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Risk Assessment and Management of Construction Project

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***Abstract*: The goal of this paper is to identify and analyze the numerous risks and their consequences associated with various phases of a construction project, as well as to give risk mitigation methods through a systematic risk management methodology. Construction projects are undertaken in difficult situations, resulting in significant levels of uncertainty and risk, which are exacerbated by strict time and schedule constraints. These risks are not adequately addressed, and as a result, the industry has underperformed. Because infrastructure projects are vast in scale and cost a significant amount of money, any waste (in terms of time, resources, or other factors) would result in significant financial losses. The losses are attributable to a variety of hazards that come with such large-scale initiatives. Through our research, we hope to reduce the financial and other negative implications of the construction project.**

***Keywords*: Risk identified, qualitative and quantitative risk analysis, mitigation of risks.**

1. Introduction

Project management is the process of applying information, skills, tools, and processes to project activities in order to meet or exceed stakeholder demands and expectations. Recognizing, analyzing, and responding to project risk, as well as maximizing the advantages of positive events while minimizing the consequences of negative events, are all part of risk management. Risk is defined as 'The uncertainty inherent in plans and the possibility of something happening that can affect the prospects of achieving business or project goals. It can be defined as the uncertainty inherent in plans and the possibility of something happening that can affect the prospects of achieving business or project goals.

Therefore, to counter all these problems related to risks we aim to conduct a study, identify and to analyze the various risks and its impact associated with different phases of a construction project, as well as to provide mitigation measures for those risks through a systematic risk management process.

Objectives of our study is as follows:

1. To identify various risk associated with the project viz contractor risk, labour risk, market risk, environmental risk etc.
2. To analysing and reducing the risk in construction project and taking control over it.
3. To minimize the financial and other negative consequences in the construction project.
4. To provide mitigation measures for all the risks identified.
5. Provide a final checklist of risks for future projects.

2. Methodology

We took the practical approach in this study. An appropriate site for site visit was selected of G+20 floors.

The methodology adopted to collect data in this project is given below:

1. Literature review and study of journals and text books related to risk analysis and risk management.
2. Preparation of Questionnaire.
3. Site visit to construction project sites.
4. Personnel interviews and questionnaire survey with in-charges and managers and collection of data from site.
5. Analyzing the collected data.
6. Qualitative analysis of data obtained from site and identify the root cause of the risk.
7. Risk response and measures to be suggested and the present data to be recorded for future reference.

After collection of the data the next step was to identify the risks incurred.

1) Risk identification

Risk identification consists of determining which risks are likely to affect the project and documenting the characteristics of each. Risk identification is not a one-time event; it should be performed on a regular basis throughout the project. Risk identification should address both internal and external risks. Internal risks are things that the project team can control or influence, such as staff assignments and cost estimates.

External risks are things beyond the control or influence of the project team, such as market shifts or government action.

2) Methods of identifying risks

1. Literature review
2. Brainstorming
3. Creative meetings
4. Interviews
5. Questionnaire survey
6. Case study

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3) Analysis of risks

Risks are analysed mainly in 2 parameters.

1. Qualitative analysis of risks.
2. Quantitative analysis of risks.

A. Qualitative Risk Analysis

Qualitative risk analysis tends to be more subjective. It focuses on identifying risks to measure both the likelihood of a specific risk event occurring during the project life cycle and the impact it will have on the overall schedule should it hit. The goal is to determine severity. Results are then recorded in a risk assessment matrix (or any other form of an intuitive graphical report) in order to communicate outstanding hazards to stakeholders.

1. Data collection.
2. Root cause analysis.
3. Probability and impact using likert scale.
4. Risk matrix.
5. Risk score.
6. Risk prioritisation.

		Consequence				
		Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	5 Almost certain	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	4 Likely	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	3 Possible	Low 3	Moderate 6	High 9	High 12	Extreme 15
	2 Unlikely	Low 2	Moderate 4	Moderate 6	High 8	High 10
	1 Rare	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

Fig. 1. Risk matrix

Risk = Probability of an event x Consequence of loss due to that event per event.

1) Risk rating

A Likert scale of 1-5 was used in the questionnaire. A Likert scale is a type of psychometric response scale often used in questionnaires, and is the most widely used scale in survey research. When responding to a Likert questionnaire item, respondents specify their level of agreement to a statement. The scale is named after Rensis Likert, who published a report describing its use (Likert, 1932). The respondents were required to indicate the relative criticality/effectiveness of each of the probability of risk factors and their impact to the management.

2) Quantitative risk analysis

Quantitative risk analysis uses verifiable data to analyze the effects of risk in terms of cost overruns, scope creep, resource consumption, and schedule delays.

1. Numerical assessment of risk impact on Cost, time, and quality of project.
2. Risk register table.

3) Risk response

Risk response development involves defining responses to threats. Responses to threats generally fall into one of five categories:

a) Accepting the risk

Taking the Chance Accepting the risk entails a thorough understanding of the danger, its repercussions, and probability, as well as a decision to take no action. The project team will respond if the risk happens. When the repercussions or likelihood of an issue occurring are low, this is a frequent tactic. This technique makes sense as long as the consequences are less expensive than the cure. Stay Away from Danger By opting out of a portion of the project, you can avoid taking a risk. This deletion of a portion of the project could have an impact on more than just the project; it could also have an impact on the business risk. Because a scaled-down product may have less revenue or cost-saving potential, changing the scope of the project may also impact the business case.

b) Avoid the risk

Stay Away from Danger By opting out of a portion of the project, you can avoid taking a risk. This deletion of a portion of the project could have an impact on more than just the project; it could also have an impact on the business risk. Because a scaled-down product may have less revenue or cost-saving potential, changing the scope of the project may also impact the business case. Risk/return is a popular expression in finance-high return on an investment, probably more risk is involved. Avoiding risks on projects can have the same effect-low risk, low return.

c) Monitor the risk and prepare contingency plans

Choose a predictive indicator to watch when the project approaches the risk point to monitor a risk. The risk strategy is to be a part of the test team and monitor the risk. Alternative courses of action are developed before a risk event occurs, and they are known as contingency plans. The most typical contingency plan is to set aside additional funds, known as a contingency fund, to use in the case of unexpected cost overruns. It's critical to make sure that this money is only utilized to cover unexpected cost overruns, not to compensate for underestimating or poor performance. Contingency plans can be thought of as a type of insurance, and they can be costly, much like insurance premiums.

d) Transfer the risk

Many huge enterprises buy insurance to cover a wide range of risks, from theft to fire.

They have effectively transferred risk to the insurance company by doing so, as the insurance company will cover the costs if a tragedy occurs. While buying insurance is the simplest way to shift risk, there are alternative options. Hiring an expert to complete the work, for example, can help to transfer risk. A fixed-price contract says that the work will be completed for a predetermined amount before it begins. Fixed schedules may also be added to such a contract, with penalties for overruns. Project managers know exactly how much this element of the project will cost with fixed-price contracts. They have essentially moved the project's cost and schedule risks to the subcontracting firm; any overruns will be the subcontractor's

responsibility. The only disadvantage to this scenario is that, knowing it would be held to the initial bid, the subcontractor will most likely raise the bid to compensate for the risk it is taking. A reimbursable, or cost-plus, contract is another type of service contract.

Subcontractors are paid depending on the amount of labour, equipment, and materials they use on a project under reimbursable contracts. On these contracts, the project bears the entire risk of cost and schedule overruns. This sort of contract does not allow the project to transfer risk, but when the job to be performed is poorly specified or the type of service is open-ended, a reimbursable contract is the only type that a subcontractor will sign. Transferring risk to another entity has obvious benefits, but it also comes with additional concerns.

e) Mitigate the risk

Mitigation is the process of dealing with a risk after it has had an influence on the project. Mitigation encompasses practically all of the steps that the project team can take to mitigate project-related hazards.

3. Data Analysis

Table 1
Impact of risks on schedule

S. No.	Name	Planned days (in days)	Actual days (in days)	Days delayed (in days)	Reason for delay
1	Start of the project.	-	-	3 days	Staffing delays due to previous project.
2	Before the start of project.	-	-	2 days	Delay in site investigation due to bad co-ordination.
3	Site clearance.	2	3	1 days	Unavailability of jcb for site clearance.
4	Concreting.	-	-	3 days	Two times malfunctioning of concrete mixture.
5	11th Floor.	18	19	1 days	Installation of lift for material.
6	Plinth level.	10	11	1 days	Poor detailing of construction plan.
7	Labours.	-	-	3 days	Incompetence between labour.
8	20th floor terrace.	18	21	3 days	Terrace plan received late
9	7th floor slab	18	19	1 days	Delay in supply of aggregates.
10	1st floor slab.	18	20	2 days	Delay in payment.
11	Plinth level.	10	25	15 days	Change in design of entrance steps.
12	4, 5, 6,7,8,9 floors.	-	-	20 days	Covid 19 Pandemic
13	4,5,6,7,8,9 floors.	-	-	3 days	Unavailability of skilled labour .
14	12th floor.	18	21	3 days	Environmental difficulty due to Cyclone.
15	Error during Installation of lift	6	9	3 days	Breakage of rope.
16	Water supply.	-	-	1 days	Shortage in supply of water due to repair work by municipal cooperation.
17	Planning phase.	-	-	8 days	Inadequate choice of project partner.
18	Electrical.	-	-	4 days	Subcontractor delay.
19	Electricity issues.	-	-	6 days (Total)	Power cuts in the area. Power failure on site.

Table 2
Impact of risks on cost

S. No.	Name	Increase in Cost (Rs.)	Reasons
1	Start of the project	10000	Staffing delays due to previous project.
2	Before the start of project	5000	Delay in site investigation due to bad co-ordination
3	Site clearance	8000	Unavailability of jcb for site clearance
4	Concreting	3000	Two times malfunctioning of concrete mixture
5	6th Floor	2000	Installation of lift for material
6	Plinth level	6000	Poor detailing of construction plan
7	Labours	8000	Incompetence between labour
8	20th floor terrace	5000	Terrace plan received late
9	7th floor slab	6000	Delay in supply of aggregates
10	1st floor slab	10000	Delay in payment
11	Plinth level	4 lakhs	Change in design of entrance steps
12	4,5,6,7,8,9 floors	3 lakhs	Covid 19 Pandemic
13	4,5,6,7,8,9 floors	25000	Unavailability of skilled labour
14	12th floor	2000	Environmental difficulty due to Cyclone
15	Transportation of materials	5000	Sudden rise in fuel
16	Materials	10000 per floor = 2 lakhs	Errors by labours Poor labour management Poor material handling
17	Error during Installation of lift	8000	Breakage of rope
18	Water supply	15000	Shortage in supply of water due to repair work by municipal cooperation.
19	Electrical	10000	Subcontractor delay
20	Rates of material	Cement – 35 per bag. Steel – 15 per kg Crushed aggregate – 100 Per brass	Due to sudden rise in material due to covid
21	Electricity issues	8000	Use of diesel generator due to power failure

Table 3
Risk register table of all the identified risks

S. No.	Risk identified	Cause	Owner	Pre mitigation		Risk score
				Probability	Impact	
1	Health risk.	Covid 19 Pandemic	Global pandemic.	4	5	20
2	Material wastage	Errors by labours. Poor labour management. Poor material handling.	Labour and supervisor	5	3	15
3	Unavailability of skilled labour	Poor labour management	Contractor.	3	4	12
4	Incompetence between labour	Incompetence between labour.	Contractor.	3	4	12
5	Delay in supply of materials.	Delay in supply of aggregates due to unavailability from the source.	Supplier.	2	5	10
6	Design change.	Change in design of entrance steps.	Architect.	2	5	10
7	Equipment Failure.	Two times malfunctioning of concrete mixture due to poor Maintenance of concrete mixer.	Contractor.	3	3	9
8	Installation of machinery.	Difficulties due to inexperience labours.	Sub-contractor.	3	3	9
9	Delay in plans.	Terrace plan received late	Architect.	3	3	9
10	Lift installation.	Breakage of rope.	Sub-contractor.	2	4	8
11	Delay in payment	Delay in payment due to improper planning of funds.	Owner.	2	4	8
12	Material rates.	Due to sudden rise in material due to covid.	Covid Pandemic. Inflation.	2	4	8
13	Delay in site investigation	Delay in site investigation due to bad co-ordination.	Surveyor and manager.	3	2	6
14	Electricity issues.	Power cuts in the area. Power failure on site.	-	3	2	6
15	Sub-contractor risk.	Sub-contractor delay.	Sub-contractor (Electrician)	2	3	6
16	Unavailability of equipment.	Unavailability of jcb for site clearance.	Contractor.	3	2	6
17	Staffing delay.	Staffing delays due to previous project.	Contractor/owners.	1	5	5
18	Poor detailing of construction plan.	Poor detailing of construction plan.	Architect.	1	4	4
19	Environmental risk.	Environmental difficulty due to Cyclone.	-	1	4	4
20	Sudden rise in fuel.	Sudden rise in fuel.	-	1	4	4
21	Supply of water.	Shortage in supply of water due to repair work by municipal cooperation.	Contractor.	1	4	4

A. Result

1. Total number of days required = 1100 days

Total number of days required with risk assessment and management = 1098 days

Number of days saved = 1150-1098

= 52 Days

2. Original Cost of the project = Rs. 13,00,00,000 /-

Cost of the project after risk assessment and management = Rs. 12,93,94,000/-

Cost of mitigation measures = Rs 25,000 /-

Cost saved = 13,00,00,000 – 12,93,94,000– 20,000

= Rs. 6,06,900 /-

B. Discussion

1. This study included 8 such site visits and analysis of risks incurred in them.
2. As well as with the help of interview and survey, 25 responses were registered and risk rating of all the risks were collected.
3. Mean and standard deviation was calculated by statistical analysis.
4. The risks were then classified into 5 major types. (Financial, Construction, Technical, Owners and Environmental risks)

4. Results and Discussion

With the help of this study, we were able to showcase the benefits of risk assessment and management and its application as seen in project 1where total of Rs. 15,96,900/- and 48 days were saved, and similarly in Project 2 and Project 3 total of Rs. 6,06,900 /- and 52 days and total of Rs 3,82,000/- and 49 days were saved respectively.

A checklist of all the risks incurred during the whole duration of these 3 projects were made for future use of risk management. This checklist was then classified into 5 major risks groups and new risks were added based on questionnaire survey and interviews. With all the data collected, the mean and standard deviation of these risks was calculated as this showcases the nature and characteristics of the risks.

With the help of this data, top 5 risks of category, 1. Financial 2. Owner and 3. Environmental risks as well as top 10 risks of 1. Construction and 2. Technical risks were found out. This checklist helps in risk management of future projects.

The top risks incurred were, 1. Construction risks (40.48%) 2. Technical risks (23.8%) 3. Financial risks (14.28 %) 4. Owner risks (14.28 %) and 5. Environmental risks (7.14%)

Table 4
Risk response for the risks

S. No.	Risk	Response Strategy	Mitigation Measure	Cost of Implementation (Rs.)	Days Saved (Days)	Cost Saved
1	Health risk.	Mitigate	1. Explaining and following all the established guidelines and protocol. 2. Train workers on the signs and symptoms of COVID-19 and an explanation of how the disease is potentially spread, including the fact that infected people can spread the virus even if they do not have symptoms. 3. Proper scheduling of labour work hours. 4. Establishing proper work framework.	10,000	-	50000
2	Material wastage	Mitigate	1. Proper labour supervision. 2. Identify reusable and recyclable materials and effectively manage them.	-	-	50000
3	Unavailability of skilled labour	Avoid	1. Establish labour guidelines. 2. Change in policy of recruitment.	-	3	25000
4	Incompetence between labour	Avoid	1. Contractors should give the labours the right information, instruction, and training so that they can work in co-ordination, safely and take steps to protect themselves from hazards.	-	3	8000
5	Delay in supply of materials.	Avoid	1. Include a Liquidated Damages Provision in the Supplier Agreement. 2. Make Supplier Liable for Delayed Delivery in the Supplier Agreement.	-	1	6000
6	Design change.	Avoid	1. Hire experience and competent company as far as possible. 2. Improve transparency. 3. Get clarification on alternate methods and cost.	-	15	4 lakhs
7	Equipment Failure.	Avoid	1. Inspection of equipment before start of every work. 2. Proper timely maintenance of equipments. 3. Regular test and review of the equipment. 4. Training labour the effective way of using the equipment to avoid failure.	2000	3	3000
8	Installation of machinery.	Avoid	1. Hire competent and experienced labours. 2. Provide safety gears. High degree of supervision.	-	3	2000
9	Delay in plans.	Avoid	1. Agreement with architect for following a strict schedule to avoid delays. 2. Ask the contractor to do other additional work in the mean time.	-	3	5000
10	Lift installation.	Avoid	1. Hire competent and experienced labours. 2. Provide safety gears. High degree of supervision.	-	1	8000
11	Delay in payment	Avoid	1. To follow a fix mechanism for payment procedures. 2. Ask the contractor to continue doing the work with additional bonus if required. 3. Effective planning of the project cash flow during execution.	-	2	10000
12	Material rates.	Accept	1. Look for alternate source of obtaining the desired resource at lesser cost.	-	-	-
13	Delay in site investigation	Avoid	1. Conduct a meeting with various parties 2. Explaining them their roles and schedule to be followed by them.	-	2	5000
14	Electricity issues.	Accept	1. Inspection of the wires, connections, boards, etc., before the start of the project. 2. Use of diesel generators.	8000	6	-
15	Sub-contractor risk.	Avoid	1. Hire competent and experienced sub-contractors. 2. To explain them clearly about their roles and responsibility on site. 3. Explaining them about the site condition prior to the start of the work.	-	4	10000
16	Unavailability of equipment.	Avoid	1.Resource allocation must be done in the planning phase itself. 2. Look for other alternate sources to see if it is economically possible. 3. Ask contractor to perform some additional work to avoid delays.	-	1	8000
17	Staffing delay.	Avoid	1. Complete agreement with the contractor about the start dates of the work. 2. Can add penalty clause in the contract to avoid this risk.	-	3	10000
18	Poor detailing of construction plan.	Avoid	1. Hire competent and experienced authority. 2.To improve Transparency and coordination between various entities working on the project. 3. To keep check about the progress of the planning stage. 4. Ask for quick rectification of the plan. 5. Perform other additional task in the mean time.	-	1	6000
19	Environmental risk.	Mitigate	1. Storing materials in proper location to avoid wastage. 2. Avoid working on those days to prevent unnecessary accidents.	-	-	-
20	Sudden rise in fuel.	Accept	-	-	-	-
21	Supply of water.	Mitigate	1. To keep reserved amount of water supply on site. 2. Look for alternate source if economically feasible.	5000	1	-
	TOTAL			25,000	52	6,06,000

Table 5
Classification of check list

S. No.	Risk	Mean	Standard deviation
	Financial risk		
1	Bankruptcy of project partner	1.88	0.87
2	Loss due to inflation date	5.33	0.94
3	Loss due to exchange rate	1.22	0.41
4	Loss due to interest rate	2	0.8
5	Insurance risk	3.11	0.98
6	Change in bank regulation	1.55	0.49
	Construction risk		
1	Health risk	19.77	3.29
2	Material wastage	14	1.44
3	Unavailability of skilled labour	13.11	1.79
4	Incompetence between labours	10.88	1.36
5	Delay in supply of materials	10.44	1.25
6	Delay in receiving plans	7.77	1.13
7	Delay in site investigation	6.44	0.6
8	Electricity issues	6.66	1.7
9	Subcontractor risk	7.11	1.36
10	Staffing delay	4.44	2.45
11	Transit of excavated murum	8.37	0.99
12	Inventory storage	7.33	0.8
13	Path of unloading material	7.77	1.13
14	Improper labour management structure	7.33	0.9
15	Site inaccessible	3.33	0.94
16	Theft of equipment	8.44	0.83
17	Shortage of material of soil	5.33	2.10
	Technical risk		
1	Design change	11.66	1.49
2	Equipment failure	9.55	1.57
3	Installation of machinery	11.33	0.9
4	Installation of lift for material	8.33	0.47
5	Unavailability of equipment	6	0.9
6	Poor detailing of construction plans	4.2	1.13
7	Change in method statement of work	4.44	0.5
8	Design change by structural engineer	10.33	2.40
9	Design change by architect	8.77	0.41
10	Error in estimation	7.55	1.26
	Owner's risk		
1	Delay in payment	7.33	0.94
2	Supply of water	3.77	0.6
3	Improper material supply structure	5.33	0.94
4	Disputes between stakeholders	7.11	0.99
5	Fall short of expected income during project	2.44	0.83
6	Competition from other companies	3.11	1.36
	Environmental risk		
1	Environmental clearance	5.55	0.83
2	Adverse impact of environment on the project	3.33	0.94
3	Impact of the project on the environment	2.66	0.92

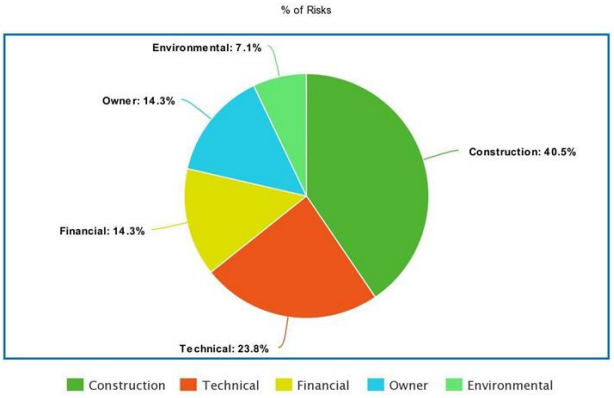

Fig. 1. Pie chart of % of risks

5. Conclusion

1. Risk management is the process of identifying, evaluating, and prioritizing risks, as well as the efficient application of resources to reduce, monitor, and control the likelihood and impact of unfavorable events.
2. Risk management will not remove all risk from project, its principle aim is to ensure the risk are managed in most efficient manner.
3. Using a survey and a site visit, this study compiled a list of risks and their influence on the construction sector. This research should aid management in identifying activities that provide a risk of damage or loss, and so give a foundation for resource allocation decisions. This allows management to make objective decisions on risk reduction

to a certain level.

4. The benefits of risk management implementation in reducing project days and costs have been emphasized with the help of the study, and a risk checklist and categorization has been completed for all future projects.

Risk management is still a new term in the construction industry, according to India, and this needs to change as quickly as feasible.

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