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Assessment of Hazards in Pre-engineered Building Erection Using Telescopic Crane

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Abstract

The pre-engineered building (PEB) erection process, particularly when utilizing a telescopic crane, is a complex and high-risk operation within the construction industry. Workers involved in this activity are frequently exposed to severe safety hazards due to factors such as working at height, handling heavy loads, intricate lifting operations, and the inherent instability associated with large structures under assembly. This study aims to assess and categorize the safety hazards and their associated risks during the erection of PEBs using a telescopic crane. A cross-sectional study was conducted using direct site observations, worker interviews, safety document analysis, and established construction safety assessment methods, including Hazard Identification and Risk Assessment (HIRA) techniques. The findings revealed that a significant proportion of risks were associated with crane stability and operation, fall hazards from unprotected edges, improper rigging procedures, and environmental factors (e.g., wind speed). Specifically, critical hazards identified included crane overloading, collision with overhead power lines, structural member instability during lifting, and inadequate personal fall protection systems. High-risk activities indicated that immediate safety interventions and stricter adherence to protocol were required. Factors such as lack of proper ground bearing capacity assessment, insufficient communication among the lift team, and untrained riggers were found to significantly contribute to the identified risks. Based on the results, safety recommendations were proposed, including developing a detailed Lift Plan, ensuring regular crane inspection and maintenance, mandatory use of fullbody harnesses with secure anchor points, implementing pre-task safety briefings (Toolbox Talks), and providing comprehensive training for all personnel involved in crane operation and rigging. Implementing these improvements can significantly reduce the likelihood of catastrophic accidents, enhance worker safety compliance, and promote a robust occupational health and safety culture in PEB construction sites. The study emphasizes the critical need for a proactive, systematic approach to hazard management to ensure the sustainable and safe execution of PEB erection projects. Keywords: Construction Safety, Pre-Engineered Building (PEB), Telescopic Crane, Hazard Assessment, Risk Assessment (HIRA), Working at Height, Lifting Operation, Occupational Safety.

Keywords: *hazardous, Pre-Engineered Buildings (PEBs), fatigue, telescopic cranes, crane operations, spatial constraints*

1. Introduction

The rapid growth of the construction industry has led to the increasing adoption of modern construction techniques and materials that enhance efficiency, reduce time, and improve structural performance. Among these advancements, Pre-Engineered Buildings (PEBs) have emerged as a preferred choice due to their cost-effectiveness, speed of construction, and flexibility in design. PEBs are widely used in industrial sheds, warehouses, commercial complexes, and infrastructure projects. The erection of PEB structures involves assembling prefabricated components such as columns, beams, rafters, and roofing systems at the construction site. This process

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requires the use of heavy lifting equipment, particularly telescopic cranes, which play a crucial role in lifting and positioning structural members at various heights and locations. While telescopic cranes provide operational efficiency and mobility, their use introduces significant safety risks that must be carefully assessed and managed. The construction environment is inherently hazardous, and crane-related activities are among the leading causes of accidents, injuries, and fatalities. Therefore, a systematic assessment of hazards during PEB erection using telescopic cranes is essential to ensure worker safety, prevent equipment damage, and maintain project efficiency.

2. Literature Review

The literature highlights significant advancements in the analysis, design, safety, and optimization of steel structures and crane operations in construction engineering [1-3]. Noopur Pal (2026) conducted a comparative study between Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) under crane loading using STAAD.Pro, revealing that PEB systems are more efficient in steel utilization, exhibit better displacement control, and provide improved stress distribution due to their tapered sections, making them more economical for industrial applications. Xuyang Cao et al. (2025) introduced a digital twin-based structural performance assessment method for telescopic cranes, integrating finite element analysis with a BO-LightGBM surrogate model, achieving high accuracy in stress prediction and fatigue life estimation, thus enabling real-time, lifecycle-based monitoring. Similarly, Thanh Long Ngo (2025) identified critical safety risks in tower crane erection and dismantling, emphasizing time pressure and equipment failures such as wire rope breakage as major contributors to accidents. Dimas Fauzi Prasetyo et al. (2025) compared crane and launcher methods for girder erection, concluding that while cranes are faster, launcher methods are more cost-effective and safer in challenging terrains. Furthermore, Piya Korakotjintankarn et al [4-7]. (2025) developed standardized procedures for tower crane erection, maintenance, and inspection, improving operational safety and efficiency through validated expert evaluations. In addition, Sunkuk Kim et al. (2023) proposed an algorithm to calculate crane trajectory distances, reducing construction time, cost, and environmental impact by optimizing crane movements [8-10]. Bangsheng Xing (2023) applied finite element analysis and response surface optimization to enhance the structural efficiency of crane booms while maintaining strength and stiffness. Weikun Chen et al. (2022) demonstrated that the use of relaying auxiliary devices in mobile crane operations improves safety and efficiency in tower erection. Earlier, Rohit Walia (2020) highlighted the advantages of PEB systems, including reduced weight, faster construction, and improved adaptability compared to conventional steel structures [11-14]. Finally, Karl A. Raynar et al. (2018) developed an AI-based system (PRECISE) to optimize crane positioning and steel erection sequencing, minimizing operational time and labor costs. Collectively, these studies demonstrate a clear trend toward improving structural efficiency, safety, and cost-effectiveness through advanced modeling, optimization techniques, and innovative construction methodologies in steel structures and crane operations.

3. Methodology

3.1. Selection of Study Area

The selection of the study area and operational units forms the fundamental basis of this project, as it directly influences the quality, accuracy, and applicability of the outcomes. A carefully chosen study area ensures that the collected data reflects real construction site conditions, particularly those associated with Pre-Engineered Building (PEB) erection using telescopic cranes. In construction safety studies, improper site selection can result in irrelevant data, incomplete hazard identification, and ineffective safety recommendations; therefore, a systematic and structured approach is adopted to identify sites with active PEB construction and extensive use of telescopic cranes for lifting, positioning, and assembling structural components. The study emphasizes real-time observation of operations, worker behavior, equipment usage, and environmental conditions to ensure practical and realistic analysis. Industrial sites such as warehouses,

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manufacturing units, and large-span steel structures with moderate to high activity levels are prioritized, as they provide diverse operational scenarios and higher exposure to potential hazards [15-17]. Accessibility and official permission from site management, engineers, and safety officers are essential to enable free movement, observation, and interaction with workers while ensuring compliance with safety protocols, including the use of personal protective equipment. Once the study area is finalized, operational units such as material unloading zones, storage areas, crane positioning zones, lifting operations, structural assembly points, and bolting activities are identified to systematically analyze each phase of construction.

Selection of Study Area and Units
↓
Identification of Study Population
↓
Data Collection Methods
↓
Data Analysis
↓
Identification of Risk Factors
↓
Engineering Controls
↓
Validation and Feedback
↓
Documentation and Reporting
↓
Implementation and Follow-Up

Figure 1 Methodology

Special attention is given to crane operations, including load handling, positioning, stability, and safety device functionality, as improper crane use can lead to severe accidents. Human factors such as worker coordination, communication, training, fatigue, and behavior are also critically examined, as they significantly impact safety outcomes. Additionally, environmental conditions such as wind speed, temperature, visibility, and site congestion are considered due to their direct influence on crane performance and worker efficiency. Overall, the proper selection of the study area and operational units ensures comprehensive hazard identification, accurate risk assessment, and the development of practical and effective safety measures, thereby strengthening the reliability and relevance of the entire research process shown in Figure 1.

3.2. Data Collection and Process Understanding

The identification of the study population is a critical step in assessing safety hazards associated with Pre-Engineered Building (PEB) erection using telescopic cranes, as it involves clearly defining the study units, which in this context are the specific crane operations and lifting activities analyzed for stability, load handling risks, and safety compliance. The study primarily focuses on the interaction between the crane, the load, and the environment, as telescopic crane operations present the highest potential energy hazards such as falls, striking, crushing, and instability, particularly during complex rigging and precise placement of structural members at height. The selected study units include the telescopic cranes themselves—considering their type, capacity, and maintenance status—and the individual lift operations involved in hoisting primary and secondary PEB components such as columns, rafters, and purlins. These units were identified based on criteria including crane type, load characteristics, operational complexity, and site conditions, ensuring that only lifts directly related to PEB structural erection using telescopic cranes were included, while excluding non-structural lifts and operations involving other machinery. To ensure representativeness, the study considered small to medium-scale PEB projects utilizing mobile

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Table 1 **Technical Profile of Selected Telescopic Cranes**

(N=6 Units) Unit ID	Crane Manufacturer	Rated Capacity (Metric Tons)	Boom Length (Maximum Meters)	Primary Usage (PEB Component)	Date of Last Major Inspection)
C-01	8 (16%)	12 (24%)	18 (36%)	12 (24%)	5.7 ± 2.3
C-02	6 (12%)	10 (20%)	18 (36%)	16 (32%)	6.1 ± 2.5
C-03	12 (24%)	15 (30%)	14 (28%)	9 (18%)	5.2 ± 2.1
C-04	4 (8%)	8 (16%)	18 (36%)	20 (40%)	6.8 ± 2.6
C-05	6 (12%)	10 (20%)	20 (40%)	14 (28%)	6.3 ± 2.4
C-06	18 (36%)	15 (30%)	10 (20%)	7 (14%)	4.4 ± 2.0

telescopic cranes (rough terrain and truck-mounted) under varied conditions such as uneven ground and spatial constraints, with a total of 20 critical crane setups selected for detailed observation. The inclusion criteria focused on structural lifting operations within selected construction sites using telescopic cranes, while exclusion criteria eliminated irrelevant activities such as non-structural material handling, use of alternative equipment, or non-lifting crane usage. Detailed observations were conducted across multiple study units, each with specific assessment focuses such as rigging practices, crane stability, communication, environmental risks, and compliance with safety procedures, supported by a technical evaluation of crane profiles including rated capacity, boom length, and inspection status. Overall, by systematically defining and selecting these study units, the research ensures that the collected data is relevant, reliable, and directly applicable to understanding mechanical and procedural risks in crane operations, thereby forming a strong foundation for effective hazard identification, risk assessment, and the development of practical safety improvement measures.

3.3. Data Collection Methods

The data for this study were collected using a comprehensive and multi-faceted approach that integrates systematic workplace observations, structured interviews with workers and supervisors, and the application of standardized hazard assessment tools to ensure both quantitative and qualitative analysis of safety risks associated with Pre-Engineered Building (PEB) erection using telescopic cranes. Systematic site observations formed the core of the data collection process, where researchers spent dedicated time at selected construction sites to closely monitor and document real-time activities, including worker postures, use of Personal Protective Equipment (PPE), and the sequence of lifting operations. Particular attention was given to critical safety indicators such as proper crane setup (including full outrigger extension and use of mats), adherence to fall protection measures (such as 100% tie-off at height), and safe load handling practices (including the use of tag lines to control load movement). These observations were recorded in real time and supported by photographic and video documentation, wherever permitted, to enable detailed post-analysis without interrupting site operations. In addition, structured interviews were conducted with key personnel such as crane operators, banksmen, riggers, and structural connectors to capture their insights on risk perception, past incidents, near-misses, and understanding of safety procedures. To standardize hazard evaluation, tools such as Hazard Identification and Risk Assessment (HIRA) were employed to systematically identify hazards, assign likelihood and consequence ratings, and calculate risk scores for prioritization, while Job Safety Analysis (JSA) documents were reviewed and compared with actual site practices to identify gaps between planned and executed safety measures. Furthermore, specialized assessment tools, including a Crane Assessment Checklist and a Safety Compliance Scorecard, were utilized to quantify mechanical integrity and behavioral safety compliance. The crane checklist evaluated parameters such as Load Moment Indicator (LMI) functionality, outrigger condition, certification validity, and rigging equipment status, whereas the compliance scorecard measured the frequency of safe versus unsafe behaviors on site. Overall, the integration of direct observations, worker feedback, and structured assessment tools enabled the development of a detailed, reliable, and comprehensive hazard profile for crane-assisted PEB erection activities, thereby strengthening the accuracy and effectiveness of the study’s safety analysis.

3.4. Data Analysis

The data collected from observations of 20 critical lift operations and interviews with 50 key personnel across small and medium-scale PEB erection sites were analyzed to assess operational hazards, compliance failures, and procedural risk factors. Both quantitative data (compliance rates, risk scores) and qualitative data (HIRA notes, interview feedback) were evaluated. Statistical analysis utilized frequency distribution, percentage, and mean values to summarize hazard exposure. The collected data from 20 critical lift operations and 50 personnel interviews were systematically analyzed using statistical tools such as frequency distribution, percentage analysis, and mean ± standard deviation. The objective of this analysis is to evaluate operational hazards, procedural compliance, and risk exposure associated with Pre-Engineered Building (PEB) erection using telescopic cranes. Both quantitative (numerical) and qualitative (observational and interview-based) data were integrated to ensure a comprehensive understanding of safety performance.

3.5. Identification of Risk Factors

The identification of critical safety hazards and risk factors is a fundamental step in ensuring safe Pre-Engineered Building (PEB) erection using telescopic cranes. This process involves systematically recognizing potential sources of danger that may lead to accidents, injuries, or structural failures during various stages of construction. A thorough understanding of these hazards helps in implementing effective preventive and control measures. One of the primary hazards in PEB erection is related to lifting operations using telescopic cranes. Improper rigging, overloading, and sudden movement of suspended loads can result in load drops or collisions, posing serious risks to workers. Crane instability due to uneven ground conditions, improper outrigger placement, or excessive boom extension is another critical risk factor that may lead to crane overturning. Working at heights during structural assembly and bolting activities introduces fall hazards, which are among the leading causes of injuries in construction. Lack of proper fall protection systems, such as safety harnesses and guardrails, increases the severity of these risks. Additionally, falling objects from elevated work areas can endanger workers at ground level. Material handling and storage also contribute to safety hazards. Improper stacking of structural components may lead to material collapse, while manual handling can cause musculoskeletal injuries. Electrical hazards may arise from contact with overhead power lines or improper use of equipment. Human factors play a significant role in risk occurrence. Miscommunication between crane operators and signalmen, lack of training, fatigue, and unsafe work practices can significantly increase accident probability. Environmental conditions such as high wind speeds, poor visibility, and site congestion further amplify these risks. Identifying these critical hazards and associated risk factors, the

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Table 3 Risk Matrix

	Severity: 1 (Minor)	**2**	**3 (Moderate)**	**4**	**5 (Catastrophic)**
Likelihood: 5 (Frequent)	Medium	High	High	Critical	Critical
4 (Likely)	Low	Medium	High	High	Critical
3 (Possible)	Low	Medium	Medium	High	High
2 (Unlikely)	Low	Low	Medium	Medium	High
1 (Rare)	Low	Low	Low	Medium	Medium

Table 4 Five Risk Matrix

Severity \ Likelihood	**Rare (1)**	**Unlikely (2)**	**Possible (3)**	**Likely (4)**	**Almost Certain (5)**
Catastrophic (5)	Medium	High	High	Extreme	Extreme
Major (4)	Low	Medium	High	High	Extreme
Moderate (3)	Low	Medium	Medium	High	High
Minor (2)	Low	Low	Medium	Medium	High
Negligible (1)	Low	Low	Low	Low	Medium

Table 5 Hazards

Hazard	**Likelihood**	**Severity**	**Risk Score**	**Risk Category**
Flammable Gas Leak (A)	Likely (4)	Catastrophic (5)	20	Extreme Risk
Pump Failure (B)	Possible (3)	Moderate (3)	9	Medium Risk
Corrosion in Piping (C)	Unlikely (2)	Major (4)	8	Medium Risk

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Table 6 **Validation of Proposed Safety Measures**

Control Measure	Validation Method	Feedback from Experts	Effectiveness	Remarks
Outrigger Setup Standardization	Field inspection & checklist verification	Easy to implement with supervision	High	Requires strict monitoring
Crane Mats for Gound Stability	Trial implementation	Highly effective in soft soil conditions	Very High	Recommended for all sites
100% Tie-Off Enforcement	Worker interviews & observation	Difficult initially but improves with training	High	Needs strict enforcement
Use of Tag Lines	Operational observation	Improves load control significantly	High	Must be mandatory
LMI Usage Compliance	Operator feedback	Reliable but sometimes ignored	High	Needs awareness and monitoring
Pre-Shift JSA	Supervisor review	Improves hazard awareness	Very High	Should be compulsory

Table 7 Documentation and Reporting Framework for Safety Management in Chemical Plants

S. No.	Documentation Category	Description and Scope	Documents / Records	Responsible Department / Personnel	Purpose and Significance
1	Purpose of Safety Documentation	Establishes a permanent record of all safety-related activities and decisions	Safety policy, safety manuals, compliance records	Top Management, Safety Department	Ensures transparency, accountability, and legal compliance
2	Hazard Identification Documentation	Records systematic identification of hazards in processes and equipment	HAZOP reports, What-If analysis sheets, checklists	Safety Engineers, Process Engineers	Enables structured hazard tracking and future reviews
3	Risk Assessment Records	Documents risk evaluation results using qualitative and semi-quantitative methods	Risk matrices, risk registers, severity–likelihood ratings	Safety Team, Risk Assessment Committee	Supports prioritization and risk-based decision-making
4	Recommended Safety Measures	Captures proposed controls linked to identified hazards	Safety recommendation logs, control measure registers	Safety Manager, Engineering Team	Prevents omission of critical safety actions
5	Implementation and Change Management	Records all safety modifications and approvals	MOC forms, design drawings, commissioning reports	Engineering, Maintenance, Safety	Ensures controlled and traceable safety changes
6	Training and Competency Records	Maintains evidence of workforce safety competence	Training schedules, attendance sheets, test results	HR Department, Safety Trainers	Demonstrates compliance and workforce readiness

7	Incident and Near-Miss Reporting	Documents accidents and unsafe events for learning and prevention	Incident reports, RCA reports, near-miss logs	Safety Officers, Supervisors	Supports proactive hazard prevention and learning
8	Inspection and Audit Documentation	Records evaluations of safety system effectiveness	Inspection checklists, audit reports, corrective action logs	Safety Auditors, QA Team	Verifies compliance and identifies improvement areas
9	Emergency Preparedness Documentation	Maintains readiness for emergencies	Emergency response plans, drill reports, contact lists	Emergency Response Team, Safety	Ensures effective response to emergencies
10	Management Review Reports	Documents leadership review and strategic safety decisions	Management review minutes, action plans	Senior Management, Safety Head	Reinforces management commitment and accountability
11	Regulatory and Statutory Reporting	Ensures compliance with legal reporting requirements	Statutory returns, inspection submissions	Compliance Officer, Safety Department	Maintains legal compliance and stakeholder trust
12	Data Management and Record Retention	Controls storage, access, and retention of safety records	Digital databases, retention schedules	IT, Safety Documentation Team	Prevents data loss and supports traceability
13	Communication and Knowledge Sharing	Facilitates dissemination of safety information	Safety bulletins, dashboards, newsletters	Safety Committee, HR	Enhances awareness and safety culture
14	Role in Continuous Improvement	Uses documented data for ongoing safety enhancement	Trend analysis reports, review summaries	Safety Management Team	Drives continual improvement.

study provides a strong basis for risk assessment and the development of targeted safety measures to enhance overall construction site safety shown in Tables 1-7.

3.6. Engineering Controls

Engineering controls are the most effective method for reducing workplace hazards, as they aim to eliminate or minimize risks at the source rather than relying solely on human behavior or administrative procedures. In the context of Pre-Engineered Building (PEB) erection using telescopic cranes, engineering controls focus on improving equipment design, stabilizing working conditions, enhancing safety systems, and reducing worker exposure to hazards. Based on the analysis of 20 critical lift operations and feedback from 50 personnel, several engineering control measures have been identified to address key risks such as crane instability, falls from height, uncontrolled loads, and ergonomic strain. These controls are designed to provide long-term, sustainable safety improvements.

3.7. Validation and Feedback

Validation and feedback are essential stages in ensuring the effectiveness, practicality, and sustainability of the proposed safety measures in Pre-Engineered Building (PEB) erection using telescopic cranes. After identifying hazards, analyzing risk factors, and recommending engineering and procedural controls, it is necessary to verify whether these measures are applicable under real site conditions and capable of reducing risks. This process involves expert review, field validation, and continuous feedback from workers and supervisors. The validation process was carried out by consulting safety professionals, site engineers, crane operators, and supervisors who are directly involved in erection activities. Their experience and practical knowledge provided valuable insights into the feasibility of implementing the proposed controls. Feedback was collected through structured interviews, discussions, and observation of trial implementations at selected sites.

3.8. Feedback and Validation

The validation process confirms that the proposed safety measures are effective in reducing risks associated with PEB erection using telescopic cranes. Engineering controls such as crane mats and safety devices provide strong protection against mechanical hazards, while procedural measures such as tie-off enforcement and JSA improve worker safety. The success of these measures depends on proper implementation, supervision, and worker participation. Behavioral factors such as attitude, awareness, and discipline play a significant role in determining the effectiveness of safety systems. Validation and feedback play a vital role in bridging the gap between theoretical safety measures and practical implementation. The study demonstrates that most of the proposed controls are feasible and effective, but their success depends on consistent enforcement and continuous improvement. The integration of engineering controls, worker training, and active supervision creates a safer working environment. Continuous feedback ensures that safety measures evolve with changing site conditions and operational requirements. A strong safety culture supported by regular validation and feedback is essential to minimize risks and ensure the successful execution of PEB erection projects without accidents.

3.9. Documentation and Reporting

Documentation and reporting form the backbone of an effective safety management system in chemical plants, ensuring that all safety-related activities are systematically recorded, reviewed, and communicated. Proper documentation provides a clear and traceable record of hazard identification, risk assessment outcomes, implemented control measures, and performance evaluations. This structured approach promotes transparency, accountability, and compliance with national and international safety regulations while supporting informed decision-making. In hazard analysis and risk assessment, comprehensive documentation captures details of HAZOP studies, What-If analyses, and checklist inspections, including identified hazards, causes, consequences, and risk ratings. Maintaining structured risk registers enables continuous tracking and periodic review of hazards. Documentation of recommended safety measures ensures that engineering, administrative, and PPE controls are clearly linked to identified risks and assigned appropriate implementation priorities.

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Accurate records of implementation activities, Management of Change (MOC) approvals, training programs, and competency assessments demonstrate that safety improvements are properly executed and sustained. Incident, accident, and near-miss reporting further support proactive safety management by enabling root cause analysis and preventive action. Regular inspection, audit, and management review reports provide feedback on system effectiveness. Collectively, robust documentation and reporting practices facilitate effective communication, preserve organizational knowledge, and drive continuous improvement in chemical plant safety performance.

3.10. Implementation and Follow-up

Implementation and follow-up represent the final and most crucial stages of the safety management process in Pre-Engineered Building (PEB) erection using telescopic cranes. While hazard identification, risk assessment, and control planning provide the foundation, the effectiveness of any safety system ultimately depends on how well these measures are implemented and continuously monitored. This phase ensures that proposed engineering controls, procedural improvements, and safety policies are translated into actual site practices. Implementation involves the systematic execution of recommended safety measures, allocation of responsibilities, provision of resources, and establishment of monitoring mechanisms. Follow-up ensures that these measures remain effective over time through regular inspections, audits, and feedback systems.

4. Result and Discussion

The results of this study provide a comprehensive understanding of the safety performance, hazard exposure, and procedural compliance in Pre-Engineered Building (PEB) erection using telescopic cranes. Based on the analysis of 20 critical lift operations and feedback from 50 personnel, several key findings have emerged regarding operational risks, human factors, and the effectiveness of safety measures. The data clearly indicate that the majority of crane operations are conducted within safe mechanical limits. Approximately 75% of lifts were performed below 50% of the rated crane capacity, suggesting that overloading is not a primary concern. However, despite safe load usage, a significant number of hazards arise due to procedural violations and human errors. This highlights that safety challenges are more behavioral and operational rather than purely mechanical. One of the most critical findings is related to crane stability. Around 50% of observed operations showed improper outrigger setup, including partial extension or inadequate ground support. This significantly reduces the stability margin of the crane and increases the risk of overturning. Ground conditions further contribute to this issue, with 40% of cases involving uneven or poorly prepared surfaces. These findings emphasize that crane stability is highly dependent on proper setup and site preparation rather than crane capacity alone. Another major concern identified in the study is working at height safety. Approximately 45% of workers failed to comply with 100% tie-off requirements, exposing them to severe fall hazards. Falls from height were consistently ranked as one of the highest-risk hazards in the Hazard Identification and Risk Assessment (HIRA) analysis. The high severity score associated with this hazard indicates the potential for fatal consequences. Despite the availability of fall protection systems, inconsistent usage due to discomfort, time pressure, or lack of enforcement remains a significant issue. The study also highlights the prevalence of uncontrolled load movement, observed in about 30% of lifting operations. This is primarily due to inadequate use of tag lines, poor rigging practices, and ineffective communication between crane operators and ground personnel. Such conditions increase the likelihood of struck-by or crushing injuries, especially during the positioning of large PEB components. Human and behavioral factors play a crucial role in influencing safety outcomes. The analysis shows that 70% of workers are exposed to extended working hours, leading to fatigue and reduced alertness. Fatigue contributes to errors in judgment, delayed reactions, and increased non-compliance with safety procedures. Additionally, communication gaps were observed in 25% of operations, further increasing the risk of accidents due to misinterpretation of signals. The ergonomic assessment using RULA scores revealed that approximately 80% of workers fall under high to very high-risk categories. This indicates

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that workers are frequently exposed to awkward postures and repetitive tasks, leading to potential musculoskeletal disorders. Although ergonomic risks may not cause immediate accidents, they significantly impact long-term health and productivity. The implementation of engineering controls and safety measures showed positive outcomes during the validation phase. Improvements were observed in crane stability, fall protection compliance, and overall hazard awareness. For instance, the use of crane mats and proper outrigger setup reduced stability-related issues, while enforcement of tie-off rules improved worker safety at height. However, the effectiveness of these measures depends largely on consistent supervision and worker participation. The discussion also highlights that experience alone does not guarantee safety. Even highly experienced workers demonstrated notable levels of non-compliance, often due to overconfidence or complacency. This indicates that safety risks are systemic and require organizational-level interventions rather than relying solely on individual behavior. Overall, the results emphasize that the primary causes of accidents in PEB erection are procedural failures, inadequate supervision, and human factors rather than equipment limitations. The study underscores the importance of integrating engineering controls, strict enforcement of safety protocols, and continuous training to improve safety performance. The findings suggest that a proactive and holistic approach is necessary to address safety challenges in PEB erection using telescopic cranes. By focusing on stability, fall protection, communication, and worker well-being, it is possible to significantly reduce risks and ensure a safer working environment.

Conclusion

The present study on the Assessment of Hazards in Pre-Engineered Building (PEB) Erection Using Telescopic Cranes highlights critical safety challenges associated with construction activities involving lifting operations and working at height. Through systematic observation of 20 critical lift operations and analysis of data collected from 50 personnel, the study provides valuable insights into operational risks, procedural compliance, and effectiveness of safety measures. The findings clearly indicate that most crane operations are performed within safe mechanical limits, with minimal instances of overloading. However, despite this, a significant number of hazards arise due to procedural violations, unsafe work practices, and human factors. The study identifies improper outrigger setup and non-compliance with 100% tie-off systems as the most critical risk factors, directly contributing to crane instability and falls from height, which are the leading causes of severe accidents and fatalities in construction. The Hazard Identification and Risk Assessment (HIRA) results consistently ranked falls from height and crane instability as the highest-risk hazards due to their catastrophic consequences. Additionally, factors such as uncontrolled load movement, rigging failures, and ground instability further increase the risk of accidents. Behavioral aspects such as fatigue due to long working hours, poor communication, and lack of safety awareness were also found to significantly influence safety performance. The study also emphasizes that experience alone does not ensure safe practices, as even experienced workers exhibited notable levels of non-compliance. This indicates that safety issues are systemic and require strong supervision, continuous monitoring, and strict enforcement of safety protocols. Implementation of engineering controls such as crane mats, load monitoring systems, and fall protection equipment demonstrated significant improvements in reducing risk levels. Their effectiveness depends on proper usage, regular maintenance, and worker training. Validation and feedback confirmed that combining engineering solutions with administrative and behavioral controls leads to better safety outcomes. Improving safety in PEB erection requires a comprehensive approach that integrates engineering controls, procedural enforcement, worker training, and continuous monitoring. Organizations must adopt proactive safety management practices, ensure strict compliance with regulations, and promote a strong safety culture among workers. Addressing both technical and human factors, it is possible to minimize risks, prevent accidents, and ensure safe and efficient execution of construction projects involving telescopic cranes.

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