D. (2005). A comparative review of risk management standards. *Risk Management*, *7*(4), 53-66.
9. Potts, K. E., Rajabifard, A., & Bennett, R. M. (2017). Supporting the risk management process with land information: a case study of Australia. *Disasters*, *41*(2), 352-364.
10. Konde, V., & Minde, P. (2017). Identification and Assessment of Risks in Construction Projects: A Case of Pune City. p. 4.
11. Thevendran, V., & Mawdesley, M. J. (2004). Perception of human risk factors in construction projects: an exploratory study. *International journal of project management*, *22*(2), 131-137.
12. Moza, A., & Paul, V. K. (2018). Analysis of claims in public works construction contracts in India. *Journal of Construction in Developing Countries*, *23*(2), 7-26.
13. Sirshar, M., Shahid, A., & Alam, Z. (2019). Comparative Analysis of Risk Management Techniques for Large-Scale Systems.

14. Moza, A., & Paul, V. K. (2017). Review of the effectiveness of arbitration. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *9*(1), 03716002.
15. Chouksey,R, Paul,V.K, Basu,C, Bawania, C(2020). Pre-Construction Measures to Prevent Delay in Construction of Residential Highrise Project. 8(7):13.
16. Zhang, Y. (2016). Selecting risk response strategies considering project risk interdependence. *International Journal of Project Management*, *34*(5), 819-830.
17. Pawar, C. S., Jain, S. S., & Patil, J. R. (2015). Risk management in infrastructure projects in India. *Risk Management*, *2*(4).
18. Sarkar, D., & Dutta, G. (2011). A framework of project risk management for the underground corridor construction of metro rail. *Indian Institute of Management*.
19. Vishambar, A., Kaustubh, S., Kartik, P., & Salunkhe, A. (2016). Risk planning in construction of highway project: Case study. *International Journal of Latest Research in Engineering and Technology (IJLRET)*, *2*(3), 57-63.
20. Force, J. T. (2018). *Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy* (No. NIST Special Publication (SP) 800-37 Rev. 2). National Institute of Standards and Technology.