

Systematic Review of Hazard Identification and Risk Control Practices in Urban Construction Projects

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Abstract- This systematic review examines hazard identification and risk control practices in urban construction projects. Urban construction projects inherently face a complex range of risks due to the dynamic nature of the urban environment, including challenges related to site conditions, regulatory compliance, worker safety, and environmental impacts. The aim of this review is to critically analyze existing methodologies and practices for hazard identification, risk assessment, and risk control in urban construction settings. The study synthesizes findings from various research studies, industry reports, and case studies, highlighting the techniques employed to identify hazards, the tools used for risk assessment, and the control measures implemented to mitigate risks. Furthermore, the review evaluates the effectiveness of these practices in reducing accidents and enhancing safety performance. It also identifies gaps in current research and provides recommendations for improving risk management frameworks in urban construction projects. The paper concludes by suggesting a unified approach that integrates technological innovations, regulatory frameworks, and industry best practices to enhance safety standards and minimize risks in future urban construction projects.

Keywords: Hazard Identification, Risk Control, Urban Construction, Safety Practices, Risk Management, Construction Safety.

I. INTRODUCTION

1.1 Overview of Urban Construction Projects

Urban construction projects involve the development of infrastructure within densely populated areas, such as residential, commercial, and industrial buildings, roadways, bridges, and public facilities. These projects often present unique challenges due to the complexities of working within an existing urban environment. Factors such as limited space, transportation constraints, regulatory requirements,

and the proximity to existing structures make urban construction significantly different from rural or suburban projects (Oziri, Arowogbadamu, & Bibire, 2018). For instance, the construction of high-rise buildings in densely populated areas often requires advanced engineering solutions, such as foundation reinforcement and structural stabilization, to mitigate risks related to ground stability and building safety (Nwafor, Uduokhai, Desmond Stephen, & Aransi, 2019).

Urban construction also requires close coordination between various stakeholders, including contractors, local authorities, engineers, and architects. The complex and dynamic nature of these projects necessitates a high level of planning, resource management, and risk mitigation strategies to ensure timely delivery and adherence to safety standards (Oziri et al., 2018). The implementation of technologies like Building Information Modeling (BIM) and Geographic Information Systems (GIS) has significantly improved project management by facilitating real-time monitoring, data integration, and enhanced communication across project teams. However, despite these advancements, urban construction projects continue to face significant risks related to worker safety, environmental impact, and community disruption, making risk management a critical aspect of their successful execution (Nwafor et al., 2019).

1.2 Importance of Hazard Identification and Risk Control

Hazard identification and risk control are crucial elements of any construction project, particularly in urban environments where the impact of risks can be more severe due to the high concentration of people,

infrastructure, and businesses. Effective hazard identification is the foundation of risk management, as it allows construction teams to anticipate and mitigate potential dangers before they escalate into accidents or incidents (Oziri et al., 2018). The complexity of urban construction sites means that hazards can arise from a variety of sources, including site conditions, construction materials, equipment failure, and human factors. Identifying these hazards early in the project enables the development of targeted risk control measures that can significantly reduce the likelihood of accidents, ensuring the safety of workers, the public, and the environment (Nwafor et al., 2019).

Risk control involves implementing strategies to minimize or eliminate identified hazards. This can range from the application of engineering controls, such as structural reinforcements and machinery safeguards, to administrative controls, such as safety training and work procedures (Oziri et al., 2018). In urban construction, the importance of these practices is underscored by the increased exposure to risks that urban environments present, such as traffic-related accidents, noise pollution, and exposure to hazardous substances. Moreover, efficient risk control practices contribute to the overall success of a project by preventing delays, reducing costs associated with accidents, and ensuring compliance with regulatory standards. As such, the integration of hazard identification and risk control practices is not only essential for safety but also for the sustainability and efficiency of urban construction projects (Nwafor et al., 2019).

1.3 Scope and Objective of the Review

This review aims to provide a comprehensive examination of the practices and methodologies used for hazard identification and risk control in urban construction projects. It focuses on assessing various techniques and tools implemented in urban construction environments to manage potential risks. The scope encompasses a detailed analysis of hazard identification methods, such as site inspections, audits, and the integration of emerging technologies like Building Information Modeling (BIM) and machine learning systems. Additionally, the review will evaluate the effectiveness of risk assessment models,

from qualitative approaches to advanced quantitative risk analysis. The objective is to not only examine current practices but also identify emerging trends that enhance safety measures, minimize risk exposure, and ensure compliance with regulatory standards in urban settings. By providing a systematic overview of these practices, the review seeks to highlight both successful approaches and areas where further improvement is needed, offering recommendations for enhancing risk management strategies in future urban construction projects.

1.4 Structure of the Paper

The paper is organized to provide a systematic and thorough examination of hazard identification and risk control in urban construction projects. Section 2 focuses on hazard identification practices, outlining the techniques employed to detect and assess potential risks in urban construction settings. It also addresses the challenges faced by construction professionals in identifying hazards in a complex and dynamic urban environment. Section 3 discusses risk assessment approaches, presenting various models and tools used to evaluate risks, prioritize them, and determine appropriate mitigation strategies. It also explores the limitations of traditional risk assessment techniques and introduces newer, more data-driven approaches. In Section 4, the review covers risk control measures, detailing strategies for mitigating identified risks, such as engineering controls, administrative measures, and the use of personal protective equipment. Section 5 provides real-world case studies of urban construction projects where effective hazard identification and risk control practices have been applied, offering practical insights into the challenges and successes encountered. Finally, Section 6 concludes the paper by summarizing key findings and providing recommendations for future research and practice, emphasizing the importance of continuous improvement in urban construction safety management.

II. METHODOLOGY

2.2 Inclusion and Exclusion Criteria

2.1 Search Strategy

The search strategy for this systematic review involved identifying relevant literature from multiple databases, including Scopus, Web of Science, and Google Scholar. The search focused on peer-reviewed articles, conference papers, and industry reports from 2015 to 2019. The search terms included combinations of "hazard identification," "risk control practices," "urban construction," "construction safety," and "risk management," ensuring the inclusion of studies from various geographical regions. Specific keywords such as "urban construction safety" and "risk management frameworks" were also used to filter articles that addressed the unique challenges of construction sites in urban areas. To guarantee a comprehensive search, references from prominent journals in the field of construction safety, management, and risk analysis were included.

Inclusion criteria were studies that specifically addressed hazard identification and risk control in urban construction projects. These studies had to be empirical or case study-based and provide detailed methodologies on risk management practices. Furthermore, studies focusing on the application of new technologies such as AI and machine learning in risk management were prioritized, as these innovations are becoming increasingly relevant in urban construction (Tawose et al., 2015; Farounbi et al., 2018). Exclusion criteria involved excluding studies that did not focus on urban environments, were not related to construction, or lacked relevance to hazard identification and risk control. Studies in languages other than English were also excluded to maintain consistency in analysis (Oziri et al., 2018; Farounbi et al., 2019).

The inclusion criteria for this review were strictly defined to ensure a comprehensive evaluation of hazard identification and risk control practices in urban construction projects. Studies included had to explicitly focus on urban construction settings and involve a clear methodological approach to hazard identification, risk assessment, and control. Empirical research, including case studies, field experiments, and reviews that discussed practical implementations of risk control systems, were prioritized. Additionally, the review aimed to include studies that provided quantitative or qualitative evidence of the effectiveness of risk management practices and that involved stakeholders in urban construction projects (Oziri et al., 2018; Nwafor et al., 2019). Studies from international construction projects were also considered to identify best practices that could be applied universally.

Exclusion criteria were established to narrow down the scope of the review. Articles that lacked a focus on urban construction or failed to include hazard identification or risk control methodologies were excluded. Additionally, studies that did not provide specific data or evidence on the effectiveness of risk management practices in real-world urban construction environments were omitted (Tawose et al., 2016; Okonkwo et al., 2018). The review also excluded theoretical studies that lacked empirical data or case study evidence as seen in Table 1. Furthermore, articles not written in English, as well as papers older than 2015, were excluded to ensure the relevance of the review to current urban construction practices and technologies (Efobi et al., 2017; Farounbi et al., 2019).

Table 1: Inclusion and Exclusion Criteria for Hazard Identification and Risk Control Practices in Urban Construction Projects

Inclusion Criteria	Exclusion Criteria	Rationale	Examples
Focus on urban construction settings	Lack of focus on urban construction	Ensures relevance to urban environments with specific construction challenges	Studies on rural or non-urban projects

Inclusion Criteria	Exclusion Criteria	Rationale	Examples
Studies with clear methodological approach to hazard identification, risk assessment, and control	Studies without hazard identification or risk control methodologies	Ensures comprehensive evaluation of hazard management practices	Articles discussing general safety without specific methods
Empirical research, including case studies, field experiments, and practical implementations	Studies without specific data or real-world evidence on risk management effectiveness	Prioritizes studies that provide practical insights into real-world risk control	Theoretical studies without empirical data
Quantitative or qualitative evidence of the effectiveness of risk management practices	Studies not written in English or published before 2015	Ensures inclusion of current, accessible, and applicable research	Non-English articles or outdated research (pre-2015)

2.3 Data Extraction and Synthesis

Data extraction for this systematic review followed a structured approach to ensure that relevant information was captured efficiently from the included studies. Key data points extracted included the study objectives, methods of hazard identification, risk control measures applied, and the outcomes or results of the risk management interventions. Additional details such as sample size, geographic location of the study, and industry sector were also recorded to identify patterns across different types of urban construction projects (Nwafor et al., 2018; Okeke et al., 2019). Studies that employed new technologies such as AI or machine learning for risk management were given special attention due to their growing significance in construction safety (Odejobi et al., 2019; Farounbi et al., 2019).

Data synthesis involved grouping the extracted data into themes corresponding to the different aspects of hazard identification, risk assessment, and control measures. The studies were analyzed to identify common practices and technologies employed across different urban construction settings. Comparative analysis was conducted to evaluate the effectiveness of various risk control strategies, including traditional and innovative approaches (Tawose et al., 2015; Evans-Anoruo et al., 2018). The synthesis process also highlighted gaps in existing research and areas where further studies are needed to improve hazard identification and risk control practices in urban

construction projects (Nwafor et al., 2019; Liadi et al., 2019).

III. HAZARD IDENTIFICATION PRACTICES IN URBAN CONSTRUCTION

3.1 Common Hazards in Urban Construction Sites

Urban construction projects are inherently hazardous due to the complex and dynamic nature of the built environment. One of the most prevalent hazards on construction sites is the risk of falls from height, which remains a leading cause of fatalities in the construction industry (Tawose, 2016; Oziri et al., 2018). These incidents often occur due to the absence of fall protection systems, inadequate scaffolding, or improperly trained workers. Similarly, the risk of structural collapses, especially in areas with unstable soil or old buildings being renovated, is also a significant concern (Efobi et al., 2017; Farounbi et al., 2019). This type of hazard can lead to severe injuries or fatalities, particularly in densely populated urban areas where construction work occurs in close proximity to existing structures and pedestrians.

Additionally, hazardous materials such as asbestos, lead, and chemicals used for painting and coating pose risks to workers and the surrounding community (Odejobi et al., 2018; Nwafor et al., 2019). Exposure to such materials can result in chronic health conditions, including respiratory diseases and cancer. Another major hazard is vehicle and machinery-related accidents, with construction vehicles

frequently involved in collisions, run-over accidents, and machinery malfunctions (Nwafor et al., 2018; Okonkwo et al., 2018). These incidents can be exacerbated in crowded urban settings where traffic congestion and limited space make navigation difficult.

3.2 Techniques for Hazard Identification

Effective hazard identification is critical to ensuring the safety of workers and the public in urban construction sites. One commonly used technique is the Job Safety Analysis (JSA), which helps identify potential hazards before a task begins by systematically assessing each step of the operation (Okonkwo et al., 2018; Evans-Anoruo et al., 2018). This method allows construction managers to develop control measures tailored to the specific risks associated with the tasks being performed. Another technique is the Hazard and Operability Study (HAZOP), which is particularly useful in complex systems such as mechanical, electrical, and chemical

engineering systems often found in urban construction projects (Tawose, 2016; Farounbi et al., 2019). By examining the design and operation of systems, HAZOP identifies potential operational hazards and establishes the need for modifications.

Furthermore, the use of risk matrices and safety audits are instrumental in quantifying the likelihood and severity of identified hazards, allowing for prioritization of risk control measures (Oziri et al., 2018; Liadi et al., 2019). The integration of digital tools such as Building Information Modeling (BIM) is also gaining traction as an advanced method for hazard identification (Bello et al., 2019; Kevin, 2018) as seen in Table 2. BIM facilitates a comprehensive visual representation of construction projects, helping stakeholders to identify hazards through virtual simulation before physical work begins. The combination of these techniques ensures that all potential hazards are systematically identified and managed effectively.

Table 2: Summary of Techniques for Hazard Identification in Urban Construction Projects

Technique	Description	Application	Benefits
Job Safety Analysis (JSA)	A technique that systematically assesses each step of a task to identify potential hazards before the task begins.	Used for routine construction tasks to tailor control measures based on task-specific risks.	Allows proactive identification of hazards and development of tailored safety measures.
Hazard and Operability Study (HAZOP)	Focuses on complex systems to identify operational hazards by examining system design and operations.	Commonly used for mechanical, electrical, and chemical engineering systems in urban construction.	Helps identify design flaws and operational risks, leading to system modifications.
Risk Matrices & Safety Audits	Methods for quantifying the likelihood and severity of hazards, enabling the prioritization of risks and the implementation of control measures.	Applied throughout the project to ensure that the most critical hazards are addressed first.	Provides a structured way to prioritize hazards based on their risk levels.
Building Information Modeling (BIM)	A digital tool that creates a visual, virtual simulation of the construction project, aiding in hazard identification before physical work begins.	Used in early project planning and design phases to identify hazards in a virtual environment.	Enables early hazard identification and mitigation through detailed visualizations.

3.3 Challenges in Hazard Identification

Despite the availability of various hazard identification methods, several challenges remain in their effective application within urban construction sites. One primary issue is the lack of proper training and awareness among workers, which can lead to underreporting of hazards and improper use of safety equipment (Evans-Anoruo et al., 2018; Farounbi et al., 2019). In many cases, workers fail to recognize potential hazards, especially in environments where risk assessments are rushed or not conducted at all. This problem is compounded by the fast-paced nature of urban construction projects, which often prioritize speed over safety, leaving little room for thorough hazard identification (Odejebi et al., 2018; Michael & Ogunsola, 2019).

Another significant challenge is the complexity of urban construction environments, where multiple projects and contractors operate simultaneously, increasing the risk of hazard overlap and miscommunication (Nwafor et al., 2018; Tawose, 2016). The lack of standardized procedures for hazard identification across different construction firms further exacerbates this issue. Additionally, the constant changes in project scope and design modifications make it difficult to maintain accurate hazard assessments throughout the project's lifecycle (Sanni et al., 2018; Liadi et al., 2019). As such, an integrated approach that combines various hazard identification techniques with continuous monitoring is necessary to overcome these challenges and improve overall safety on urban construction sites.

IV. RISK ASSESSMENT APPROACHES

4.1 Risk Assessment Models

Risk assessment is a critical element of hazard management in urban construction projects. Various models are used to evaluate potential risks, ranging from qualitative methods to more advanced quantitative models. One common model employed is the Failure Mode and Effect Analysis (FMEA), which systematically evaluates the possible failures of a process and their consequences, helping prioritize risks based on severity and likelihood (Tawose, 2015).

Another widely used model is the Risk Matrix, which categorizes risks into different levels of severity, helping decision-makers identify high-priority hazards (Odejebi & Ahmed, 2018). The Fault Tree Analysis (FTA) also plays a crucial role in risk modeling by identifying the root causes of risk events and enabling better control strategies (Efobi, 2017). Moreover, the Monte Carlo Simulation method, a statistical tool used to model the probability of different outcomes, provides more precision in evaluating uncertain risks in urban construction projects (Morah, 2019).

These risk assessment models offer varying levels of detail and applicability, depending on the project's complexity and the risk being assessed. However, their implementation can be challenging. For example, the Bow-Tie Model provides both risk likelihood and consequences in a clear visual format, but it requires accurate data to be effective (Liadi, 2019). Additionally, while these models help prioritize hazards, they can sometimes fail to capture the dynamic interactions between different risks, which is crucial in urban construction projects where the environment constantly changes (Evans-Anoruo, 2019). Ultimately, risk assessment models must be integrated with real-time data and regular reviews to remain effective in preventing accidents and ensuring construction safety.

4.2 Tools and Methods for Risk Evaluation

Risk evaluation in urban construction projects is a multi-step process that incorporates several tools and methods to assess the severity, likelihood, and potential impact of identified hazards. One of the most frequently used tools is the Risk Register, which helps document all identified risks along with their evaluation, enabling a structured approach to risk management (Tawose, 2016). Other tools, such as the Hazard and Operability Study (HAZOP), allow for a systematic examination of processes to identify risks early, especially during the design phase (Odejebi & Ahmed, 2018). Additionally, Quantitative Risk Assessment (QRA) tools, such as the Event Tree Analysis (ETA), provide probabilistic models that assess the likelihood of different risk scenarios and their impacts on construction safety (Okonkwo, 2019).

Moreover, Geographic Information Systems (GIS) have gained significant attention in urban construction projects, particularly for spatial risk evaluation. GIS tools integrate hazard data with geographical information, enabling more precise risk analysis in large-scale urban projects (Uduokhai et al., 2018). Furthermore, the use of Artificial Intelligence (AI) and Machine Learning (ML) algorithms in risk evaluation is becoming increasingly popular. These tools analyze vast amounts of historical construction data to identify patterns and predict potential risks (Farounbi, 2019). Despite their usefulness, these methods are often criticized for their high costs and the need for specialized skills in handling complex datasets (Nwafor et al., 2018). Nevertheless, their potential to revolutionize risk management practices by providing accurate, data-driven risk assessments cannot be overstated.

4.3 Limitations of Current Risk Assessment Methods

Despite the advancements in risk assessment methods and tools, several limitations remain in effectively managing risks in urban construction projects. One significant limitation is the subjectivity in risk evaluation. Many models, such as the Risk Matrix, rely heavily on expert judgment, which can lead to inconsistent results, especially when different experts interpret data differently (Efobi, 2017). Additionally, data limitations pose a significant challenge. The accuracy of risk assessments is often contingent upon the quality and availability of data, and in urban construction, obtaining reliable data is frequently difficult due to the dynamic nature of the construction environment (Farounbi et al., 2019). Inadequate data can lead to inaccurate risk evaluations, which undermine the effectiveness of risk control measures.

Furthermore, lack of integration among different risk assessment tools is another limitation. While tools like FMEA, HAZOP, and Monte Carlo Simulation offer valuable insights, they are often used independently, without incorporating the results from other tools. This siloed approach reduces the overall efficiency and comprehensiveness of risk management efforts (Morah, 2019). Another challenge is the complexity of urban environments, which often makes it difficult to assess the full spectrum of risks that may arise. Risks

related to traffic, weather, and community engagement, for instance, may not be adequately captured by traditional risk assessment models (Michael et al., 2019). To address these limitations, it is crucial to continuously update risk assessment methods to reflect the evolving nature of urban construction projects and incorporate interdisciplinary approaches to risk evaluation.

V. RISK CONTROL MEASURES IN URBAN CONSTRUCTION

5.1 Control Hierarchy in Risk Management

In urban construction projects, an effective control hierarchy is essential for managing risks systematically. The hierarchy begins with hazard identification, followed by risk assessment, and concludes with risk control strategies. The first step in the hierarchy involves identifying potential hazards on construction sites, including structural risks, environmental risks, and safety risks (Tawose, 2015). Once hazards are identified, a risk assessment is performed to evaluate the potential impact and likelihood of these risks, ensuring that appropriate risk control measures are implemented (Efobi, Akinleye, & Fasawe, 2017). This process prioritizes the most critical risks, ensuring that resources are allocated effectively to mitigate them (Oziri, Arowogbadamu, & Bibire, 2018).

Effective risk control practices, based on the hierarchy, include eliminating hazards, substituting safer materials or processes, implementing engineering controls, and using personal protective equipment (PPE) (Farounbi, Okafor, & Oguntegbe, 2019). These measures are categorized as either preventive or corrective controls (Odejobi & Ahmed, 2018). The control hierarchy ensures that the most effective controls are implemented first, with less effective solutions being used as a last resort (Akindamola et al., 2018). According to Nwafor et al. (2018), incorporating a control hierarchy approach allows for a comprehensive safety culture, where decision-making processes are aligned with minimizing worker exposure to hazards, thereby promoting overall safety on construction sites.

5.2 Implementation of Safety Measures

The implementation of safety measures in urban construction projects requires careful planning and execution, integrating both proactive and reactive strategies. Effective safety measures encompass training programs, the use of advanced technology, and the enforcement of safety standards. According to Evans-Anoruo (2019), safety training ensures that workers are aware of potential hazards and the necessary precautions. It has been found that safety training not only reduces accidents but also enhances productivity by reducing downtime associated with workplace injuries (Gado, 2019). Furthermore, technological innovations, such as safety monitoring systems and real-time hazard detection technologies, have significantly improved the effectiveness of safety measures in urban construction settings (Babatope et al., 2019).

In addition to training and technology, safety regulations play a critical role in managing risks. Regulatory frameworks ensure that safety standards are adhered to, and they provide a basis for accountability (Tawose, 2016). Implementing these safety standards requires a collaborative effort from contractors, workers, and safety officers. Nwafor et al. (2019) highlight the importance of regulatory compliance, noting that projects with stringent adherence to safety regulations are less likely to experience delays or accidents. Moreover, the use of personal protective equipment (PPE), such as helmets, gloves, and protective footwear, remains a fundamental safety measure to prevent injuries in high-risk environments like construction sites (Michael, Ogunsola, & Oguntegbe, 2019).

5.3 Case Studies of Successful Risk Control

Case studies play a significant role in demonstrating the practical application of risk control measures in urban construction projects. One such case involved the construction of a high-rise building in Lagos, where a comprehensive risk control framework was implemented. This framework utilized hazard identification techniques, risk assessment methods, and a multi-layered approach to risk control, resulting in a notable reduction in accidents and downtime

(Akinola et al., 2018). The success of this project was attributed to the proactive use of safety protocols and continuous monitoring, which ensured that risks were identified and mitigated promptly (Odejebi & Ahmed, 2019). Additionally, the project benefited from regular safety audits, which helped in identifying potential risks early on and preventing accidents (Okonkwo, Ogunwole, & Okeke, 2018).

Another case study, involving a large infrastructure project in the Niger Delta region, highlighted the importance of integrating environmental considerations into risk control measures. The project faced significant environmental risks, such as flooding and soil erosion, which were mitigated through the use of sustainable construction practices and the implementation of flood control systems (Michael, Ogunsola, & Oguntegbe, 2019). The use of advanced modeling tools to predict and manage environmental impacts allowed for more effective risk control and improved the project's overall sustainability (Sanni, 2019). These case studies emphasize the importance of a holistic approach to risk control, where safety, environmental, and regulatory risks are all addressed simultaneously to ensure project success and worker safety.

VI. CONCLUSION AND FUTURE DIRECTIONS

6.1 Key Findings

The systematic review revealed several key findings related to hazard identification and risk control practices in urban construction projects. One of the most significant insights is the increasing reliance on technology, particularly Building Information Modeling (BIM) and machine learning, to identify and assess hazards. These technologies have proven to be effective in early-stage hazard detection, enabling real-time monitoring and predictive analytics. BIM, for instance, allows for the visualization of potential risks during the design phase, facilitating proactive mitigation strategies before construction even begins. Additionally, the review highlighted that despite technological advancements, traditional methods such as site inspections, safety audits, and worker safety reporting remain fundamental to hazard identification.

These methods, while time-consuming, still serve as critical components in ensuring site safety.

Another key finding is the inconsistency in the application of risk assessment models across different stages of urban construction projects. While some projects employ sophisticated quantitative methods, such as Monte Carlo simulations and fault tree analysis, others continue to rely on simpler, qualitative approaches like risk matrices. This disparity suggests a lack of standardized practices within the industry, which can lead to varying levels of effectiveness in risk management. Furthermore, the review found that the integration of risk control measures, such as engineering controls and administrative safety protocols, is highly dependent on project size, budget, and the regulatory environment. Larger projects tend to implement more comprehensive risk control measures, while smaller projects often struggle to allocate sufficient resources to safety management.

6.2 Gaps in Current Practices

Despite the advancements in hazard identification and risk control, several gaps in current practices were identified. One of the primary gaps is the lack of integration between hazard identification, risk assessment, and risk control measures. Often, these components are treated as separate stages, leading to disjointed safety management strategies. For instance, hazard identification may occur early in the project, but the information may not be effectively communicated to the teams responsible for risk assessment or control, causing delays in implementing appropriate mitigation strategies. Additionally, the review found that risk assessments are frequently based on outdated data or limited information, which can lead to inaccurate risk evaluations and, ultimately, ineffective risk control measures.

Another significant gap is the insufficient involvement of all stakeholders in the safety process. While construction managers, safety officers, and engineers are typically engaged in hazard identification and risk control, workers and subcontractors are often not actively involved. This lack of engagement can lead to a disconnect between the theoretical safety measures implemented by managers and the practical realities

faced on-site by workers. The review also identified a gap in the training and education provided to construction workers regarding hazard identification and risk control. Many workers still lack sufficient safety training, especially on the use of new technologies and advanced risk assessment models. This gap highlights the need for continuous education and training programs that emphasize safety culture and the importance of risk management at every level of the construction process.

6.3 Recommendations for Future Research and Practice

For future research and practice, several recommendations emerged from the review. First, there is a need for a more integrated approach to hazard identification, risk assessment, and risk control. Future research should explore how these components can be more effectively linked through digital platforms that enable real-time communication and data sharing across all project teams. For instance, integrating BIM with risk assessment tools and real-time monitoring systems could create a more seamless workflow, allowing for immediate updates to risk control measures as new hazards are identified. Moreover, the industry would benefit from standardized risk management frameworks that can be applied consistently across different project types, ensuring that all urban construction projects adhere to the same high safety standards.

In addition, future research should focus on the development of advanced predictive models that can anticipate emerging hazards in urban construction projects. These models could leverage machine learning algorithms and big data analytics to forecast risks based on historical data, environmental factors, and project-specific variables. Moreover, there is a need for more research into worker engagement in hazard identification and risk control processes. This includes exploring methods for involving workers in safety decision-making, as their firsthand experience on-site can provide valuable insights into real risks. Lastly, there should be a stronger emphasis on continuous worker education, particularly in the context of new technologies and risk management systems, to ensure that all stakeholders are equipped

with the knowledge and tools necessary to mitigate risks effectively.

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