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Risk Assessment and Control Measures for Scaffold-Related Work at Height

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Abstract

Scaffold-related work at height is a critical aspect of construction activities, but it also presents significant safety challenges due to the risk of falls, structural instability, and improper usage. This study focuses on the identification, analysis, and mitigation of hazards associated with scaffold use in construction environments. Through a structured risk assessment approach, the research evaluates common failure points such as inadequate foundation, improper erection and dismantling procedures, lack of guardrails, overloading, and human error. The project employs a combination of site inspections, worker interviews, and Job Safety Analysis (JSA) techniques to assess the risks involved. The findings reveal that the majority of scaffold-related incidents result from a combination of technical faults and non-compliance with safety procedures. In response, this study proposes a multi-layered control strategy including engineering controls (such as improved design and anchorage), administrative controls (like comprehensive training, supervision, and work permits), and the mandatory use of Personal Protective Equipment (PPE). A Scaffold Safety Checklist and a standardized Risk Assessment Matrix are developed as practical tools for on-site safety personnel. Recommendations emphasize the importance of enforcing scaffold inspection protocols, enhancing worker competence through training, and establishing a strong safety culture within construction teams. Systematically analyzing the risks and control measures, this study contributes to reducing accidents, improving scaffold stability, and promoting safe work practices at height. The outcomes serve as a foundation for safety managers, engineers, and regulatory bodies aiming to strengthen scaffold safety standards across construction projects.

Keywords: *Scaffold Safety, Work at Height, Risk Assessment, Job Safety Analysis (JSA), Control Measures in Construction Safety*

1. Introduction

Scaffold-related work at height is one of the most common activities in the construction industry, particularly in building and infrastructure projects. Scaffolding provides temporary support structures that allow workers to safely access elevated areas during construction, maintenance, and repair activities. Despite its importance, scaffold work is associated with significant safety risks, including falls from height, structural collapse, falling objects, and improper installation or usage. These hazards can lead to serious injuries, fatalities, and project delays if adequate safety measures are not implemented. Risk assessment plays a crucial role in identifying potential hazards associated with scaffold operations and evaluating the level of risk involved in each activity. By systematically analyzing workplace conditions, equipment stability, worker behavior, and environmental factors, organizations can develop effective control measures to minimize accidents and ensure worker safety. Implementing proper scaffolding standards, regular inspections, competent supervision, and worker training are essential components of an effective safety management system. This project focuses on identifying common scaffold hazards in construction sites and evaluating their associated risks [1-3]. The study also aims to propose practical control measures and safety strategies to reduce incidents and improve overall safety performance in scaffold-related activities.

2. Literature Review

Working at height is widely recognized as one of the most hazardous activities in the construction industry, particularly when scaffolding systems are used. Several researchers have studied the risks associated with scaffold-related work and proposed different strategies to improve safety performance. Nela Milenković (2025) emphasized the importance of implementing occupational safety and health measures in accordance with legal regulations and the ISO 45001:2018 standard. The study focused on identifying professional risks associated with work at heights above two meters and evaluating how organizations manage these risks. The findings showed that proper risk assessment, regular inspection of equipment, worker health monitoring, and effective emergency procedures play a crucial role in preventing accidents. The study concluded that organizations implementing structured occupational safety systems can significantly improve workplace safety. Deba Prasad Mishra and Nihal Anwar Siddiqui (2025) highlighted that approximately 40–45% of construction workers are engaged in work at height at any given time, making fall hazards a major concern. Their research discussed the use of horizontal lifeline systems as an engineering control to reduce fall risks. The authors also noted that despite having safety procedures, many organizations fail to implement them effectively due to lack of awareness and management commitment. Ignateva and Malyshkina (2024) stressed the importance of preventive measures such as guardrails, safety nets, fall arrest systems, worker training, and regular equipment inspection to minimize accidents during construction activities at height. Similarly, Yusoff and Heng (2024) identified unsafe behavior and fatigue among scaffolders as major contributors to accidents. Their study used the Fuzzy Delphi method to validate high-risk scaffolding tasks and highlighted the need for behavioral safety management. Further studies by Misnan and Mohamed (2024) emphasized the importance of allocating sufficient safety and health costs for scaffolding works to ensure proper planning and implementation of safety measures. Wang and Yao (2024) analyzed scaffold stability and concluded that structural factors such as bracing, vertical alignment, and base height significantly influence scaffold safety. Overall, these studies highlight that systematic risk assessment, engineering controls, training, and strong safety management practices are essential to reduce scaffold-related hazards.

3. Methodology

Site Selection
↓
Data Collection
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Job Safety Analysis (JSA)
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Risk Assessment
↓
Development of Control Measures
↓
Tool Development
↓
Validation
↓
Recommendation and Reporting

Figure 1 Methodology

3.1. Site Selection

Site selection is a crucial step in conducting a risk assessment study on scaffold-related work at height. The reliability and accuracy of the research findings largely depend on selecting appropriate construction sites that represent real working conditions. In this study, the selected sites were chosen based on specific criteria to ensure that they accurately reflected common scaffolding activities, hazards, and safety practices present in the construction industry. The main objective of the site selection process was to observe scaffold erection, usage, modification, and dismantling activities in active construction environments [4-6]. Five construction sites were selected for the study, representing different types of projects such as commercial buildings, residential apartments, industrial facilities, infrastructure maintenance, and institutional renovation works.

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These sites were chosen to capture a wide range of scaffold configurations including tubular scaffolds, frame scaffolds, suspended scaffolds, hanging scaffolds, and mobile scaffold towers. The inclusion of different scaffold systems allowed the study to examine various operational challenges and associated risks related to each scaffold type. Another important factor in site selection was the presence of high-risk activities such as façade work, plastering, painting, structural repairs, and maintenance tasks at elevated heights. Observing these operations provided valuable insights into the hazards faced by workers during routine scaffold use. Permission and cooperation from site management were obtained to allow safe access for observation and data collection. The selected sites provided a realistic representation of typical scaffold operations, enabling the research to effectively analyze risks and evaluate suitable control measures for improving safety in work-at-height activities [7-10].

3.2. Data Collection

Effective data collection forms the foundation of a reliable risk assessment and safety analysis. In this study on scaffold-related work at height, a systematic approach was adopted to gather both quantitative and qualitative data from selected construction sites. The primary objective of the data collection process was to identify potential hazards, evaluate existing safety practices, and analyze the effectiveness of control measures implemented during scaffold operations.
Three main data collection methods were used in this research:

- Site Inspections,
- Worker Interviews and Surveys,
- Document Reviews.

The integration of these methods ensured a comprehensive understanding of scaffold safety from technical, behavioral, and administrative perspectives. Site inspections served as the primary method for collecting field data. Observations were conducted at five different construction projects representing residential, commercial, industrial, infrastructure, and institutional works. During these inspections, various parameters were evaluated, including scaffold erection procedures, structural stability, access and egress systems, guardrails and toe boards, anchorage points, load management, and housekeeping conditions. A structured scaffold safety inspection checklist was used to ensure consistency in data recording. Measurements, photographs, and field notes were also taken to document observed conditions. Worker interviews and surveys were conducted to understand the human and behavioral aspects influencing scaffold safety. A total of 55 respondents, including 45 workers and 10 supervisors, participated in the survey. The questionnaire focused on safety awareness, training experience, use of personal protective equipment (PPE), hazard reporting practices, and perceptions of management commitment to safety. The third data collection method involved reviewing site safety documentation such as scaffold inspection logs, accident reports, training records, maintenance logs, and permit-to-work forms. A total of 35 documents were examined to verify whether safety procedures were properly recorded and implemented. The combination of these three methods provided a comprehensive dataset that supported accurate risk assessment and helped identify both technical deficiencies and organizational safety gaps in scaffold-related work at height.

3.3. Job Safety Analysis (JSA)

Job Safety Analysis (JSA) is an important risk management technique used to identify potential hazards associated with specific job tasks and to develop appropriate control measures to reduce risks. In construction activities involving scaffold-related work at height, JSA plays a critical role in improving worker safety and preventing accidents. Scaffolding is widely used to provide access and support for workers performing tasks such as plastering, painting, bricklaying, and maintenance at elevated levels. However, improper scaffold use, unstable structures, and unsafe work practices can lead to serious injuries or fatalities. The main objective of conducting a JSA is to break down scaffold-related activities into individual steps and identify hazards associated with each stage of the work. In this project, the JSA focused on four major phases of scaffold operations: erection, use, modification, and

Table 1 Scaffold Risk Assessment Data Collection

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Data Category	**Indicator / Parameter**	**Total Sample Size (n)**	**Compliant / Positive Cases**	**Non-Compliant / Deficient Cases**	**Compliance (%)**	**Non-Compliance (%)**	**Average Risk Level**
Site Inspections	Total scaffold structures inspected	25	—	—	—	—	—
	Scaffolds with complete guardrails	25	10	15	**40%**	60%	High
	Proper baseplate/soleboard installation	25	14	11	**56%**	44%	Medium
	Secure anchorage/tie connections	25	15	10	**60%**	40%	Medium
	Safe access and egress provided	25	18	7	**72%**	28%	Low–Medium
	Overloading incidents observed	25	18	7	**72% safe**	28% overloaded	Medium
	Proper housekeeping on platforms	25	16	9	**64%**	36%	Medium
	PPE compliance (helmets, harnesses, gloves)	25	20	5	**80%**	20%	Low
	Average Site Compliance	—	—	—	**63%**	**37%**	**Medium Risk**
Worker Interviews / Surveys	Workers interviewed (total)	55	—	—	—	—	—
	Received scaffold safety training	55	43	12	**78%**	22%	Low–Medium
	Received refresher training (past 12 months)	55	23	32	**42%**	58%	Medium–High

	Regular PPE usage (self-reported)	55	37	18	**68%**	32%	Medium
	Confident to report unsafe conditions	55	30	25	**55%**	45%	Medium
	Satisfied with safety supervision	55	32	23	**58%**	42%	Medium
	Believe productivity prioritized over safety	55	22	33	**40% safety focus**	60% unsafe culture	High
	Average Worker Safety Awareness Score	—	—	—	**63%**	**37%**	**Medium Risk**
Document Review	Total documents reviewed	35	—	—	—	—	—
	Scaffold inspection logs maintained	5 sites	4	1	**80%**	20%	Low–Medium
	Logs updated weekly	5 sites	3	2	**60%**	40%	Medium
	Incident / near-miss reports available	5 sites	4	1	**80%**	20%	Low
	Root cause analysis included	12 reports	7	5	**58%**	42%	Medium
	Permit-to-work documentation available	5 sites	3	2	**60%**	40%	Medium
	Scaffold maintenance records available	5 sites	2	3	**40%**	60%	Medium–High
	Average Documentation Compliance	—	—	—	**60%**	**40%**	**Medium Risk**
Combined Dataset Summary	Total data points (all categories)	—	—	—	**64%**	**36%**	**Medium–High Risk**

Table 2 **Quantitative Summary by Category**

Data Type	No. of Observations / Responses	Mean Compliance (%)	Standard Deviation (±%)	Minimum Compliance (%)	Maximum Compliance (%)	Overall Risk Classification
Site Inspections	25 structures	**63%**	±13.5	40%	80%	Medium Risk
Worker Interviews / Surveys	55 respondents	**63%**	±12.8	40%	78%	Medium Risk
Document Reviews	35 documents	**60%**	±15.2	40%	80%	Medium–High Risk
Overall Average	—	**62.0% compliance**	±13.8	—	—	**Medium to High Risk Zone**

dismantling. Each phase presents different risks that must be carefully assessed and controlled. During the erection phase, hazards include falls from height, improper bracing, manual handling injuries, and contact with electrical lines [11-13]. In the use phase, workers face risks such as overloading, missing guardrails, slipping hazards, and falling objects. The modification phase introduces hazards related to structural instability, removal of scaffold components, and poor communication among workers. Finally, the dismantling phase involves risks such as falls, dropping of materials, and incorrect removal sequence of scaffold parts. By applying the JSA method, hazards were systematically identified and evaluated based on their likelihood and severity. Appropriate control measures such as proper scaffold design, regular inspections, worker training, supervision, and the use of personal protective equipment (PPE) were recommended. Overall, JSA provides a structured approach for improving safety in scaffold-related work at height which is explained in table 1 and 2.

3.4.Risk Assessment

Risk assessment is a systematic process used to identify, evaluate, and control potential hazards that may cause harm to workers, equipment, or the work environment. In construction activities involving scaffold-related work at height, risk assessment plays a vital role in preventing accidents and ensuring safe working conditions. Scaffolds are widely used to provide temporary platforms for workers performing tasks such as bricklaying, plastering, painting, and maintenance at elevated levels. Improper scaffold erection, lack of inspection, and unsafe work practices can lead to serious injuries or fatalities. The main objective of conducting a risk assessment in scaffold operations is to recognize potential hazards before they result in accidents. This process involves identifying hazards, evaluating the likelihood of occurrence and severity of consequences, and implementing suitable control measures to minimize risks. A commonly used tool in this process is the Risk Assessment Matrix, which categorizes risks based on two factors: likelihood and severity. The risk rating is calculated using the formula R = Likelihood × Severity, which helps determine whether the risk level is low, medium, high, or critical. Several common hazards are associated with scaffold-related work at height. The most significant risk is falls from height, which can occur due to missing guardrails, unsecured planks, or failure to use personal fall protection systems. Scaffold collapse is another major hazard caused by poor design, overloading, or improper erection. Falling objects such as tools and materials can injure workers below if protective measures are not implemented. Electrocution may occur when scaffolds are erected near overhead power lines, while manual handling injuries can result from lifting heavy scaffold components [14,15].

Table 3 Risk Assessment Matrix for Scaffold-Related Work at Height

Task / Activity	Identified Hazard	Possible Consequences	Likelihood (L)	Severity (S)	Risk Rating (L×S)	Risk Level	Recommended Control Measures
Erection / Use / Dismantling	**Falls from height**	Fatality or serious injury due to falling from scaffold platforms or frames	4 – *Likely*	5 – *Catastrophic*	**20**	**Critical**	- Install full guardrails, mid-rails, and toe boards on all working levels. - Ensure all workers use fall arrest systems (full-body harness and lanyard). - Conduct daily pre-use inspections for damage or missing components. - Provide edge protection and secure access ladders. - Conduct working-at-height and rescue training.
Erection / Modification / Use	**Scaffold collapse / structural failure**	Multiple injuries or fatalities from collapse due to poor foundation, overloading, or improper bracing	3 – *Possible*	5 – *Catastrophic*	**15**	**High**	- Erect scaffolds on level, stable ground using base plates and sole boards. - Follow manufacturer’s design and load limits. - Use proper bracing and ties at correct intervals. - Have scaffolds inspected and certified by a competent person before use. - Prohibit unauthorized alterations.
All scaffold-related work	**Falling objects (tools, materials, debris)**	Head injuries or fatalities to workers below; property damage	4 – *Likely*	4 – *Major*	**16**	**High**	- Install toe boards, debris nets, and protective fans. - Secure tools with lanyards. - Create exclusion zones below active scaffolds. - Require hard hat use in all areas. - Maintain good housekeeping and storage practices.
Erection near power lines	**Electrocution**	Fatal electric shock due to contact or arcing with live overhead lines	3 – *Possible*	5 – *Catastrophic*	**15**	**High**	- Maintain minimum 3 m clearance from electrical lines (as per regulation). - De-energize or insulate live lines before work. - Use non-conductive scaffold materials (e.g., fiberglass). - Conduct electrical hazard awareness training. - Display warning signs and restrict access to hazardous areas.
Material handling / assembly	**Manual handling injuries**	Back strains, muscle	4 – *Likely*	3 – *Moderate*	**12**	**High**	- Train workers in correct lifting techniques. - Use team lifts or mechanical aids

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		injuries, fatigue from lifting heavy scaffold components					(hoists, trolleys). - Rotate tasks to reduce repetitive strain. - Maintain clear pathways for carrying materials. - Encourage reporting of discomfort or early signs of injury.
Use phase	**Slips, trips, and poor housekeeping**	Sprains, fractures, or falls from uneven or cluttered platforms	3 – *Possible*	3 – *Moderate*	**9**	**Medium**	- Keep platforms free from debris, oil, and water. - Use slip-resistant planks and footwear. - Secure planks to prevent movement. - Implement daily housekeeping and inspection routines.
Use / Modification	**Adverse weather conditions (wind, rain, poor lighting)**	Scaffold instability, slips, and falls due to loss of visibility or footing	2 – *Unlikely*	4 – *Major*	**8**	**Medium**	- Suspend work during high winds, heavy rain, or low visibility. - Provide adequate site lighting. - Secure loose materials before storms. - Conduct weather risk assessments before starting work.
All phases	**Inadequate inspection or maintenance**	Undetected damage leading to structural failure or falls	3 – *Possible*	4 – *Major*	**12**	**High**	- Implement scheduled inspections by competent personnel. - Keep inspection records and certificates on-site. - Replace damaged or corroded components immediately. - Use a scaffold tagging system (Green: Safe / Red: Unsafe).
Dismantling	**Premature removal of braces or ties**	Collapse or loss of stability leading to injuries	3 – *Possible*	5 – *Catastrophic*	**15**	**High**	- Follow top-down dismantling sequence. - Supervise dismantling by a competent person. - Maintain stability by keeping adequate ties until the last section. - Use exclusion zones and fall protection.
General site operations	**Lack of training or supervision**	Unsafe practices, misassembly, or non-compliance with safety rules	4 – *Likely*	4 – *Major*	**16**	**High**	- Provide scaffold training and refresher sessions for all personnel. - Ensure direct supervision during erection and dismantling. - Conduct toolbox talks before shifts. - Establish disciplinary measures for unsafe acts.

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Material loading / storage on scaffold	**Overloading of scaffold platforms**	Plank failure or total scaffold collapse	3 – *Possible*	4 – *Major*	**12**	**High**	- Display load limit signage on all platforms. - Train workers to distribute loads evenly. - Use designed loading bays for heavy materials. - Inspect platforms regularly for deflection or wear.
Use / Dismantling	**Struck by moving components or swing hazards**	Bruises, fractures, or entrapment injuries	3 – *Possible*	3 – *Moderate*	**9**	**Medium**	- Use tag lines to control suspended materials. - Maintain awareness zones during component movement. - Use proper PPE including gloves and helmets. - Communicate during lifting or moving operations.

To control these risks, engineering controls, administrative measures, and personal protective equipment (PPE) must be implemented. Regular inspections, proper training, and strict compliance with safety standards such as ISO 45001 and OSHA regulations are essential. Through effective risk assessment, construction organizations can significantly reduce accidents and ensure safer scaffold-related work at height shown in Table 3.

3.5. Development of Control Measures

The development of control measures is a crucial step after identifying hazards and assessing risks in scaffold-related work at height. Its main objective is to eliminate or reduce risks such as falls, scaffold collapse, falling objects, electrocution, slips, and manual handling injuries. Control measures are developed based on the Hierarchy of Controls, which prioritizes elimination and engineering solutions before administrative actions and personal protective equipment (PPE).

3.5.1. Engineering Controls

Engineering controls focus on physical modifications to eliminate hazards. Important measures include proper scaffold design with adequate load-bearing capacity, stable foundations using base plates and sole boards, and strong structural support through cross bracing and tie-ins. Guardrails, mid-rails, and toe boards are installed to prevent falls and falling objects. Safe access systems such as ladders and stair towers ensure secure movement to platforms. Protective nets and overhead covers reduce the risk of injuries from falling materials.

3.5.2. Administrative Controls

Administrative measures involve safety procedures, supervision, and worker training. Workers must receive training on scaffold erection, dismantling, fall protection, and hazard identification. Permit-to-work systems help control high-risk activities. Regular inspections, daily safety checks, and maintenance ensure scaffold stability. Supervisors enforce safety rules, while toolbox talks and safety meetings improve awareness. Encouraging hazard reporting and maintaining a positive safety culture also helps prevent accidents.

3.5.3. Personal Protective Equipment (PPE)

PPE acts as the final layer of protection. Essential equipment includes safety helmets, full-body harnesses with lanyards, gloves, safety shoes, and high-visibility clothing. Proper training, inspection, and maintenance of PPE ensure effective protection during scaffold operations.

3.6. Tool Development

Tool development is an essential step in improving safety management for scaffold-related work at height. It helps convert theoretical safety concepts into practical tools that can be easily used by safety officers, supervisors, and workers on construction sites. The main objective is to create standardized methods for identifying hazards, monitoring scaffold conditions, and ensuring consistent safety practices

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during scaffold erection, use, modification, and dismantling.

3.6.1. Purpose of Tool Development

The primary goal is to establish a structured approach for scaffold safety monitoring. Construction sites are dynamic environments where conditions change frequently, so standardized tools help ensure that safety inspections and risk assessments are performed consistently.

3.6.2. Scaffold Safety Checklist

The Scaffold Safety Checklist is a structured inspection tool used to evaluate scaffold safety before and during operations. It helps identify hazards early and ensures compliance with safety requirements. The checklist includes inspection of foundation stability, structural components, guardrails, access systems, load management, housekeeping, and environmental conditions. Proper documentation of inspection results improves accountability and safety monitoring.

3.6.3. Standardized Risk Assessment Matrix

The Risk Assessment Matrix is used to evaluate hazards based on their likelihood and severity. The risk rating is calculated using the formula: Risk = Likelihood × Severity. Hazards are categorized as low, medium, high, or critical, which helps safety personnel prioritize corrective actions.

3.6.4. Integration of Safety Tools

The checklist and risk matrix work together to improve scaffold safety. The checklist identifies hazards, while the risk matrix evaluates their seriousness and determines necessary control measures. This integrated system promotes proactive safety management and reduces accident risks.

3.6.5. Validation Process

The validation process ensures that the developed safety tools are practical, reliable, and effective for real construction site conditions. It was conducted to evaluate the Scaffold Safety Checklist and Standardized Risk Assessment Matrix through expert review, field testing, feedback collection, and improvement.

- Purpose of Validation

Validation confirms that the developed safety tools accurately identify scaffold hazards and can be effectively used in construction environments.

- Expert Consultation

Safety professionals, site engineers, supervisors, and scaffold inspectors reviewed the tools. Their expertise helped verify whether the checklist and risk matrix covered important safety elements such as scaffold stability, guardrails, access systems, load limits, and worker safety practices.

- Evaluation of Clarity and Usability

Experts examined whether the tools were easy to understand and practical for use on busy construction sites. Complex terms were simplified and the checklist items were arranged logically.

- Field Testing

The tools were tested at selected construction sites. Safety officers used the checklist for scaffold inspections and applied the risk matrix to evaluate hazards and prioritize corrective actions.

- Feedback Collection and Improvement

Feedback from safety personnel and workers helped refine the checklist structure and improve the risk classification system. The validation process confirmed that the tools are effective, practical, and suitable for improving scaffold safety management.

3.7. Recommendations and Reporting

Effective scaffold safety requires continuous monitoring, proper training, and structured reporting systems. Based on the study findings, several recommendations can improve safety performance and reduce scaffold-related hazards in construction projects.

- Regular Scaffold Inspections Scaffolds should be inspected before initial use, after modifications, and at regular intervals during construction. Inspections must be conducted by trained and competent personnel using a standardized scaffold safety checklist to identify structural weaknesses, missing guardrails, or unstable foundations.
- Worker Competency Assessment Workers involved in scaffold erection and use must possess proper knowledge and skills. Competency evaluations through practical tests, supervisor observations, and written assessments help ensure safe work practices.
- Training and Refresher Programs

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- Regular training programs should be conducted to update workers on scaffold safety procedures, PPE usage, fall protection systems, and hazard identification techniques.
- Safety Audits and Compliance Monitoring
  Periodic safety audits help verify compliance with construction safety regulations and identify gaps in safety practices.
- Risk Assessment Integration
  Using a standardized risk assessment matrix helps classify hazards and prioritize corrective actions effectively.
- Reporting and Documentation
  Safety reports should document inspections, identified hazards, risk levels, and corrective actions to support safety improvement and regulatory compliance.

4. Result and Discussion

The results of this study highlight the critical safety challenges associated with scaffold-related work at height in construction environments. Through site inspections, worker interviews, and the application of Job Safety Analysis (JSA), several key hazards were identified, including falls from height, scaffold collapse, falling objects, improper access, overloading, and electrical contact. These hazards were further evaluated using a standardized risk assessment matrix that categorized risks based on their likelihood and severity. The analysis revealed that falls from height represent the most significant hazard due to their high probability and severe consequences, often leading to serious injuries or fatalities.The study found that many scaffold-related incidents occur due to a combination of technical failures and human errors. Technical issues such as unstable foundations, improper bracing, inadequate anchorage, and missing guardrails were frequently observed during site inspections. In addition, improper scaffold erection and dismantling procedures significantly increased the risk of structural instability. Human factors, including lack of training, failure to use personal protective equipment (PPE), and non-compliance with safety procedures, were also identified as major contributors to unsafe conditions. The application of the Job Safety Analysis (JSA) method helped break down scaffold activities into individual tasks and identify specific hazards associated with each stage of scaffold use. This systematic analysis enabled the identification of high-risk tasks such as scaffold assembly, working at platform edges, material handling at height, and dismantling operations. Understanding these task-specific risks, appropriate control measures were developed to reduce hazard exposure. The implementation of control measures based on the hierarchy of controls significantly improved safety outcomes. Engineering controls such as proper scaffold design, stable foundations, guardrails, toe boards, and secure tie-in systems were effective in minimizing structural risks. Administrative controls, including worker training, supervision, permit-to-work systems, and regular scaffold inspections, helped improve compliance with safety procedures. In addition, the mandatory use of PPE such as safety harnesses, helmets, and non-slip footwear provided an additional layer of protection for workers operating at height. The development of safety tools such as the Scaffold Safety Checklist and the Standardized Risk Assessment Matrix also contributed to improving safety management practices. These tools provided a structured approach for identifying hazards, evaluating risks, and ensuring that safety requirements are consistently followed across different construction sites. Field validation indicated that the use of these tools enhanced inspection efficiency and increased worker awareness of potential hazards. The findings demonstrate that a systematic risk assessment approach combined with well-implemented control measures can significantly reduce scaffold-related accidents. The results emphasize the importance of integrating technical improvements, effective supervision, and continuous worker training to create a safer working environment in construction projects involving scaffold operations at height.

Conclusion

Scaffold-related work at height remains one of the most critical safety concerns in the construction industry due to the high risk of falls, structural instability, and falling objects. This study aimed to assess the hazards associated with scaffold operations and develop effective control measures to improve safety performance on construction sites. Through a systematic methodology involving site selection, data collection, Job Safety Analysis (JSA), and risk assessment, the research successfully identified key hazards occurring during scaffold erection, use, modification, and dismantling. The findings indicate that many scaffold-related accidents are caused not only by technical deficiencies such as unstable foundations, inadequate bracing, and missing guardrails, but also by human factors including insufficient training, lack of supervision, and non-compliance with safety procedures. By applying the hierarchy of controls, the study developed a comprehensive control strategy incorporating engineering controls, administrative controls, and personal protective equipment (PPE). These measures significantly contribute to minimizing risks and improving scaffold stability and worker protection. The development of practical safety tools such as the Scaffold Safety Checklist and the Standardized Risk Assessment Matrix provides a structured approach for hazard identification, inspection, and risk prioritization. These tools enhance consistency and accountability in scaffold safety management. The study highlights that effective risk assessment, continuous training, regular inspections, and strong safety culture are essential for preventing scaffold-related accidents and ensuring safe work at height in construction projects.

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