

Review of Technical Risk Management in Construction Projects

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Abstract: Complex and dynamic construction project environments introduce uncertainty and risk, requiring time constraints. Over the last several years, construction has been in turmoil. This industry is driven by private investors, and securitized real estate has grown. It has several commercial and technical risks, many of which are greater than traditional ones. Thus, risk evaluation is needed. Risk assessment helps project managers identify and manage risks. This study states that risk assessment quantifies project threats to persons and property. A key aspect of the study's methodology was a mail or in-person survey of surrounding building companies of varying sizes. Comprehensive literature study is initially conducted to identify risk indicators that affect construction industry performance. The survey questionnaire examines construction hazard cross-sectional behavior. The prototype survey questionnaire was prepared after examining construction risk management literature. This research identifies and evaluates risks and provides a risk management framework for investors, developers, and contractors employing Indian contractors for building projects.

Keywords: Technical risk management, Construction project risks, Project performance

I. INTRODUCTION

Construction projects are known for being very complicated and including a lot of uncertainty from several sources. It is challenging to conduct a comprehensive assessment of construction projects since they bring together hundreds of parties. However, these initiatives also provide a perfect setting for study on risk management. Furthermore, a number of tools and methodologies have previously been established specifically for building projects, which are often utilized in management research. However, there is a disconnect between risk management strategies and how construction contractors actually use them. In the field of business, project management has lately drawn a lot of attention. Projects' high degree of risk is one of their main features [1–3].

This implies that an excessive number of unfavorable occurrences might lead to project delays, overspending, poor project outcomes, or even complete failure. Project managers are encouraged to lower risks via improved planning and control in order to raise the likelihood that their projects will succeed. All stages of the project's life cycle need risk management, beginning with the planning stage, when hazards must be recognized and evaluated. A reaction strategy to some of the major hazards should then be put into action, along with remedies that might lessen concerns. Risk monitoring is required throughout the project's execution phase to track recognized risks, track residual risks, find new risks, and guarantee that risk strategies are carried out [4–5].

Since construction projects take a lot of time and money, having strong risk management abilities is essential if the projects are to be finished on schedule, within budget, and with the desired level of quality. Everywhere there is risk, but building projects are particularly so. Construction-related operations have the potential to cause deadly injuries, financial catastrophes, operational disruptions, and delays, among other consequences. Although there are several justifications for using risk management, the primary one is that it may provide substantial advantages that much outweigh the expenses involved.

OBJECTIVE OF THE STUDY

The building sector mostly entails inherent hazards. Although risk cannot be eliminated, it may be controlled. To anticipate their potential detrimental consequences on initiatives, it is helpful to comprehend the major risks. Research on risk assessment and management has been conducted by a variety of individuals, mostly in industrialized nations. It is imperative for emerging nations like India to be efficient and competitive in order to deliver value to stakeholders and avoid falling far behind in the competitive globe.

Few studies have been conducted in this field in underdeveloped nations like India. with order to ensure employment and turn a profit, it is crucial to control the risks involved with building projects, especially in developing nations. As a result, this research aids in identifying the main hazards and potential countermeasures for the risks the construction sector faces. Every danger listed in the questionnaire has the potential to occur in every building project.

METHODOLOGY

The survey questionnaire, which will be obtained from contractors either in person or by mail, is a major component of the study's overall approach. To determine the risk variables influencing the overall performance of building projects, a comprehensive literature research is carried out. Additionally, a few interviews with business professionals were done to assess the questionnaire's efficacy.

Questionnaire Structure: Annexure 1 displays the structured interview questions. There are two sections to the questionnaire. General information including the project's worth, experience, and firm type is included in the first section, while technical risk factors for assessment are included in the second.

Questionnaire Design: Investigating the cross-sectional behavioral pattern of technical hazards in building projects is the goal of the survey questionnaire. The questionnaire was developed using pertinent building risk literature as a guide.

RISK RATING

The questionnaire included a Likert scale with a range of 1 to 5. The most popular psychometric response scale in survey research is the Likert scale, which is often used in surveys. Respondents indicate how much they agree or disagree with a proposition by answering a Likert questionnaire item. Each risk factor's relative criticality and efficacy as well as its influence on management had to be indicated by the respondents.

SAMPLE COMPOSITION

Public and private developers, project managers, principal contractors and subcontractors, senior consultants and engineers, and upper management staff (i.e., managing director and senior associate) were among the respondents who were all working in the sector. It should be mentioned that this survey has a rather small sample size. There are two possible causes for this.

First off, the questionnaire took a lot of time and would discourage respondents from participating since it attempted to investigate 51 risk variables associated with building projects. Second, certain practitioners in the business may not be familiar with the questionnaire's comprehensive substance. The efficiency of the questionnaire survey may be weakened by the limited sample size. The carefully chosen sample pool of business professionals, together with their extensive expertise and deep understanding, may make up for the aforementioned shortcoming.

DATA ANALYSIS METHOD

Two sets of data are included in the survey feedback: the probability of each risk occurring and the degree to which it affects the project's goals in terms of budget, schedule, quality, environment, and safety. In this study, the risk significant indicator created by Shen et al. (2001) was used. Equations (6) may be used to get the significance score for each risk evaluated by each respondent with regard to the influence on a certain project goal.

RISK MANAGEMENT INVOLVES FOUR PROCESSES, NAMELY

Technical risk management in construction projects has become a pivotal aspect of modern project management due to the complex, multifaceted, and capital-intensive nature of construction activities. The systematic approach to managing

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technical risks ensures that projects are executed efficiently, within budget, on time, and with adherence to safety and quality standards. Technical risks in construction may arise from a variety of sources, including design errors, construction method inadequacies, substandard materials, labor issues, equipment failures, environmental constraints, and regulatory compliance challenges.

To effectively manage these risks, the process is generally organized into four interconnected phases: risk identification, risk assessment, risk mitigation, and risk monitoring. Risk identification is the foundational step where all potential technical risks are systematically recognized and documented. In this phase, project managers, engineers, and other stakeholders analyze project plans, design documents, site conditions, and historical project data to detect any factors that could compromise project performance.

Techniques such as brainstorming sessions, Delphi method, checklists, and failure mode and effects analysis (FMEA) are commonly employed to ensure that both obvious and subtle risks are captured. Accurate risk identification is crucial because undetected risks can escalate into significant cost overruns, schedule delays, and safety hazards. Once risks are identified, the next critical step is risk assessment, which evaluates the likelihood and potential impact of each identified risk. Risk assessment involves both qualitative and quantitative approaches.

Qualitative assessment classifies risks based on their severity and probability, often using risk matrices or ranking systems to prioritize the most critical threats. Quantitative risk assessment, on the other hand, applies numerical methods such as Monte Carlo simulations, sensitivity analysis, and fault tree analysis to predict potential consequences in financial, temporal, or safety terms. The assessment process provides a clear understanding of which risks demand immediate attention and which can be monitored with less urgency. Following assessment, the third process, risk mitigation, focuses on developing strategies to reduce the probability or impact of the identified risks.

Mitigation measures in construction projects are diverse and can include design modifications, adoption of advanced construction techniques, rigorous quality control, preventive maintenance schedules, contingency planning, and procurement of reliable materials and equipment. Risk mitigation also involves contractual and legal measures, such as including clauses that allocate responsibilities for specific risks to contractors or subcontractors. Proactive risk mitigation is particularly important in technical risk management because many construction risks, if left unmanaged, can cause cascading effects, including rework, structural failures, and reputational damage.

The final phase, risk monitoring, is an ongoing process that ensures previously identified risks remain under control and that new risks are detected promptly. Risk monitoring requires continuous surveillance of project activities, site inspections, performance audits, progress reporting, and stakeholder communication. Modern construction projects increasingly use digital tools such as Building Information Modeling (BIM), project management software, and risk tracking dashboards to enhance the monitoring process. Effective risk monitoring allows project teams to adjust mitigation strategies in real time, respond quickly to unforeseen events, and maintain overall project resilience.

The interplay among these four processes identification, assessment, mitigation, and monitoring forms a continuous feedback loop that strengthens the project's ability to handle technical uncertainties. Numerous studies have highlighted the significance of technical risk management in construction. For instance, research by Zhi (1995) emphasizes that structured risk management reduces cost overruns and delays, while Hillson and Simon (2020) note that early identification and quantification of technical risks enhance decision-making and resource allocation.

The integration of risk management practices with project planning, scheduling, and quality control ensures that technical risks are not addressed in isolation but are considered within the broader context of project objectives. Furthermore, the dynamic nature of construction environments, influenced by factors such as changing client requirements, weather conditions, labor skill variability, and technological advancements, necessitates that technical risk management remains flexible and adaptive. Risk identification techniques must evolve to capture emerging threats, and assessment methods must accommodate new types of data and uncertainty modeling.

Similarly, mitigation strategies should leverage innovative materials, automation, prefabrication, and sustainable construction practices to reduce exposure to technical risks. Risk monitoring, aided by real-time data collection and analytics, ensures that project managers maintain situational awareness and can implement corrective actions before risks escalate into crises.

Despite the clear benefits, challenges in implementing technical risk management persist. Many projects suffer from incomplete risk registers, subjective assessment methods, inadequate stakeholder involvement, and limited integration with other management systems. Addressing these challenges requires commitment from top management, allocation of sufficient resources, training of personnel in risk management methodologies, and fostering a culture that values proactive risk thinking. In addition, collaboration between designers, engineers, contractors, and clients is essential to ensure that technical risks are comprehensively understood and effectively mitigated.

Overall, technical risk management in construction projects, through the structured processes of identification, assessment, mitigation, and monitoring, serves as a critical mechanism for achieving project success. By systematically anticipating, evaluating, and controlling technical uncertainties, construction projects can achieve improved safety, quality, cost efficiency, and schedule adherence. The iterative and adaptive nature of these processes ensures that technical risks are managed continuously throughout the project lifecycle, providing a robust framework for decision-making and resource allocation.

As the construction industry faces increasing complexity, technological advancements, and regulatory demands, the importance of rigorous technical risk management cannot be overstated. Implementing these four processes in an integrated and proactive manner enhances not only the likelihood of project success but also stakeholder confidence, organizational reputation, and long-term sustainability.

Consequently, adopting comprehensive technical risk management practices should be viewed as an indispensable component of modern construction project management, ensuring that projects are resilient, efficient, and capable of delivering intended outcomes despite the inherent uncertainties of the construction environment.

Risk identification is the process of identifying the risks that are most likely to have an impact on the project and recording their attributes.

Risk Quantification: Assessing the range of potential project outcomes by analyzing risks and risk interactions.

Risk Response Development: Outlining how to respond to hazards and improve opportunities.

Risk Response Control: Adapting to shifts in risk as the project progresses.

TECHNICAL RISK ASSESSMENT METHODOLOGY (TRAM)

Klein and Cork (1998) created the TRAM framework to evaluate the technical hazards of a suggested system. The framework offers a methodical framework for choosing evaluation techniques and incorporating the outcomes of using those techniques into a cohesive system-wide assessment. The decomposition concept is the main tenet upon which TRAM is based. According to the decomposition concept, a system is evaluated in part by breaking it down into smaller systems, on which a more thorough evaluation is conducted, rather than as a whole throughout the assessment process.

TRAM FRAMEWORK

There are seven distinct stages that make up TRAM. Although the seven-phase technique is a logical process, its systematic aspect shouldn't be compromised. It is meant to be adaptable and iterative.

STRUCTURE PHASE

The assessment is structured at the structure phase by breaking down the system to be evaluated into a hierarchically arranged collection of assessment areas. The whole system may be divided into sections, with as many sublevels as necessary. Assessment areas are used to arrange the detailed evaluation. While the assessment's structure makes sense, it may be expanded upon or changed as needed at any point after that. The last, seventh TRAM phase focuses on integrating assessment data from various areas, whereas the next five phases are typically arranged in the bound assessment areas [8].

RISK IDENTIFICATION, ASSESSMENT METHOD IDENTIFICATION, AND RISK ASSESSMENT PHASES

The technical hazards that pertain to the assessment area are discovered during the risk identification phase. Finding the different assessment techniques that may be used to each risk is part of the assessment method identification process [9]. During the risk assessment phase, specific hazards are estimated using a specific methodology.

METHOD INTEGRATION AND RISK INTEGRATION PHASES

The findings of all the methods utilized are integrated in the method integration phase, and assessments are combined as needed in the risk integration phase to provide a comprehensive picture of risk in the assessment area under consideration.

HIERARCHICAL INTEGRATION PHASE

The last stage of TRAM is called the hierarchical integration phase, during which evaluations from every field are methodically combined from the bottom up to provide a system-wide assessment.

II. CONCLUSION

In India, risk management is still a relatively new concept in the building industry, and this has to change right now. By facilitating prompt decision-making, the risk assessment system will enable developers to work on projects more quickly. Every rating agency will score projects using a different approach. The system will assist the government in creating a risk-reduction plan. Developers and investors will be more receptive to public-private partnership initiatives as a result. The bidding projects can become more competitive as a result. The method will allow lenders to make credit decisions quickly, potentially accelerating the project's financial closing. A third-party risk evaluation would undoubtedly bring up important issues that aren't often brought up while a project is being finalized.

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