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Assessment of Construction Risk Management (CRM) in Sustainable Construction Projects

Deepak Patel[1], Deepak Jain[1], Ajay Sinha[1], Yash Mothe[1]

[1]*Department of Civil Engineering, Medi-Caps University, Indore, Madhya Pradesh, India.*

Abstract

Risks have a substantial influence on the core objectives of construction projects. Risk management is a crucial component of project planning and management in the construction industry, as well as hazard identification, quantitative appraisal, proper risk management measures, and, ultimately, risk control via monitoring. Financial, environmental, social, and construction-related risks are among the dangers associated with building projects that are analyzed and addressed via risk management. The dangerous and unpredictable nature of the situation in the building sector was never a secret. It can be affected by external factors (technical, design, logistical, physical, operational, environmental, socio-political, force majeure, etc.), which might undercut endeavors or lead to an irreversible aberration. As a result, risk management is now a crucial tool for locating particular threats, assessing them, and thinking about the best preventative actions for a certain project. Initiatives for sustainable development involve greater risk than conventional construction. Using a risk management strategy that includes well-documented processes, this study suggests a one-stop solution for all dangers that are most likely to arise over the lifespan of a building project. It seeks to conduct a thorough evaluation of construction risk management (CRM) research of all the risks that are associated with the construction work.

Keywords: Risk management, construction projects, project planning, construction hazards.

1. Introduction

As the nation's economy has expanded rapidly in recent years, the real estate market has also begun to expand quickly and is showing strong development momentum. Nonetheless, the risk associated with construction has continued to rise. As benefits and risks are mutually exclusive, the bigger the benefit, the greater the corresponding risk, decisions regarding construction project investments should precisely predict risk as well as take both into account (Low, 2023). The risk was defined as an aspect of uncertainty that might influence the objectives of the project, either favorably or unfavorably (Rafindadi et al., 2014). The risk that the construction sector faces must be managed since it is well acknowledged to be high-risk. Risks often have an impact on a project's timeline, budget, quality, health and safety, and environmental sustainability. They are there at every stage of a project's development. Because they are businesses that operate in the construction sector, construction firms must be exposed to risks that arise outside of projects as well as hazards associated with running a business (Low et al. 2009). Construction risk management (CRM) refers to the coordinated actions that a company takes to mitigate construction risk. Construction risk is the result of uncertainty affecting a company's goals in the construction sector. CRM includes all RM actions at the project, company, and industry levels in the context of the construction sector (Zhao, 2023).

Several countries have researched risk management. According to El-(2008) Sayegh's research, inflation, and abrupt price increases are the biggest danger in the United Arab Emirates. Delay is a serious concern in the construction industry in the UAE (Faridi and El-Sayegh 2006). In 1997, Shen's top three concerns in Hong Kong were a lack of manpower for subcontractors, incomplete or inaccurate design information, and changes in the terrain and climate. Similar to this, Zou et al.'s 2007 research in China determined that client deviations, rising construction supply prices, project finance challenges, and a compressed project timeline were the most important risks. Controlling risk factors is crucial for every project's success, claim Perera et al. (2014). According to Kates et al. (2001), sustainability is the process of meeting human demands while maintaining the planet's vital resources for future generations. When achieving sustainability is a top priority, sustainable construction refers to the planning, implementation, and management of green building initiatives (Kibert 2016). The building sector has significant negative effects on society, the environment, the economy, and social issues (Zuo et al. 2012). Since waste is one of the emerging environmental challenges, sustainability has recently been a popular topic. Even though people produce solid garbage every day in their homes, the building sector is the biggest waste generator. The UAE has become one of the top countries for creating garbage, with 75% of its trash coming from the building industry (Al-Hajj and Hamani 2011).

E-mail ID: deepak.patel@medicaps.ac.in

Global support for sustainable construction efforts has recently increased. The growing prices of conventional building materials and energy, particularly in light of government regulatory incentives, are additional considerations that prompt individuals to think about sustainable construction. Nonetheless, because of the elevated dangers they carry, there are still significant barriers to green construction. These dangers range from inadequate green project management to the inability to complete the project within reasonable budgetary restrictions (Robichaud and Anantatmula 2011). The goal of a green risk assessment is to get more knowledge about the degree of uncertainty associated with diverse elements that support sustainable human development. Reduced resource consumption, reduced energy consumption, and reduced environmental contamination are the objectives (Xie et al. 2010).

Construction risk management (CRM) is the coordinated effort that an organization participates in to steer and control construction risk. Construction risk is the result of uncertainty affecting a company's goals in the construction sector. In the context of the construction business, CRM comprises all RM activities at the project, company, and industry levels. The diversity of themes is linked to the complexity and diversity of hazards, as well as the fact that CRM cannot operate independently and must be integrated with other management processes inside a business. Over the years, these publications with varied foci have added to the body of knowledge in CRM. Research, meanwhile, has examined the CRM knowledge domain in its entirety. (1) What constitutes the CRM knowledge domain's underlying intellectual structure is important to comprehend. (2) What are the new CRM research themes? Some of the gaps found in the literature are, first, due to its age, information on the fundamental mathematics of risk has been eliminated. Second, regarding the fundamental studies on human decision-making, there has been no attempt to exhaust the large literature on decision theory itself. The current study is interested in how much of this has permeated the literature on construction and project management.

2. Methodology

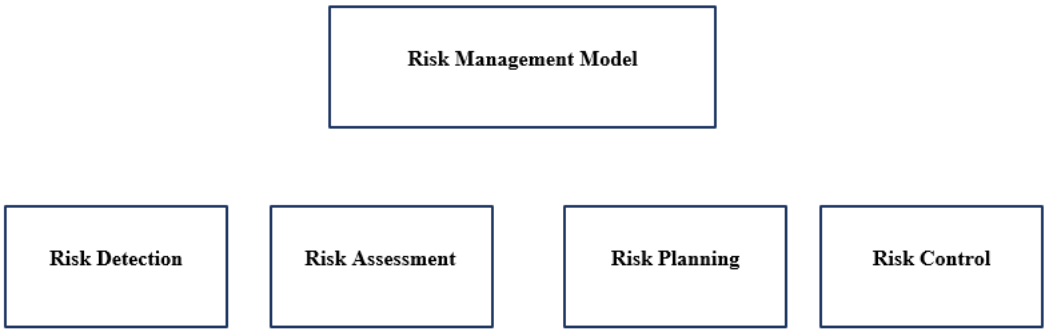

Figure. 1. Sustainable Project Risk Management Models

2.1 Step-by-step methodology to be followed

- To categorize risk in construction projects and to show risk management methodologies, including the monitoring and control phases.
- To evaluate major risk management techniques practiced in managing risk in the construction industry.
- To recognize and assess important risk elements, their frequency, severity, and effects on various construction project types.
- To determine project risk indicators based on typical parameters and to calculate the likelihood that each will occur.

Table 1. Risk detection, assessment, planning, and control

Processes	Tools and Techniques	Outcome
Risk Detection	● Work breakdown, management process, and system flow are only a few examples of analysis. There are also brainstorming, checklists, knowledge experts, and judgmental processes.	● Risk sources and possible risk occurrences can be identified. ● Checking the project's risks are also possible.
Risk Assessment	● Risk probability and Impact Assessment, Risk Ranking and classification	● Time lag Risk evaluation ● Risk based emergency planning
Risk Response Preparation	● Strategy for Risk mitigation planning	● Baseline/risk response plan ● Responsibility Distribution
Risk Response Management	● Risk monitoring	● Risk related remedial measures

3. Risk Detection

Construction-related risks include technical risks, financial risks, management risks, legal risks, environmental risks, and health and safety risks.

Table 2. Construction Risks and Their Occurring Factors

Sr No	Type of Risk	Risk Occurring Factor
1	Technical Risk	Errors in Design with Poor Construction Quality
2	Management Risk	Lack of Quality site supervision
3	Financial Risk	Lack of Funds during Process
4	Financial Risk	Inflation rate Increase or Decrease
5	Environmental Risk	Variations in Environmental Conditions and Natural Disasters
6	Legal Risk	Variation in the design norms stated in Contract
7	Health and Safety Risk	Lack of Safety Equipment and measures
8	Political Risks	Change in government rules and bye-laws

3.1 Identification of construction risks

According to the company and the project team, the initial phase of the RMP is typically informal and may be completed in a variety of methods (Amoo et al., 2023). It implies that while spotting threats, future endeavors should heavily depend on past performance. To identify potential hazards, an allocation must be done. The organization has the power to choose and make preparations in this regard. Threats and dangers may be difficult to eliminate, but managing them is easier if they are understood. Before any problems develop, the fundamental causes of the risks should be identified and assigned for better risk management. Hazards must be recognized to compile a list of potential risks that need to be addressed in a project. Numerous methodologies are used to identify all the risks that might have an impact on a particular project. The project team and the project at large should both gain from the strategy you adopt. By bringing them to the project team's attention, potential issues are meant to be made aware of.

3.1.1 Stages of Risk in Construction

A. Risk during the Preliminary Design Process

It can be caused due to unnecessary competition, poorly recognized investors with poor self-esteem, or overestimating the cost of the project.

B. During the Tender Process

In the Tender process, there is a risk of corruption, tender cancellation, or submitting bad quotes according to the project.

C. During the Detailed design process

It occurs due to a lack of an experienced design team or poor aesthetic level or use of Improper technology during the construction process.

D. During Construction

It caused due to various factors like

- Improper Soil testing
- Poor sustainable construction project management abilities
- Subpar sustainable construction job quality and bad work schedule
- Equipment failure during the process
- Less employee performance or absence
- Improper management of material & resources
- Poor quality control

E. Investment / Finance

It is caused due to risk of Political or Economic stability or Improper cost plan, Inflation, and poor enforcement or compliance with the law.

F. Green Team and Materials

- Client resistance to implementing novel green concepts.
- The consultant and contractor have little expertise with sustainable construction methods.
- The scarcity of trustworthy green suppliers and subcontractors, shortage or long lead time of green materials.
- Insufficient documentation and knowledge of new green technology; and poor performance of green materials.

4. Risk assessment

The second stage of the RMP, known as risk analysis, comprises looking through the information gathered on the potential risk. From all of the threats identified during the identification phase, a short list of risks with the greatest potential impact on the project is created during the risk analysis process (Khaddour & Deng, 2023). Two different types of methods—qualitative and quantitative—have been developed for the study of the suggested risk. When threats can be found anywhere along a descriptive range from high to low levels, the qualitative approaches are most effective. Quantitative approaches, which are based on numerical calculations, are used to estimate the likelihood and impact of the identified threats. Since describing risks rather than quantifying them is more practical, businesses typically employ a qualitative approach. It is difficult to choose the optimal risk assessment model for a certain project since many methods make use of different assumptions that fall into the quantitative and qualitative categories. The scale of the project, the kind of risk, and the requirements and criteria for each specific methodology should all be taken into consideration while selecting a technique.

4.1. Quantitative methods

Labor-intensive analysis utilizing quantitative methods is needed. The job should be evaluated in light of the benefits and outcomes of the technique of choice; for example, smaller efforts may just require the identification and mitigation of threats, whereas bigger projects necessitate more in-depth investigation. Quantitative methods are used to quantify a risk's effect on a project. Due to the number of resources needed, including complicated software and trained employees, they are more appropriate for medium and big projects (Zou et al., 2012).

4.1.1 Decision Tree

Using decision tree analysis exercises, project managers will be able to compare different courses of action against one another and evaluate the risks, chances of success, and potential benefits of each.

4.1.2 Sensitivity Analysis

Sensitivity analysis is a method used in NPV analysis to determine how modifications to the underlying input variables will impact how lucrative a certain project will be.

4.1.3 Scenario Analysis

Scenario analysis aids in calculating the expected value of a portfolio after a certain period by assuming specific changes in the values of the portfolio's assets or the occurrence of significant events, such as an interest rate shift.

4.1.4 Probability and Impact Matrix

One of the most popular techniques for qualitative evaluation is the Probability and Impact Matrix. The two components of risk—impact on an objective and likelihood of occurrence (s)—are the foundation of this strategy. The main goal is to focus on the risks that have been identified to include a likelihood and impact matrix and give an example of a procedural approach to risk management. This is accomplished by assessing the risk's likelihood of materializing as well as its implications for time, cost, and quality.

4.2. Qualitative methods

Using descriptive scale-based qualitative methodologies for risk assessment, the likelihood and effect of risk are stated. These easy steps may be used when a quick review is necessary for small or medium-sized projects. This technique is typically employed when there aren't enough, few, or no numerical data available, as well as when there aren't enough resources in terms of time or money. Additionally, this method is frequently used when there are limited time and financial resources, insufficient, constrained, or nonexistent numerical data, as well as all of the above (Daweina& Adam, 2023). Additionally, this method is frequently used in situations where there are insufficient, limited, or no numerical data as well as limited time and financial resources. Prioritizing possible risks can assist in identifying those that will have the most impact on the project, and by focusing on those threats, the project's overall performance will be improved. The accuracy of data required to produce meaningful analysis is a disadvantage of qualitative approaches. For the risk analysis to be useful to the project team, the information must be accurate, high-quality, dependable, and trustworthy as well as be aware of the risk (Zhang, 2023).

4.2.1 Risk Priority Number

As was previously said, qualitative approaches are used when there are not enough, few, or no numerical data accessible, as well as when time and money are limited. The potential dangers are ranked in order of highest impact on the project to determine their priority. Next, to enhance the project's overall performance, these threats are concentrated (Varouqa, 2023).

4.2.2 Direct Judgement Method

When you consult an expert to gain a knowledgeable opinion, it is judgment. It is a method of project planning that bases estimations of quantitative project components, such as dates and potential resources, on the professional's judgment.

4.2.3 Ranking Method

Sorting by examination. Two projects produced the same net value of incremental production over time with the same investment, but one project is still profitable longer than the other.

4.2.4 Statics Method

Static methods (also known as static functions) are methods that are declared as members of an object but that can only be accessed from the function Object of an API object and not from an instance of the object created using the function Object.

4.3 Risk Response

The course of action that must be done in response to the risks and hazards that have been identified is described in the third phase of the RMP. The reaction strategy and technique selected are determined by the type of dangers present. Participants in this risk management process will also agree that the risk necessitates the appointment of a supervisor to monitor the course of the response (Bk &Jedynak, 2023). A risk can be managed better the less effect it has. The most common risk response strategies are risk avoidance, risk reduction, risk transfer, and risk retention. It could occasionally be difficult to make judgments based on insufficient data. By postponing action in the face of danger until the essential information is available, this can be prevented. Even though waiting to make decisions is a common tactic, it is not always the best option, especially when minimizing significant risks. They need to be handled earlier on in the procedure.

4.3.1 Risk Response Planning

4.3.1.1 Risk Avoidance

By removing the chance that the project may be carried out differently while still attempting to achieve its aims, risk can be reduced. Extend the timetable or reduce the scope of the project to loosen the project goal that is in jeopardy, or change the project management strategy to eliminate the risk or dissociate project objectives from the risk's impacts.

4.3.1.2 Risk Transfer

Risk must be transferred by locating a third party willing to take over risk management and accept responsibility for it should it occur. A danger that has been handed off to another party is still active; its ownership and control have only shifted. By transferring risk, financial risk exposure can be managed (Mitkov, 2023). The goal is to ensure that the party best equipped to manage the risk owns and takes responsibility for it.

4.3.1.3 Risk Mitigation/Reduction

Risk mitigation lowers the chance and/or effects of a risk occurrence to a bearable level. Early intervention to lessen a risk's likelihood and/or impact is frequently more beneficial than waiting to try and repair the harm after the danger has passed.

4.3.1.4 Risk Exploit

By providing the opportunity that certainly materializes, this strategy aims to remove the uncertainty linked to a specific upside risk. remove any ambiguity about a specific upside risk. A potentially hazardous circumstance that, if it happens, will favorably impact the accomplishment of the project's goals is referred to as an opportunity.

4.3.1.5 Risk Share

Assign the risk of a chance to a separate person who can increase both the likelihood that it will occur and the potential benefits if it does. Both allocating opportunities and transferring threats include the use of a third party, allowing the beneficiaries the chance to take part in any potential advantages, and requiring the recipients of the threats to assume responsibility.

4.3.1.6 Risk Enhance

The goal of this response is to change the "magnitude" of the advantageous risk. By increasing the opportunity's possibility and/or significance, the project's benefits are maximized. actively locating the opportunity's trigger conditions, enhancing them, and striving to advance or improve the opportunity's cause.

4.3.1.7 Risk Acceptance

Ultimately, neither opportunities nor hazards can be avoided, but by recording them, we may at least let people know they have been found and exist—a process some refer to as passive acceptance. The project manager and the project team agree to take the necessary actions if and when the risk materializes by choosing to accept the risk.

4.3.1.8 Contingency Plan

This requires having a fallback plan in place in case a risk manifests. Money that is periodically set aside to deal with unanticipated risks can also serve as a form of contingency.

4.4 Risk Monitoring & Control

Constant risk monitoring is necessary to adapt to shifting project conditions. During the months or even years that construction projects can last, weather conditions, laws, costs, and other factors can change. It's essential to make the appropriate adjustments to avoid non-compliance and unanticipated expenditures (Hwang et al, 2017). Due to the extensive breadth of construction risk management, Excel spreadsheets are no longer sufficient to help in effectively managing risk, which is the main purpose of the discipline. Instead, a lot of companies now rely on risk management tools to keep employees safe and projects on schedule. Risk control comes as the process's final phase. We must keep an eye on the effectiveness of the reaction measures after their installation and any alterations to the project risk profile. Did the response-related activities aid or hinder the project's ability to accomplish its objectives? The responses to hazards should also be documented for later reference and project planning. This RMP stage is essential because it collects and tracks all information relevant to the identified risks. New risks are found, existing risks are monitored, and outmoded hazards are eliminated from the risk assessment and project with the help of continuous RMP oversight. Maintaining track of the risks' status and, if required, taking remedial action are the objectives of monitoring and controlling.

5. Conclusion

Assessing and identifying risks is a crucial part of project risk management. For sustainable building projects, it is vital to recognize and assess possible risks. This enables the proper planning and management of risk responses. A literature review revealed thirty risks, which were then utilized in a poll to evaluate each risk's likelihood and possible effects. The top five hazards for sustainable building are, in descending order of severity: a lack of client money; an inadequate description of the scope; incomplete or incorrect design information; design revisions; and an extremely short deadline. To mitigate these hazards in green construction programs, the necessary authorities must develop creative approaches. Project managers and consultants may also take part in training sessions that will educate them on how to anticipate possible issues that can develop in sustainable building projects. They will be better equipped to manage risks and take practical solutions into account before starting the project if they do this. The success of a project may be significantly impacted by the hiring of qualified managers, engineers, and laborers. Such experts can give guidance during the building process and help less-experienced individuals.

The construction business is dynamic, thus any of the following risks—which may be managed through risk assessment—could lead to the project's failure.

a) Avoided

b) Reduced

Hence, this would lead to the crucial element of the current situation - The project will be completed more quickly and smoothly since uncertainty will be reduced. Successful project execution minimizes the financial uncertainties these risks cause. The risk management strategy is only seldom implemented since there is a lack of information and awareness among the populace. Additionally, there is a lack of project risk management expertise, which affects the project's goals. In this publication, the risk management process (analysis, identification, and reaction) is thoroughly examined. To accomplish varied objectives, risk might be categorized in a variety of ways.

While some have primarily divided risk in construction projects into external risks and internal hazards, others have categorized risk into more intricate categories. Making decisions requires considering the hazards of the options, which is suggested by all of the examined methodologies. These categories rely on the project's situation and the surrounding environment. Some approaches are more or more accurate at measuring risk than others, but they all require a certain amount of knowledge, resources, and precise data (ranging from medium to high levels). The quantitative technique is more complex even if it requires more resources than the qualitative approach.

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