Risk Management and Delay Mitigation in Construction Projects: A Comprehensive Literature Review

Ramana V[1], Dr. P.A. Prabakaran[2]

[1] *Post Graduate Student, Civil Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India.*
[2] *Assistant Professor, Civil Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India.*

ABSTRACT

The construction industry is characterized by complex project environments, multiple stakeholders, and inherent risks that contribute to delays, cost overruns, and productivity challenges. This literature review synthesizes existing research on key factors influencing construction project performance, including poor site management, labor shortages, ineffective risk management, and emerging technological advancements. Studies highlight various approaches to mitigating these issues, such as risk maturity models, machine learning applications, and proactive risk identification frameworks. Furthermore, the role of Building Information Modelling (BIM), stakeholder collaboration, and strategic planning in improving construction efficiency is examined. By analyzing a range of methodologies and risk mitigation strategies, this review provides valuable insights for researchers, policymakers, and industry professionals. The findings emphasize the importance of data-driven decision-making, structured risk management, and innovative technologies in reducing delays and enhancing overall project success. Future research should focus on refining existing frameworks and integrating emerging technologies to further strengthen risk management practices in the construction sector.

Keyword: - *Risk management, Project performance, Construction project delays.*

1. Introduction

The construction industry is highly intricate, requiring coordination among various stakeholders while navigating uncertain risks and ever-changing project conditions. Because it involves numerous stakeholders, uncertain hazards, and fluctuating project environments, the construction industry is by its very nature complicated. Poor risk management, delays, cost overruns, and execution inefficiencies are still common issues that affect project success. These topics have been the subject of numerous studies, which have identified important elements that impact the success of construction projects, including site management, labor shortages, risk assessment frameworks, and technology improvements.

This study of the literature looks at a wide range of studies on productivity issues, risk management techniques, construction project delays, and new technology advancements. Serdar Durdyev et al. (2018) discuss the reasons behind project delays, Shadi Shayana et al. (2019) discuss risk management techniques during project execution, and Erfan Hoseini et al. (2019) discuss the function of risk maturity models. Innovative methods are also highlighted in the review, including the use of complex networks in risk assessment (Jing Wang et al., 2023), the integration of Building Information Modelling (BIM) in safety management (Ahsan Waqar et al., 2023), and machine learning for project delay prediction (Ahmed Gondia, 2020). This review attempts to give a thorough grasp of the current issues and developments in construction management by combining these many works. The knowledge acquired can assist researchers, politicians, and business experts in creating practical plans to reduce delays, increase risk control, and boost project performance in general.

2. Literature Review

Serdar Durdyev et al (2018) This study examines 149 factors that have been linked to construction project delays, emphasizing ten prevalent ones such as bad site management, communication problems, weather, labour shortages, and planning difficulties. Notably, these conclusions were greatly influenced by researchers from underdeveloped nations. With insights that can assist address the several reasons of construction project delays, the study is a useful tool for academics and professionals alike. The largest contribution to the identification of CPDs (delays in construction projects) came from developing nations. Two major CPDs are inadequate site management and a lack of workers.

Shadi Shayana et al (2019) this paper discussed about the effective risk management during the construction execution stage is crucial for project success, existing research primarily concentrates on risk management during the planning phase. This study addresses the gap by identifying critical success factors for risk management specifically during the execution stage, where most risks manifest. A mixed-method approach was employed, combining a questionnaire survey and follow-up interviews with construction professionals to prioritize various success factors. A total of 55 professionals participated, highlighting four key factors: a) project management capacity, b) knowledge and experience, c) early involvement of contractors, and d) socio-cultural influences. The findings of this research not only identify these critical success factors but also establish their relative importance, providing construction professionals with a framework to prioritize risk management strategies during project execution. This framework aims to serve as a valuable tool for enhancing planning and decision-making processes regarding risk management in construction projects.

Erfan Hoseini et al (2019) the literature highlights the increasing relevance of Risk Maturity Models (RMM) in various industries for assessing and improving risk management practices; however, a validated RMM specific to the construction sector is lacking. To address this gap, the Generic Risk Maturity Model (GRMM), inspired by the European Foundation for Quality Management (EFQM) model, was developed and validated through qualitative content analysis of existing risk management literature and expert feedback from focus group sessions. The GRMM is designed to be user-friendly and provides project managers with a clear framework for identifying potential improvements in risk management, facilitating cross-project analysis and continuous learning. While the GRMM shows promise for enhancing risk management in construction projects, further research is recommended to explore its real-world application and impact on project performance.

Nguyen Van Tam et al (2020) this paper discussed about the current study investigates critical factors (CFs) affecting construction labour productivity (CLP) from the perspectives of project managers and contractors. Through an extensive literature review, the study identifies 45 CFs, categorized into six primary groups: manpower, management, work conditions, project-related factors, and external influences. A total of 203 valid responses were collected, comprising 56 project managers and 147 contractors, who completed a structured questionnaire based on their experiences in construction projects. The CFs were ranked using a relative importance index and descriptive statistics, including mean and standard deviation. Analysis of the results revealed significant differences between project managers' and contractors' views on the most influential factors impacting CLP, highlighting the need for improved communication and collaboration between these stakeholders to enhance productivity in the construction industry.

Ahmed Gondia (2020) this paper shows the significant challenges of project delays in the construction industry, primarily due to the complexity of projects and the interdependence of various delay risk sources. This study aims to leverage machine learning techniques to enhance the analysis and prediction of project delay risks using objective data sources. Initially, relevant delay risk factors were identified, and a multivariate dataset encompassing the time performance of previous projects and associated delay-inducing risks was compiled. An exploratory data analysis was conducted to uncover the system's complexity and interdependence. The study identified and trained two machine learning models—decision tree and naïve Bayesian classification algorithms—on the dataset to predict project delays. Cross-validation tests were performed to evaluate the predictive performance of both models, revealing that the naïve Bayesian model outperformed the decision tree model in terms of accuracy. Ultimately, this research harnesses machine learning's potential to facilitate evidence-based decision-making and empower proactive project risk management strategies amidst the dynamic nature of inherent risk factors.

Olcay Genc (2021) this paper examines key risk factors affecting construction projects in Turkey by assessing their likelihood of occurrence. Recognizing that risk identification is the initial step in effective risk management, the study addresses a gap in the literature regarding the prioritization of risk variables. Utilizing the Relative Importance Index (RII) and Exploratory Factor Analysis (EFA), the researchers analyzed 201 valid responses to a questionnaire that included 33 risk variables. The findings highlight disaster and force majeure, project management, technical management, external factors, and design-estimation as the primary risks in construction projects. Among the most likely risks identified are the use of unqualified subcontractors, payment delays, and economic issues like inflation, late change orders, and budget overruns. Conversely, risks such as floods, boycotts, and natural disasters like hurricanes and tornadoes are deemed rare. The study suggests that practitioners who consider these identified risk factors in their evaluations can enhance the accuracy of their risk management strategies and cost estimations.

Ahsan Waqar et al (2023) this paper discussed about the building Information Modelling (BIM) is gaining traction in the construction industry for enhancing risk management, yet its application in safety management within Malaysia's oil and gas sector remains underexplored. This study aims to identify the challenges associated with using BIM for safety management in this hazardous industry and to uncover the root causes of resistance to its adoption. Utilizing exploratory factor analysis and structural equation modelling, the research analyzed survey data from industry professionals. The findings reveal that knowledge obstacles, creative hurdles, technical barriers, supervisory barriers, and functional barriers are the primary challenges impeding BIM adoption for safety management. These barriers were shown to significantly impact the implementation of BIM in safety management processes. The study offers critical insights for policymakers, industry practitioners, and academics aiming to enhance safety management practices through BIM in Malaysia's oil and gas construction sector. Future research could investigate additional factors influencing BIM adoption in this context.

Elhosin Yousri et al (2023) this paper shows the important of risk identification in construction management, as it significantly impacts time and cost performance. Improved risk management strategies can mitigate the severe consequences of identified risks. Recent fluctuations in the Egyptian currency and restrictions on importing engineering materials have notably influenced existing construction regulations in Egypt. This research involved a pilot survey of 15 expert engineers to verify the applicability of previously identified risk factors in the Egyptian context, resulting in the selection of 35 relevant risk factors. A five-point Likert scale was employed to analyze the data from 95 participants. The study aims to redefine and prioritize these risks based on current circumstances. High-risk factors identified include funding issues from contractors, material price volatility, unrealistic project duration estimates, and shortages of construction materials. Addressing these high-risk components is essential for stakeholders to enhance project success and overall performance.

Jun Zhao et al (2024) this paper emphasizes the critical importance of building safety in the construction industry for protecting contractors and workers. It advocates for proactive risk management to identify potential hazards before operations begin, employing a systematic "pre-incident" approach. The research indicates that neglecting effective risk management can compromise safety and introduce unpredictable risks, especially with the industry's rapid pace. However, emerging building technologies present solutions to these safety challenges, enhancing quality, speed, and cost-effectiveness. The study explores the relationship between risk management and these innovative technologies through a questionnaire, highlighting their direct connection and the need for corrective measures to improve building safety performance.

Esraa S. Almaliki et al (2024) this paper discussed about the construction industry faces numerous risks that significantly impact project performance, often hindering completion within the specified limits of time, cost, and quality. Various studies have identified critical risk factors, such as delays in preparing and approving project drawings, consultant approvals for modifications, inflated cost estimates, and financial difficulties during project execution. Methodologies including qualitative interviews and statistical analyses like mean, standard deviation, and regression have been used to rank these risks and understand their relationships with project performance. Key issues identified include delays in material approvals by project owners and low productivity among workers and machinery. Effective risk management, emphasizing early identification and proactive strategies, is essential for mitigating these challenges and enhancing overall project outcomes. The literature provides valuable frameworks for stakeholders to assess and address risks, ultimately guiding them toward more successful project completions.

Abroon Qazi et al (2016) this paper shows the challenges in managing complexity and risk in long-term NPD projects, where complexity spans structural, dynamic, and interactional elements across technical,

organizational, and environmental domains. Standard risk management approaches inadequately address the interdependence of complexity and risk, often failing to incorporate emerging risks over the project lifecycle. To bridge this gap, the ProCRiM framework integrates complexity and risk management by identifying causal relationships between complexity attributes and risks, supported by tools like Bayesian Belief Networks (BBNs) for analyzing risk interactions. Case studies and models demonstrate the limitations of existing approaches, which often rely on isolated risk assessments and intuition, lacking comprehensive frameworks to handle interdependencies. ProCRiM's structured approach emphasizes continuous monitoring, utility functions for decision-maker preferences, and systematic risk interaction analysis, aiming to offer a holistic, data-driven model that enhances risk prioritization and mitigation strategies for complex projects.

Jingya You et al (2018) this paper examines how uncertainty in construction projects leads to opportunistic supplier behaviour. It distinguishes between environmental and behavioural uncertainty, both increasing the risk of such behaviour. Contracts play a key role in controlling, coordinating, and adapting to mitigate these risks. The study, based on data from 220 projects, finds that higher contractual control reduces opportunistic actions, particularly under environmental uncertainty, while coordination helps manage behavioural uncertainty. It suggests that well-designed contracts can curb opportunistic behaviour, but emphasizes the need to balance complexity and costs. Future research should explore the dynamic nature of uncertainty and relational factors like trust.

Hui Lu et al (2019) this paper examines uncertainties in rock mass classification systems, focusing on the Q-system used in underground construction. It highlights how mischaracterized joint characteristics lead to unreliable Q-value estimates and advocates for probabilistic analysis via Monte Carlo simulation (MCS) to capture variability in rock conditions. Key parameters like RQD and Jn are emphasized for determining Q-values, with MCS enhancing statistical accuracy and numerical modelling aiding in assessing rock mass responses. A case study of the Shimizu tunnel illustrates the effects of varying conditions on evaluations, concluding that MCS is effective for estimating probabilistic Q-values and that sensitivity analysis is essential for improving rock mass assessments.

Peter E.D. Love et al (2020) this paper discussed about the rework in the construction industry, defined as the cost of redoing work, excluding change orders. It highlights a trend where safety is prioritized over quality, leading to non-conforming products and safety risks, illustrated by case studies like the Mascot and Opal Towers. Analysis of 569 projects found that 210 experienced non-conformances, resulting in average rework costs of 18% of contract value and a 15% annual profit loss. Using NVivo software, the authors identified themes related to rework and quality violations, recommending robust quality management systems to catch non-conformances before asset handover. The authors conclude that neglecting rework and quality hampers organizational learning and urge the construction industry to better integrate quality management with safety outcomes.

Jing Wang et al (2023) this paper explores complex networks and set pair analysis (SPA) to measure vertex similarity and improve community detection. It introduces new methods and algorithms like KPCMV and VSFCM for better accuracy. Rough set theory is also examined for handling incomplete network data, aiding decision-making and security. The research highlights applications in link prediction, influence maximization, and other fields, emphasizing the versatility of complex network models across various domains.

Shuo Wang et al (2023) this paper proposes a new method to assess construction performance under deep uncertainty, where traditional probability-based methods like Monte Carlo simulations are ineffective. It combines discrete-event simulation (DES), fuzzy C-means clustering, Bayesian regularization back propagation neural networks (BRBNN), and particle swarm optimization (PSO) to create prediction intervals for project outcomes. The method, validated through a case study, shows greater accuracy and reliability compared to Monte Carlo simulations, aiding decision-making on project duration and cost without relying on precise probability distributions.

Roope Nyqvist et al (2023) this research proposes a network-based uncertainty management model (UNM) to improve construction risk management by addressing interdependencies among risks. Developed with Finnish AEC industry input, the UNM visualizes uncertainties as a weighted network, aiding better decision-making and collaboration. Initial testing showed the model's potential in enhancing risk identification and management. Though limitations include data availability and lack of comparisons with other methods, the UNM offers a holistic, practical approach to managing construction uncertainties and lays the groundwork for future innovations in risk management.

Zhang et al (2002) The paper discusses the importance of selecting an appropriate concessionaire for successful BOT projects, emphasizing risk management and capacity. It highlights the use of the Kepner-Tregoe decision analysis technique in concessionaire selection frameworks. Various procurement protocols for BOT projects are still being tested, indicating a need for best practice benchmarks. The research analyses current concessionaire selection practices worldwide to improve procurement processes in regions lacking expertise. The paper concludes that effective tender assessment involves detailed scoring and consensus among panel members.

Amy Maulany Setyaman et al (2013) The study aims to organize information for decision-making regarding issues in survey and soil investigation due to new cost efficiency policies implemented in 2012. It employs Kepner and Tregoe's analytical process, including situation, problem, decision-making, and potential problem analyses. The research combines qualitative methods, such as interviews, with quantitative methods, specifically SMART analysis. Five alternative solutions were identified, with the best being to establish an "umbrella contract" with a selected surveyor company. The implementation plan for the selected solution aligns with Power Engineering Consultant's current conditions.

Ravinder Jhorar et al (2016) The research paper addresses the issue of clamping pad breakage during the leak testing process in industrial settings, which affects product quality control. It employs a systematic methodology, including Kepner-Tregoe analysis and quality control tools, to identify root causes of clamping pad failures. The study highlights the importance of redesigning clamping pads to reduce breakage and improve efficiency, ultimately leading to negligible failure rates. The findings suggest that the proposed methodology is universally applicable for failure analysis across various industrial problems.

Petit et al (2019) The paper evaluates options against WANT objectives to assess findings. Weighted scores are computed to determine the relative performance of alternatives. Duration Underrun, Owner's target duration, and Duration Overrun are eliminated from feasible options. The owner's Optimal Duration target fits the criteria perfectly. The abstract discusses incentive contracts and maximizing profit for project owners and contractors.

Gita Kurnia et al (2020) The study aims to improve Soekarno-Hatta Airport's on-time performance using creative problem-solving approaches from January 2016 to December 2018. Root causes identified include an integrated baggage handling system, slow passenger loading, late departures, and unpredictable weather. Proposed solutions involve implementing the Cris belt Conveyor System to enhance baggage handling efficiency. The study benchmarks Soekarno-Hatta against Singapore's Changi Airport for performance improvement strategies. Future research should consider additional factors affecting airport on-time performance for comprehensive strategies.

Bayuntoro Wiyono et al (2021) The research addresses corporate governance issues in the Grand Ussu Hotel and Convention, focusing on collusion, corruption, and family feuds. The author employs the Kepner-Tregoe analysis for rational decision-making to establish clear authority and responsibility. Alternative solutions are proposed based on cost and benefit analysis, including appointing a CEO from the owners. The final recommendations include appointing a new CEO and improving internal controls and human resource management. The methodology involves qualitative and quantitative approaches, utilizing interviews and surveys for data collection.

Yorry Franky Simanjuntak et al (2021) The upstream oil and gas industry significantly impacts the environment through exploration and production waste, including crude oil spills. Efficient planning and implementation processes are crucial for achieving remediation targets at PT XYZ. The alignment between COCS volume and processing capacity is vital for effective land acquisition and remediation implementation. The author employs various analytical methods, including RCA and Kepner-Tregoe approaches, to identify problems at PT XYZ. Identified issues include factors related to process, people, planning, scheduling, and regulation.

Taufik Hidayat et al (2022) The research focuses on accident prevention programs at Pertamina EP Regional 2 Zone 7 (PEP R2Z7) to achieve zero accidents. Historical data analysis from 2018 to 2021 revealed 40 work-related accidents, necessitating targeted prevention programs. The study emphasizes prioritizing accident prevention programs based on root cause analysis. Established programs include the Iman Campaign and new proposals like Task Observation for high-risk jobs. The proposed solutions aim to reduce accident cases and enhance workplace safety.

Anindito Priyambudi et al (2023) The study addresses equipment reliability challenges in Ammonia production, focusing on Semi-lean Pump 107-JB's performance and operational efficiency. It employs Overall Equipment Effectiveness (OEE) metrics to evaluate and enhance pump reliability. The research identifies root causes of low reliability, including inadequate maintenance and overworking the pump. A Maintenance Implementation Plan is developed, predicting OEE improvement from 63.63% in 2022 to 96.74% in 2024.The study suggests IoT Probe Sensors for real-time monitoring as an effective solution.

Tayori Tantarto et al (2023) The study analyses subcontractor selection using Risk Management and the Analytical Hierarchy Process (AHP) to improve project outcomes. Key criteria identified include Technical Capability, Quality, and Performance History, which influence subcontractor selection. The research highlights the importance of addressing ongoing work issues to enhance project execution efficiency. Focus group discussions were utilized to determine relevant criteria for subcontractor selection. The findings aim to assist PT Bangun Beton in completing projects on time and with quality.

3. Conclusion

The literature highlights the significant challenges and risks associated with construction projects, including delays, poor site management, labor shortages, and ineffective risk management strategies. Researchers have explored various approaches to mitigate these issues, such as risk maturity models, machine learning applications, and proactive risk identification frameworks. Additionally, studies emphasize the importance of effective communication, stakeholder collaboration, and innovative technologies like BIM in enhancing project performance. Addressing these challenges through structured risk management and data-driven decision-making can lead to improved efficiency, reduced delays, and overall project success. Future research should focus on refining existing models and exploring emerging technologies to further enhance risk mitigation and project execution in the construction industry.

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