

EVALUATING RISK FACTORS AND THEIR IMPACT ON SAFETY, COST, AND TIME PERFORMANCE IN HIGH-RISE BUILDING CONSTRUCTION

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Abstract

The nature of high-rise building construction projects is complicated and prone to a number of risks that have a high impact on safety, cost and time performance. The purpose of this study was to assess some of the risk variables that determine the project performance in the high-rise construction industry. The quantitative design was embraced, and the 100 construction professionals were asked to be sampled using a structured questionnaire. Descriptive statistics, correlation, and regression techniques were used in the analysis of the data. The findings revealed that the most important risks were the safety risks, financial risks, labor risks, and regulatory risks. The risk factors and the project performance issues were observed to be in a strong positive relationship with the level of risks being high resulting in increased accidents, cost overruns, and delays. Regression analysis also found out that safety and labor risks affect the performance in terms of safety, cost in terms of financial and design risks and regulatory and environmental risks in the project schedules. The Research has found that there is a strong need to have well-coordinated and comprehensive risk management measures in order to enhance safety, cost control, and time-based supply of high-rise construction projects.

Keywords: Risk Analysis, High-Rise Construction, Safety, Cost Overrun, Time Delay, Project Performance.

1. INTRODUCTION

The high population rate of urban centers all over the world has substantially necessitated the high rise infrastructure especially buildings. Vertical expansion has been an option that has been established to facilitate residential, commercial and mixed-use developments in urban areas limited in land and where it is expensive to buy land. However, high-rise construction works are complex as by their nature, owing to their size, technological demands and the number of stakeholders involved such as architects, engineers, contractors, consultants, and the regulatory authorities. This multiplicity lays more risks on such projects which can negatively influence the project performance.

Safety, cost, and time are the three important parameters that normally limit construction projects. Any failure in these parameters may cause either failure of the project or inefficiency. Due to structural requirements, height and complex construction procedures, high-rise buildings are especially susceptible to the uncertainties. Such uncertainties can be caused by technical, financial, environmental and regulatory factors and human factors. Consequently, the key to successful completion of the project is the proper identification, assessment, and management of risk.

1.1 Concept of Risk in Construction Projects

Risk in construction is the likelihood of the events of uncertainty that may either have a positive or negative impact on a project that are irregular. Negative risks that are mainly identified in the high-rise construction are risks related to safety, cost increases, and delays. These risks can either be internal like bad planning, poor resource allocation, and unskilled labor, or external like changes in market fluctuations, environmental uncertainties and changes in policies.

All the construction risks can be divided into various types, which are technical risks, financial risks, operational risks, environmental risks, and managerial risks. As an example, technical risks can entail design problems or construction problems whereas financial risks can entail inflation, funding or cost estimation problems. Equally, there are operational risks caused by failure of machinery or lack of productivity by employees. The initial step to successful risk management is to understand the nature and origin of these risks.

1.2 Importance of Risk Management in High-Rise Construction

The risk management will be important in reducing uncertainties as well as increasing the chances of the project success. In high-rise construction where there is very limited room between the edge and the cliff, the risk management must be proactive to guarantee safety, keep the budget within check, and the project timelines. Successful risk management entails orderly steps like identification, risk analysis, risk evaluation and mitigation of risks.

Among the most risk-related areas, the safety of workers should be considered as one of the most important since high-rise construction areas are highly likely to give rise to accidents, because of height work, heavy machinery, and complicated operations. Also, cost management is essential since unexpected risks may result in major budget increases. Time management is also necessary because errors in timely completion of a project may lead to loss of money and contract penalties.

Incorporation of the modern technologies like Building Information Modeling (BIM), Artificial Intelligence (AI), and new project management software have greatly enhanced the possibilities to forecast and control risks. The technologies are useful in enhancing planning, real-time monitoring, and efficient communication between the stakeholders thus reducing uncertainties as well as enhancing the outcomes of the projects.

1.3 Scope and Objectives of the Study

This research undertaking dwells on analyzing the key risk factors that affect the safety, cost, and time performance of the building construction project in high-rise buildings. It tries to find out which risks should be considered as the most severe and the way these risks affect the overall project performance. The research also aims at analyzing the interaction between various categories of risks and how they all impact the outcome of projects.

The objectives of the study are specific and they are:

- To determine the major risk factors of construction projects on high rises.
- To measure the effects of such risks on safety, cost and time performance.
- To examine the correlation between the various categories of risk.
- To propose powerful risk mitigation strategies to enhance the performance of the project.

At the realization of these objectives, the study aims at offering very useful information to construction professionals, project managers, and policymakers so that they can make knowledgeable choices and embrace sound risk management practices when undertaking high-rise construction projects.

2. REVIEW OF LITREATURE

In a study, Rajeshkumar and Sreevidya (2019) aimed at assessing the performance of various formwork systems on the construction of high-rise buildings. The authors used regression analysis to test the connection between the decision to use formwork and the success of the project. According to their findings, the formwork type had a profound effect on the construction efficiency, cost and duration of the project. The research focused on highlighting how inappropriate choices of formwork systems contributed to higher risks of the project that manifested through project delays and budget overruns, hence overall performance of the project.

With a database-aided design approach, Saini et al. (2024) examined the performance of the high-rise buildings. The research was conducted on combining past project information and sophisticated analytical systems in order to enhance decision-making in construction planning. The researchers realized that data-driven design plans improved structural safety, minimized uncertainties and project outcomes. In their work, they emphasized the importance and criticality of risk factors that could adversely affect the safety and the overall performance of a building due to inadequate design assessment and the use of data.

Tayyab et al. (2023) also examined issues that affect cost overruns in high-rise building construction in India. The research concentrated on major factors including bad project planning, change in price of materials, inefficiency in labor and delay in approvals. The results showed that managerial and financial risks were the major factors that escalated the cost of projects. The conclusion of the authors was that the effective risk management measures and better coordination among stakeholders was the key to reduce the cost overruns and increase project efficiency.

Tripathi and Mittal (2025) carried out a research on risk assessment and prioritization of occupational risks in the building of high-rise buildings in India. The researchers came up with a methodology to determine and rank safety-related risks through structured evaluation methods. Their results showed that working at heights, accidents involving equipment and poor safety measures were some of the most severe occupational hazards. The research noted that risk ranking and proactive safety planning were both improperly done and contributed to the increased chances of accidents and poor performance of the project. It was ruled that the high-rise would need to have effective risk assessment structures to enhance the safety outcomes.

The study by Vahedi Nikbakht et al. (2024) aimed to determine the factors that lead to delay risks during high-rise construction projects through the application of multi-criteria decision-making approaches, including the Analytic Hierarchy Process (AHP) and VIKOR methods. The paper has found some of the key delay-causing elements such as ineffective planning of the project, ineffective resource distribution, budgetary constraints, and regulatory permission. The findings revealed that managerial and financial risks were the greatest contributors to the project delays. The authors emphasized that the adoption of the latest decision-making tools allowed more precise prioritization of the risks and contributed to the improvement of the best project management practices.

3. RESEARCH METHODOLOGY

The current research used a systematized methodology to measure the risk factors that affect high-rise building construction and to examine how the factors affect safety, costs, and time performance. The methodology was developed in a way that would give logical consistency, empirical validity and analytical rigor.

3.1 Research Design

This study assumed descriptive and analytical design. The descriptive part helped in identifying and categorizing different risk factors that were involved in high-rise building projects. The relationships between the mentioned risk factors and the main project performance measures, such as safety, cost, and time, were analysed with the help of the analytical component.

3.2 Research Approach

This study took a quantitative research approach. This method allowed gathering systematic data and using statistical methods to estimate the extent of influence of determined risk factors on the project performance. The study was quantitative in nature thus making it objective and also enabling the generalization of results.

3.3 Sources of Data

It was a study whose foundation was on both primary and secondary data.

A structured questionnaire was used to collect primary data by sending the questionnaire to construction professionals working on high-rise building projects. The questionnaire was developed based on a five-point Likert scale in order to facilitate the perceptions of the respondents towards different risk factors and their effects.

The secondary data were collected in the form of peer-reviewed journals, books, conference papers, and industry reports in the area of construction risk management and high-rise building projects. These sources were a theoretical basis and helped in the formulating of the research structure.

4.4 Sampling Design

The purposive sampling method was used to identify respondents with the pertinent knowledge and experience in the high-rise construction projects. It used the sample of civil engineers, project managers, contractors, site supervisors, and safety officers.

The study was conducted on 100 respondents. This was deemed to be sufficient to carry out statistical analysis and make meaningful conclusions.

3.5 Variables of the Study

The variables involved in the study were as follows:

- Independent Variables (Risk Factors): Design and technical risks, financial risks, labor risks, safety risks, environmental risks and regulatory risks.
- Dependent Variables (Project Performance Indicators): Cost performance, performance in terms of time and safety performance.

3.6 Instrument Design

The research instrument was structured questionnaire that was split into a number of sections. The initial section involved demographic data of the respondents whereas the following sections involved the quantification of the severity and impact of various risk factors.

All the questions of the questionnaire were to be evaluated on the five-point Likert scale, which includes strongly disagree and strongly agree. To make sure that the instrument is clear, relevant, and content valid, the subject experts reviewed it.

3.7 Data Analysis Techniques

The data obtained were examined with the help of the relevant statistical software to fulfill the research objectives:

- The average and standard deviation of risk factors were calculated with the help of Descriptive Statistics.
- Correlation Analysis was performed to evaluate the directions and strengths of the relationship between the risk factors and the performance indicators.
- The Multiple Regression Analysis was used to determine how the independent variables influenced the dependent variables and the most significant ones.

3.8 Reliability and Validity of the Instrument

The consistency of the questionnaire was also measured through the use of the Cronbach Alpha coefficient that ensured internal consistency of the measurement items. A value above 0.7 was considered to be acceptable reliability.

The validity was also achieved by the expert judgment and the compatibility of the questionnaire items with the research objectives and constructs. This assisted to ensure content and construct validity.

3.9 Ethical Considerations

Strict ethical standards were observed when conducting the research. Respondents were recruited on a voluntary basis and an informed consent was given before collecting data. The respondents kept their privacy and anonymity and the information gathered in the study was exclusively academic.

4. DATA ANALYSIS AND RESULT

This subdivision provides the statistical analysis of the data gathered with the participation of 100 respondents engaged in high-rise construction projects. The analysis is aimed at defining important risk factors and investigating their influence on the safety, cost and time performance through descriptive statistics, correlation and regression analysis.

4.1 Descriptive Analysis of Risk Factors

The significance of different risk factors was tested with the help of descriptive statistics involving the means value and standard deviation.

Table 1: Descriptive Statistics of Risk Factors

Risk Factor	Mean	Standard Deviation	Interpretation
Safety Risks	4.35	0.62	Highly Significant
Financial Risks	4.20	0.70	Highly Significant
Labor Risks	4.10	0.65	Significant
Design & Technical Risks	3.95	0.72	Moderate
Regulatory Risks	3.85	0.75	Moderate
Environmental Risks	3.70	0.80	Moderate

The findings revealed that the highest mean score was safety risks followed by the financial and labor risks. This implied that the most serious issue in high-rise buildings constructions was the safety related concerns.

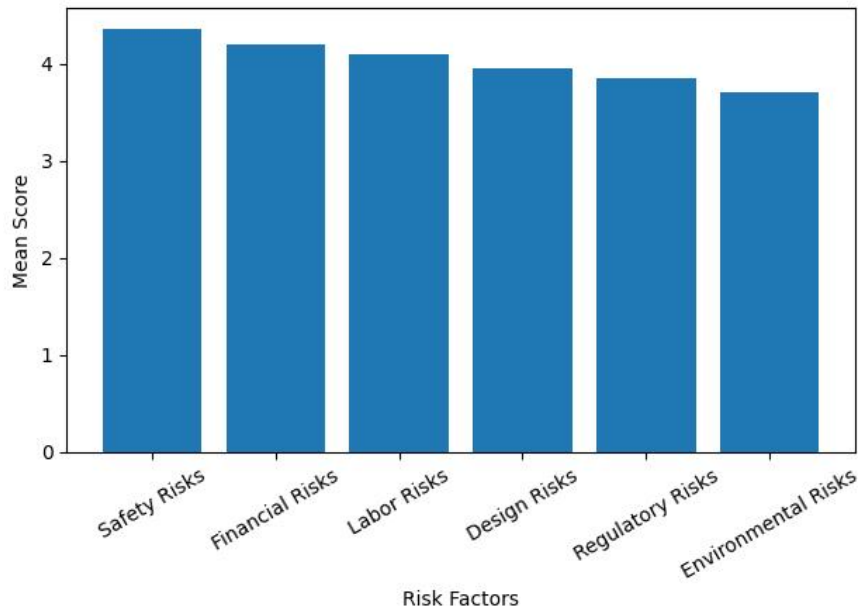


Figure 1: Mean Score Distribution of Risk Factors

The graphical presentation revealed a clear indication that safety and financial risks prevailed over other risk factors, which are very influential in project performance.

4.2 Impact of Risk Factors on Project Performance

Correlation analysis was used to determine the relationship between the risk factors and the performance indicators.

Table 2: Correlation Analysis between Risk Factors and Performance Variables

Variables	Correlation Coefficient (r)
Safety Risks – Safety Issues	0.78
Financial Risks – Cost	0.72
Regulatory Risks – Time	0.69
Labor Risks – Safety	0.74
Design Risks – Cost	0.68

Correlation outcomes indicated that risk factors have strong positive results with performance indicators. The most correlated were safety issues, which were associated with safety risks and cost overruns, which were highly impacted by financial risks.

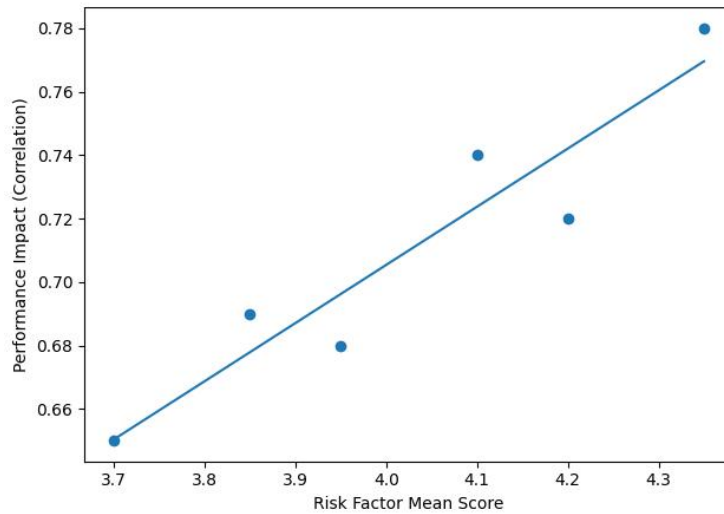


Figure 2: Correlation between Risk Factors and Project Performance

The scatter plot revealed that there was a positive linear relationship whereby deterioration of project performance was related to increase in the risk levels.

4.3 Regression Analysis

The analysis was conducted using multiple regression analysis to identify the effects of risk factors on the aspect of safety, cost and time output.

Table 3: Regression Analysis Results

Dependent Variable	Significant Predictors	Beta Value	Significance (p-value)
Safety Performance	Safety Risks, Labor Risks	0.62, 0.55	< 0.05
Cost Performance	Financial, Design Risks	0.58, 0.49	< 0.05
Time Performance	Regulatory, Environmental	0.60, 0.52	< 0.05

The outcomes of regression established that safety and labor risks had significant influence on the safety performance. Cost overruns were caused by financial and design risks and regulatory and environmental risks were the leading causes of project timelines.

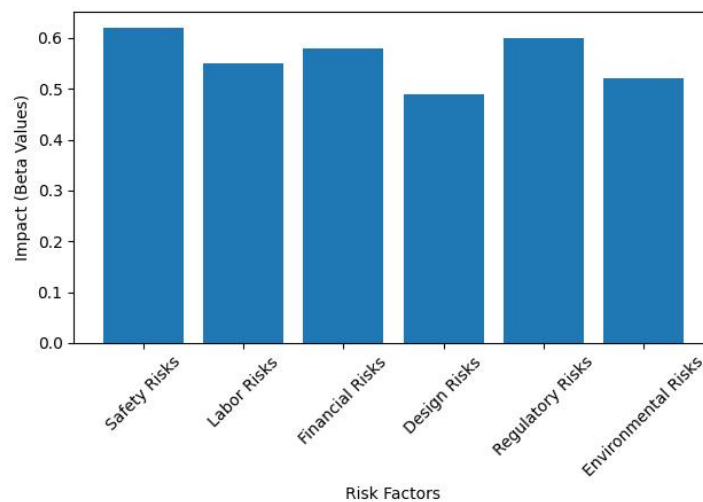


Figure 3: Impact of Risk Factors on Safety, Cost, and Time

The figure depicted the relative effects of the various risk factors on performance indicators, since various risks affected various project outcomes.

4.4 Reliability Analysis

Cronbachs Alpha was used to test the reliability of the questionnaire.

Table 4: Reliability Statistics

Variable Category	Cronbach's Alpha
Risk Factors	0.82
Safety Performance	0.79
Cost Performance	0.81
Time Performance	0.77

The values of Cronbach's Alpha were all above 0.7 meaning that there was high internal consistency and reliability of the data collection instrument.

4.5 Summary of Key Findings

The analysis revealed that:

- Safety risks were the most important factor that affected high-rise construction projects.
- Cost overruns were greatly attributable to financial risks.
- The main cause of time overruns was regulatory delays.
- All the risk factors were strongly positively related to the project performance problems.
- The statistical findings have proved the fact that efficient risk management is very vital in enhancing safety, cost and completion time.

5.DISCUSSION

The purpose of the current study was to assess the effect of different risk factors on the high-rise building construction projects on safety, cost, and time performance. The results of descriptive, correlation, and regression analyses were meaningful to understand how risk management is a key to project success.

The descriptive analysis showed that the most important risk was the safety risk, then it was the financial risk and the labour risk. This observation was in line with the results of a study conducted by Tripathi and Mittal (2025), who pointed out that occupational risks that included working at height, equipment risks, among others were one of the most urgent issues during high-rise construction. Likewise, other research papers by Manzoor et al. (2021, 2022) also highlighted that the number of accidents and disruption of project settings mainly occurs due to safety-related risks. The mean value of the safety risks in the current research was high, which indicated that the safety of workers is one of the main concerns in high-rise construction work.

The correlation analysis revealed that there was a strong positive relationship between project performance indicators and risk factors which implies that higher degree of risk causes negative impacts on safety, cost and time. This result was in line with the research by Tayyab et al. (2023), who found financial and managerial risks to be among the significant causes of cost overruns. The high relationship between financial risks and cost performance in the current study was also a testimony that the effect of poor financial planning, change in prices and mismanagement of resources had huge influence on project budgets.

The regression analysis showed more insights on the predictive effect of the various risk factors. Safety and labor risks have been identified to have a significant effect on the safety performance and therefore human factors and working conditions are critical in preventing accidents. The findings confirmed the conclusions of Li et al. (2018), who highlighted the significance of safety management practices and training of the workforce in minimizing the construction hazards.

In addition, the design and financial risks were detected as the key cost performance determinants. This corresponded with the conclusions made by Rajeshkumar and Sreevidya (2019), who have shown that design-

related decisions, including the choice of formwork, have a direct influence on controlling cost and efficiency in construction. The lack of planning in the design process and technical failures are likely to result in the rework and, thus, higher costs of a project.

Regulatory and environmental risks were found to be the most important in terms of time performance. Such an observation matched Vahedi Nikbakht et al. (2024), who also listed regulatory approvals and inefficient planning as major contributors to the postponement of the projects. Other environmental unpredictabilities like weather and site restrictions also contribute to the scheduling problems in high rises.

In general, the research has emphasized that risk factors are interdependent and have an overall effect on the result of the projects. Problems with safety may create delays, high costs, whereas financial limitations may affect the quality of safety and compromise the standards of safety. This interrelationship highlighted the importance of having an integrated approach of risk management, as opposed to viewing risks as independent entities.

The results also supported the need to implement the latest technologies like Building Information Modeling (BIM) and data-based decision-making that Saini et al. (2024) recommend. The tools have the potential of improving the prediction of risks, accuracy in planning and coordination among stakeholders.

Finally, it was determined in the discussion that appropriate risk management is critical in enhancing safety, cost control, and timely construction of high-rise buildings. The research made a contribution to the current literature by giving a combined analysis of the risk factors and their combined effect on key performance indicators.

6. CONCLUSION AND RECOMMENDATIONS

The current research thoroughly assessed the most critical risk factors on the high-rise building construction project in terms of safety, cost, and time. It was found that safety risks were considered to be the most crucial ones, then there were financial, labor, and regulatory risks which greatly affected the overall performance of a project. The statistical analysis proved that these risk factors are highly interconnected and their combination creates the effect of project delays, cost overruns, and safety incidents. The paper has also pointed out that insufficient planning, financial mismanagement and absence of effective safety controls continue to present significant issues in the construction of high-rises. Moreover, the findings demonstrated the need to use a proactive and combined risk management strategy to reduce uncertainties and maximize the efficiency of the project. In general, the research achieved some important input to the construction professionals in the sense that it proved that proper risk identification, assessment, and mitigation are fundamental in attaining successful and sustainable project outcomes.

- **Introduction of Advanced Safety and Risk Management Systems:** Construction companies must embrace the end-to-end safety management, routine risk evaluation, and constant monitoring systems to reduce accident cases and enhance the safety of workers, particularly in high-rise construction projects.
- **Enhancing Financial Planning and Resource Management:** Correct budgeting, cost control procedures and effective resource allocation must be done to minimize cost overruns and improve financial stability within the project life cycle.
- **Implementation of New Technologies and Regulatory Adherence:** Adoption of modern technologies, including Building Information Modeling (BIM), AI-powered monitoring systems, and enhanced collaboration with regulatory bodies can be used to contribute to minimizing delays and enhancing the performance of the project, in general.

REFERENCES

1. Ahn, H., Son, S., Park, K., & Kim, S. (2022). Cost assessment model for sustainable health and safety management of high-rise residential buildings in Korea. *Journal of Asian Architecture and Building Engineering*, 21(3), 689-700.
2. Ansari, R., Dehghani, P., Mahdikhani, M., & Jeong, J. (2022). A novel safety risk assessment based on fuzzy set theory and decision methods in high-rise buildings. *Buildings*, 12(12), 2126.
3. Balkis, A., Janani, M. S., & Gandhi, A. M. (2021). A study on critical risk assessment and safety management for a high rise building. *International Research Journal of Engineering & Technology (IRJET)*, 8(4), 324-331.
4. Chen, H., Mao, Y., & Wang, R. (2024). Safety risk prediction model of high-rise building construction based on key physiological index. *Buildings*, 14(12), 3795.
5. Haslinda, A. N., Xian, T. W., Norfarahayu, K., Hanafi, R. M., & Fikri, H. M. (2018, April). Investigation on the factors influencing construction time and cost overrun for high-rise building projects in penang. In *Journal of Physics: Conference Series* (Vol. 995, No. 1, p. 012043). IOP Publishing.

6. Kilintan, K., Perera, B. A. K. S., Kajavathani, P., Sandanayake, Y. G., Gunatilake, S., & Waidyasekara, K. G. A. S. (2022, June). Factors affecting construction time performance in high-rise building projects in Sri Lanka. In *Proceedings of the 10th World Construction Symposium* (pp. 492-505).
7. Li, Y., Ning, Y., & Chen, W. T. (2018). Critical Success Factors for Safety Management of High-Rise Building Construction Projects in China. *Advances in Civil Engineering*, 2018(1), 1516354.
8. Manzoor, B., Othman, I., & Manzoor, M. (2021). Evaluating the critical safety factors causing accidents in high-rise building projects. *Ain Shams Engineering Journal*, 12(3), 2485-2492.
9. Manzoor, B., Othman, I., & Waheed, A. (2022). Accidental safety factors and prevention techniques for high-rise building projects—A review. *Ain Shams engineering journal*, 13(5), 101723.
10. Pham, H. C., Tran, S. V. T., & Lee, U. K. (2025). Prioritizing Critical Factors Affecting Occupational Safety in High-Rise Construction: A Hybrid EFA-AHP Approach. *Buildings*, 15(15), 2677.
11. Rajeshkumar, V., & Sreevidya, V. (2019). Performance evaluation on selection of formwork systems in high rise buildings using regression analysis and their impacts on project success. *Archives of Civil Engineering*, 209-222.
12. Saini, D., Dokhaei, B., Shafei, B., & Alipour, A. (2024). Performance evaluation of high-rise buildings using database-assisted design approach. *Structural Safety*, 109, 102447.
13. Tayyab, M., Furkhan, M., Rizwan, M., Jameel, M., & Chadee, A. (2023). A study on factors influencing cost overrun in high-rise building construction across India. *Journal of Smart Buildings and Construction Technology* | Volume, 5(01).
14. Tripathi, P., & Mittal, Y. K. (2025). Risk assessment and ranking methodology for occupational hazards in construction: a case of Indian high-rise projects. *Smart and Sustainable Built Environment*, 14(6), 1927-1949.
15. Vahedi Nikbakht, M., Gheibi, M., Montazeri, H., Yeganeh Khaksar, R., Moezzi, R., & Vadiee, A. (2024). Identification and ranking of factors affecting the delay risk of high-rise construction projects using AHP and VIKOR methods. *Infrastructures*, 9(2), 24.