CHAPTER 132

Study on Safety and Risk Management on Construction Projects with Special Reference to Building Projects in Pune

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ABSTRACT

The construction industry is inherently hazardous, with safety and risk management playing a critical role in ensuring worker well-being and project efficiency. This study focuses on analyzing safety practices and risk management strategies in building construction projects in Pune. Given Pune's rapid urbanization and increasing vertical expansion, the research aims to evaluate existing safety protocols, identify challenges, and propose solutions for improving workplace safety. The study employs a mixed-method approach, incorporating primary data collection through structured surveys and interviews with industry professionals and secondary data analysis of construction safety reports and regulations. A total of 103 responses were collected from professionals across 36 construction organizations in Pune, providing insights into workforce experience, safety training, regulatory compliance, and hazard mitigation measures. Findings reveal that while safety awareness is prevalent, gaps exist in implementation due to cost constraints, inadequate training, and limited regulatory enforcement. Key concerns include fall protection, equipment maintenance, emergency preparedness, and adherence to safety guidelines during adverse weather conditions. The study highlights the importance of proactive risk management strategies, including regular safety audits, enhanced training programs, and the integration of advanced technologies such as Building Information Modeling (BIM) and IoT-based hazard detection. By fostering a robust safety culture and strengthening risk mitigation frameworks, construction firms can reduce accidents, enhance compliance with occupational health and safety regulations, and improve overall project sustainability. This research contributes to the ongoing discourse on construction safety by offering practical recommendations for stakeholders in Pune's construction sector.

Keywords: Safety management, Risk assessment, Construction safety, Building projects, Pune

1.0 Introduction

The construction industry is one of the most hazardous sectors in the world, with a high incidence of workplace injuries, fatalities, and financial losses due to safety violations and risk mismanagement.

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The preservation of project efficacy, the safeguarding of resources, and the well-being of personnel are contingent upon the implementation of risk management and safety measures (Lerman *et al.*, 2012). The importance of safety and risk management is heightened in urban centres like Pune, where accelerated infrastructural development and building construction are prevalent (Kodag & Kodag, 2023). A comprehensive risk assessment and safety management approach are required to mitigate potential hazards in construction projects, which include high-rise structures, commercial spaces, and residential buildings, due to the complexities involved. This research is dedicated to the evaluation of the efficacy of the current safety measures and risk management practices in the building construction sector of Pune, as well as the identification of areas that require refinement in order to improve the sustainability of projects and the welfare of workers (Pathak *et al.*, 2018).

Safety and risk management strategies that are effective are essential for reducing the probability of accidents and guaranteeing adherence to occupational health and safety (OHS) regulations. Construction labourers are at risk of experiencing a variety of hazards, including accidents from heights, equipment malfunctions, fire hazards, and material handling injuries. Furthermore, the viability of a project and the confidence of investors can be influenced by financial and reputational hazards. The demand for stringent safety protocols is exacerbated by the surge in construction projects that Pune, a swiftly developing metropolitan metropolis, experiences (Apurva, 2020). It is essential to incorporate safety measures into the planning, design, and execution phases of construction projects. This encompasses the implementation of Personal Protective Equipment (PPE), site safety audits, emergency response planning, and worker training programs. In order to improve on-site safety, advanced risk management techniques are currently being implemented, including real-time hazard detection through IoT-based sensors, Building Information Modelling (BIM)-based safety analysis, and risk probability matrices (Wehbi, 2022). Construction firms can substantially reduce their exposure to risk by emphasising safety culture and effective risk management frameworks. Incidents, improve operational efficiency, and ensure regulatory compliance in Pune's construction landscape. The fundamental practice of safety risk management in construction projects ensures the success of projects and the well-being of labourers. In the high-stakes and dynamic construction industry, prioritising safety is both a strategic necessity and a moral obligation.

Ekemezie & Digitemie, (2024), the industry involves numerous tasks, heavy machinery, and work at significant heights, all of which introduce risks that require stringent safety protocols and accident prevention measures. Over time, the construction sector has evolved, continuously improving safety practices in response to past incidents that underscored the need for comprehensive risk management. This historical evolution has shaped modern safety protocols, reinforcing the industry's commitment to worker protection. However, as construction projects become more complex due to technological advancements, increasing scale, and evolving risks, existing safety methodologies must adapt. The need for change is driven by the imperative to integrate innovative safety technologies, enhance risk assessment

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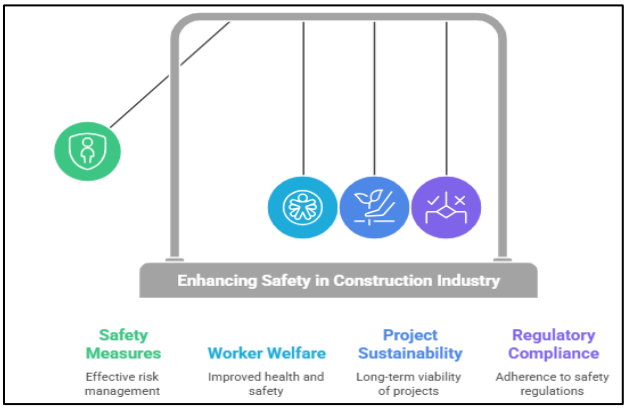
strategies, and ensure compliance with new industry demands. The construction sector must embrace a proactive approach, revitalizing and redesigning safety methods to protect workers and maintain efficiency. By advancing safety risk management frameworks, construction projects can achieve sustainability, reduce hazards, and uphold industry standards, making safety an integral part of every project's success (Nwasike *et al.*, 2024).

Figure 1: Enhancing Safety in Construction Industry



Source: Authors' own

1.1 Challenges in implementing safety and risk management practices

Despite the recognized importance of safety and risk management, several challenges hinder their effective implementation in Pune's building projects. One of the primary issues is the lack of awareness and training among construction workers regarding safety protocols (Manjula & Silva, 2014). Many laborers, particularly in informal employment setups, have limited access to safety education and equipment. Additionally, cost constraints often lead construction companies to compromise on safety measures to maximize profits, which results in increased accident rates and project delays. Regulatory enforcement and compliance are also major concerns.

While national and state-level construction safety regulations exist, their implementation at the site level is inconsistent due to poor monitoring and lack of accountability. The dynamic nature of construction activities further complicates risk assessment, as unforeseen hazards can arise due to design modifications, environmental conditions, and workforce inefficiencies. Addressing these challenges requires a multi-faceted approach, involving stronger regulatory policies, technological integration, stakeholder collaboration, and a proactive safety culture to ensure the protection of workers and the successful completion of building projects in Pune.

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1.2 Value addition through effective safety and risk management

The integration of structured safety and risk management mechanisms into construction projects offers numerous advantages, including economic and human benefits. Initially, it substantially decreases the occurrence of workplace accidents and injuries, thereby guaranteeing the safety of construction personnel. A well-managed safety framework also improves workforce morale and productivity, as employees feel secure in a risk-mitigated environment. From a financial standpoint, effective risk management leads to cost savings by minimizing project delays, legal liabilities, and medical compensations arising from accidents. It enhances the credibility and reputation of construction firms, making them more attractive to investors and clients who prioritize safety and sustainability. Moreover, compliance with safety regulations ensures smooth project approvals from regulatory bodies, reducing bureaucratic hurdles. The adoption of modern technologies such as AI-driven predictive analytics, real-time safety monitoring, and digital risk assessment tools can further refine safety strategies (Abbas & Duijster, 2025). For Pune's rapidly expanding construction sector, investing in safety and risk management is not just a regulatory necessity but a strategic advantage that contributes to long-term growth and development. This study aims to explore best practices, identify gaps, and propose recommendations for improving safety and risk management in Pune's building construction projects to foster a safer and more resilient industry (Godinho *et al.*, 2019).

2.0 Literature Review

The construction sector is inherently hazardous, with working at elevated levels posing a significant safety risk. As vertical expansion increases, effective safety risk management becomes crucial. Rubio-Romero *et al.* (2013) reviewed economic aspects, accident statistics, legal regulations, and scaffolding types, highlighting standard scaffolding's superior safety performance over nonstandard variants (Rubio-Romero *et al.*, 2013). Though costlier, standardized scaffolding enhances safety and simplifies maintenance, benefiting global construction practices. Shapira *et al.* (2013) examined 21 safety factors for tower crane sites, gathering insights from 19 managers in Israel (Shapira *et al.*, 2013). Their study aimed to establish safety protocols, highlighting challenges in identifying accident root causes and the importance of addressing multi-crane operations and worker exposure. Zhang *et al.* (2024) analyzed 2,991 questionnaires to explore how construction project owners influence worker safety behavior (Zhang, 2024).

They found that owners' objectives, safety organization, and hazard management significantly impact worker safety practices. Smita Bhole (2016) discussed key construction accident causes, such as worker negligence, improper procedures, and lack of safety measures (Bhole, 2016). The study emphasized the need for collaboration among all stakeholders to improve safety standards and minimize risks. Goh *et al.* (2018) examined high-rise construction safety, noting that untrained workers, unsafe actions, and weak management contribute to

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accidents. They suggested a reward-penalty system for safety compliance and emphasized continuous site inspections for effective accident prevention.

Dewlaney *et al.* (2012) assessed the impact of environmentally friendly construction practices on safety. They found that these practices could increase risks like falls and strains, necessitating better safety management and design integration. Future research should enhance eco-friendly construction safety through improved planning and material risk assessment. Fortunato *et al.* (2012) also studied green construction risks, finding increased exposure to heights and heavy machinery, leading to greater physical strain. They emphasized balancing sustainability with worker safety and suggested strategies for mitigating occupational hazards in eco-friendly construction. Lan & Daigle (2014) analyzed Quebec's trench work regulations, revealing ambiguities that could lead to safety issues.

They recommended clearer definitions, risk identification, and updated soil classification criteria to prevent accidents. Zhao *et al.* (2015) studied electrical injuries in construction, advocating for a systemic accident analysis approach. They emphasized that accidents result from interrelated factors rather than solely worker error, recommending comprehensive system evaluations for risk reduction. Abubakar Sadiq (2016) focused on falls from heights (FFH) in Saudi Arabia, identifying key causes such as inadequate training, lack of inspections, and missing PPE. The study called for stronger safety programs, risk assessment models, and enhanced management commitment to mitigate FFH risks. Bussier & Chong (2022) explored the link between psychological distress and human error in construction safety. They found that addressing psychological distress reduces errors and enhances safety, advocating for both organizational and individual strategies to manage mental well-being at heights. Vijayan & Ms (2018) examined India's construction safety laws, noting inadequate implementation in Kerala (Vijayan, 2018). They emphasized workforce protection, urging builders, contractors, and authorities to collaborate in preventing major injuries and fatalities for the overall well-being of society.

Gurcanli *et al.* (2022) studied fatal construction accidents in Turkey, focusing on small and mid-sized residential projects where most accidents occur (Gürcanlı *et al.*, 2022). The study examined 25 concrete residential buildings in Istanbul and estimated safety costs during early project stages. Findings revealed that safety costs accounted for 1.92% of total construction costs, with 0.85 USD per man-hour needed for compliance. Sarah Phoya *et al.* (2012) analyzed health and safety risk management in Tanzania's construction industry. The study revealed that risk management is solely the contractor's responsibility and occurs only during construction. Risks are assessed informally through experience and discussions. Challenges include site configuration and procurement systems, highlighting the need for stakeholder involvement to improve safety management.

Fung *et al.* (2010) examined occupational health and safety in construction, emphasizing the need for systematic risk assessments. Many professionals rely on personal experience rather than structured evaluation methods. A Risk Assessment Model (RAM) was

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developed to assess project risks, proving useful for identifying high-risk activities and preventing accidents based on historical data. Al-Anbari *et al.* (2015) developed the RASH method for assessing safety and health risks in Oman's construction sector. The method classified risks into safety and health categories, improving accuracy over traditional risk analysis. RASH provided more reliable risk estimation, showing statistical significance and enhancing risk management strategies for improved workplace safety. Gunduz *et al.* (2018) introduced a user-friendly risk assessment method for SMEs in construction, replacing probability estimates with control levels for more practical implementation. Applied to 22 SMEs, the method helped them update risk strategies efficiently. The approach promotes safer work environments, addressing the gap in risk assessment knowledge among small construction firms. King *et al.* (2014) investigated construction site accidents in Malaysia, identifying common safety practices and related challenges. Key issues included worker negligence, lack of financial support for safety, and communication barriers. Solutions included improved safety training, and increased budget. Zhang *et al.* (2022) Through surveys and interviews with industry professionals, safety risk management in Chinese underground construction projects was evaluated. The investigation revealed deficiencies in environmental preparedness and equipment maintenance, while construction planning and hazard communication were identified as strengths. The results provide policymakers with valuable insights to improve the safety strategies of subway construction in China.

2.1 Research gaps

In spite of the extensive research conducted on safety and risk management in the construction industry, there are still substantial gaps. There is a dearth of an integrated framework that addresses safety across diverse construction environments, despite the fact that numerous studies concentrate on specific construction hazards, including scaffolding safety, tower crane risks, and high-rise construction accidents. Additionally, while risk assessment models such as RAM and RASH have been developed, their application remains limited, especially among small and medium enterprises (SMEs), which struggle with implementation due to a lack of resources and expertise. Furthermore, studies highlight the role of worker behavior, psychological distress, and inadequate training in accidents, yet few address strategies to improve compliance and worker engagement systematically. Safety challenges in emerging economies, particularly in trench work, electrical safety, and eco-friendly construction, also require further exploration. There is a pressing need for a holistic approach integrating risk assessment, training, stakeholder involvement, and technological advancements to enhance safety practices across the construction sector.

3.0 Research Methodology

A mixed-method approach was employed to conduct the survey, utilizing both online and offline methods to reach a diverse range of respondents across different geographical

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regions. Online surveys were distributed through construction industry forums, social media platforms, and targeted email lists, while paper-based surveys were administered at construction sites to include workers without online access. The survey questionnaire was structured to collect quantitative and qualitative data, allowing for a comprehensive analysis of safety practices and perceptions among construction workers. A survey was conducted using a structured questionnaire, yielding 103 individual responses from professionals across 36 distinct organizations within Pune's construction industry. The respondents held various positions and possessed diverse levels of experience, providing a comprehensive overview of the workforce composition. This sample size aligns with general recommendations for survey research, ensuring a balance between statistical reliability and practical feasibility. The diversity in organizational representation and respondent experience enhances the study's ability to generalize findings and draw meaningful conclusions about safety and risk management practices in Pune's construction sector.

3.1 Data Collection Methods

Primary data collection: A structured questionnaire was distributed to 103 individuals from 36 construction organisations in Pune. This sample size is consistent with the standard ranges employed in construction research, thereby guaranteeing the availability of reliable data for analysis. In order to evaluate safety awareness, training, risk perception, and compliance with safety protocols, the survey evaluated a variety of roles, such as construction labourers, site supervisors, project managers, and safety officers. Furthermore, in order to acquire a more comprehensive understanding of safety practices and risk mitigation strategies, semi-structured interviews with industry experts and direct on-site observations were implemented.

Secondary data collection: A comprehensive literature review was conducted, encompassing existing research papers, safety reports, construction safety guidelines, and government regulations pertinent to occupational safety in Pune's construction industry. Furthermore, past accident reports and safety incident records were analyzed to identify common risks and recurring safety issues in building projects. This secondary data provided a contextual foundation, enriching the analysis of primary data and facilitating a holistic understanding of safety and risk management practices within the local construction sector.

4.0 Data Analysis

A structured questionnaire survey yielded 103 individual responses from professionals across 36 distinct organizations within Pune's construction industry. This sample size is considered adequate for statistical analysis in social science research, providing a balance between precision and resource constraints. The diverse representation enhances the study's ability to generalize findings and draw meaningful conclusions about safety and risk management practices in Pune's construction sector.

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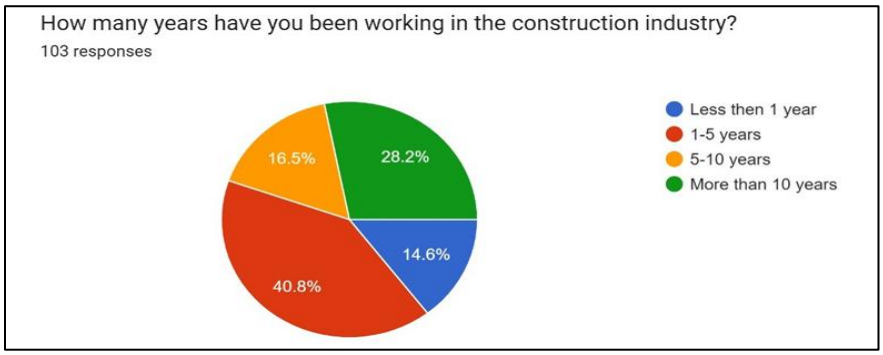
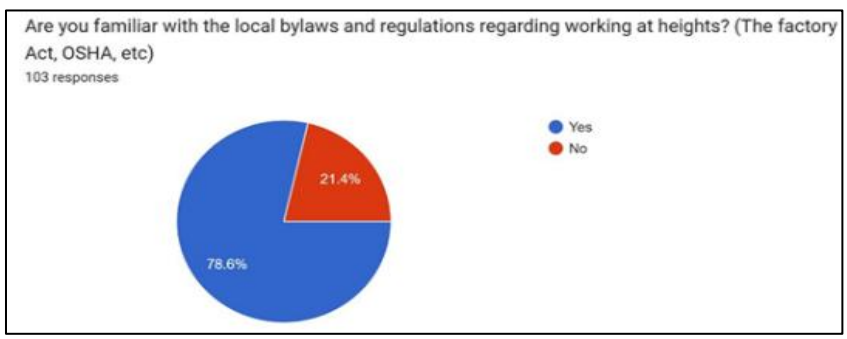
Figure 1: Working in the Construction Industry



The survey results reveal the distribution of work experience among 103 respondents in the construction industry. The discipline is significantly represented by relatively new professionals, as evidenced by the fact that the largest group (40.8%) has 1–5 years of experience. This is followed by 28.2% of respondents who have over 10 years of experience, indicating a robust representation of seasoned professionals. Additionally, 16.5% of respondents have 5–10 years of experience, while 14.6% have been in the industry for less than a year. This diverse distribution highlights a well-balanced workforce, where experienced professionals contribute expertise while newer entrants bring fresh perspectives. The findings emphasize the importance of targeted safety training programs catering to both experienced and novice workers to enhance workplace safety and efficiency in the construction sector.

Figure 2: Local Bylaws and Regulations Concerning Working at Heights



The survey results indicate the distribution of work experience among 103 respondents in the construction industry. The largest group (40.8%) has 1–5 years of experience, reflecting a significant presence of relatively new professionals in the field. This is followed by 28.2% of respondents who have more than 10 years of experience, showcasing a strong representation of

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seasoned professionals. Additionally, 16.5% of respondents have 5–10 years of experience, while 14.6% have been in the industry for less than a year. This diverse distribution highlights a well-balanced workforce, where experienced professionals contribute expertise while newer entrants bring fresh perspectives. The findings emphasize the importance of targeted safety training programs catering to both experienced and novice workers to enhance workplace safety and efficiency in the construction sector.

Figure 3: Regular Training on Safety Regulations and Standards for Working at Heights

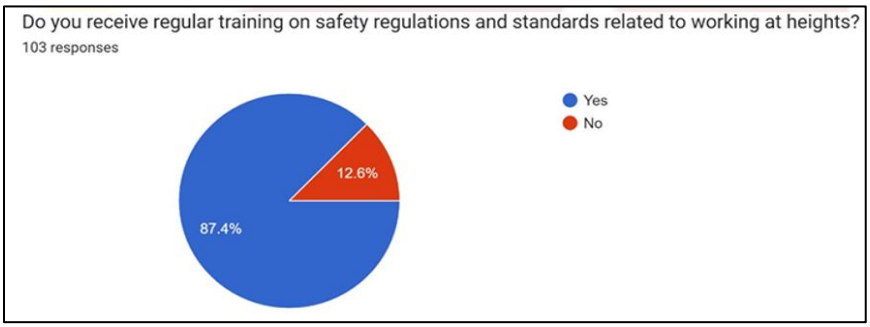
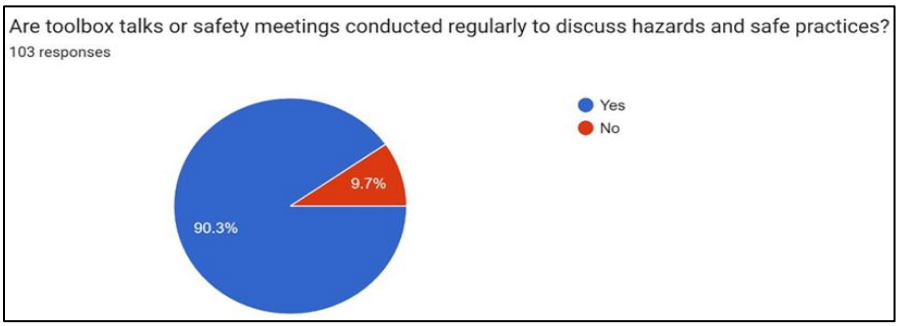


Figure 3: Toolbox Talks or Safety Meetings Conducted Regularly to Discuss Hazards and Safe Practices



The survey results indicate that 87.4% of respondents receive regular training on safety regulations and standards related to working at heights, reflecting a strong focus on workplace safety in the construction industry. However, 12.6% of respondents do not undergo such training, which poses a potential safety risk. Ensuring that all workers receive regular safety training is essential for reducing workplace accidents and maintaining compliance with safety regulations. Companies should strive for full participation in training programs to improve hazard awareness, reinforce safety measures, and foster a safer working environment for

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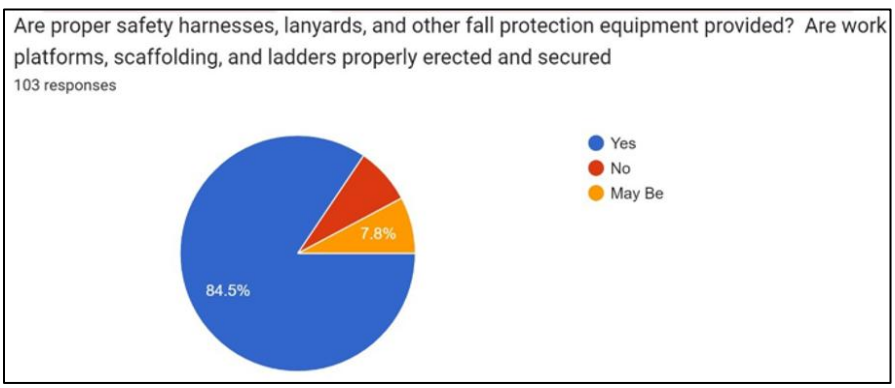
construction workers. The survey results indicate that 90.3% of respondents confirm that toolbox talks or safety meetings are conducted regularly to discuss hazards and safe practices, demonstrating a strong commitment to workplace safety communication. However, 9.7% of respondents report that such meetings are not held consistently, highlighting a gap that needs to be addressed. Regular toolbox talks are crucial for reinforcing safety awareness, preventing accidents, and ensuring that workers stay informed about potential hazards. Construction companies should aim for 100% compliance in conducting these meetings to maintain a culture of safety and risk prevention on-site.

Figure 4: Availability and Proper Installation of Fall Protection Equipment



84.5% of respondents affirm the availability and effective installation of fall protection equipment, including safety harnesses, lanyards, scaffolding, ladders, and work platforms, according to the survey results. Nevertheless, 7.8% of respondents indicate that the equipment is either not provided or not adequately secured, while another 7.8% are uncertain. This implies that, despite the fact that the majority of construction sites prioritise fall protection, a small number continue to experience safety compliance gaps.

To mitigate risks, companies should ensure that all workers have access to properly installed and maintained fall protection equipment, reinforcing safety training and inspections to eliminate potential hazards.

The survey results indicate that 93.2% of respondents believe workers are provided with sufficient protection from falling objects, reflecting strong safety measures in place at most construction sites. However, 6.8% of respondents feel that protection is inadequate, which presents a potential risk for workplace injuries. To ensure complete safety, companies should reinforce the use of protective barriers, helmets, and secure storage of materials at heights. Regular safety inspections and strict compliance with safety protocols can further minimize the risk of falling object-related accidents in construction sites.

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Figure 5: Adequacy of Protection Against Falling Objects

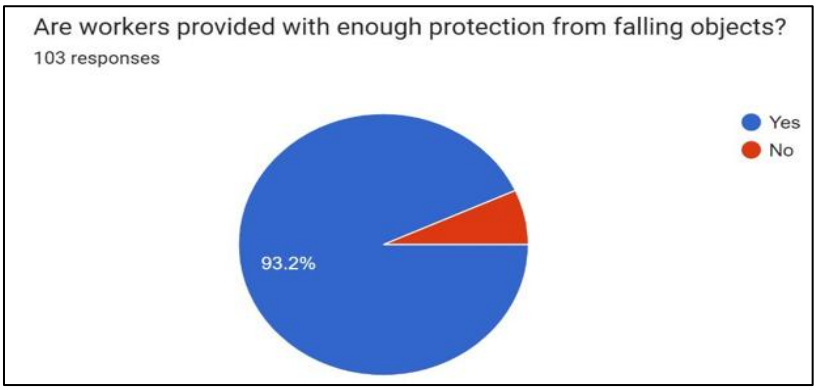
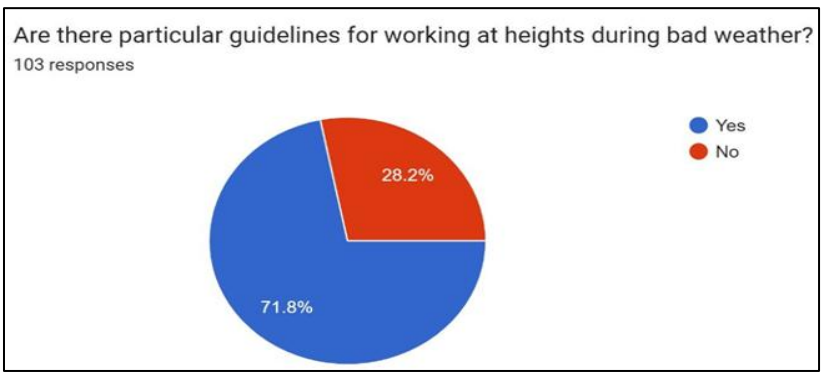


Figure 6: Availability of Guidelines for Working at Heights During Bad Weather



The survey results indicate that 71.8% of respondents confirm the existence of specific guidelines for working at heights during adverse weather conditions, which is a positive sign of safety preparedness. However, 28.2% of respondents report a lack of such guidelines, presenting a significant safety concern. Working at heights during bad weather, such as strong winds or heavy rain, increases the risk of falls and accidents. Construction companies should ensure that comprehensive weather-related safety protocols are established, communicated, and strictly enforced to protect workers from hazardous conditions. Regular training and reinforcement of these guidelines can further improve workplace safety.

The survey results reveal that 53.4% of respondents report the absence of hazards such as slippery surfaces, unguarded openings, or unstable structures, indicating that safety measures are implemented in many construction sites. However, 46.6% of respondents acknowledge the presence of such hazards, which presents a significant risk to worker safety. These hazards can

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lead to slips, falls, and severe injuries if not properly addressed. Construction companies must prioritize hazard identification, regular site inspections, and immediate corrective actions to eliminate these risks. Implementing better site management, signage, and protective barriers can further enhance workplace safety and minimize accident occurrences.

Figure 7: Presence of Workplace Hazards Such as Slippery Surfaces, Unguarded Openings, or Unstable Structures

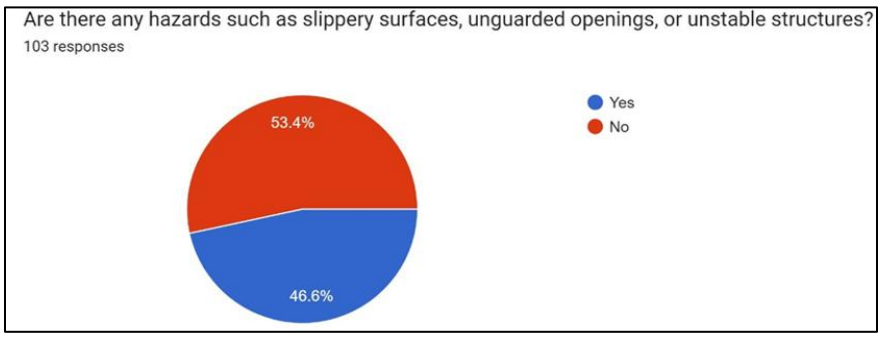
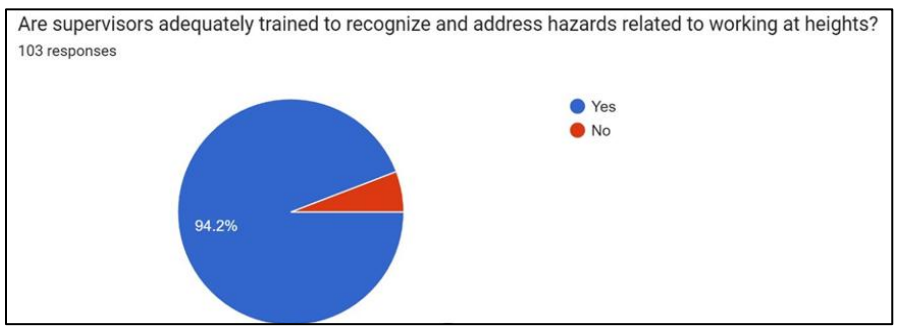


Figure 8: Supervisor Training on Recognizing and Addressing Hazards Related to Working at Heights



The survey results indicate that 94.2% of respondents believe that supervisors are adequately trained to recognize and address hazards related to working at heights. This suggests a strong emphasis on leadership training and hazard management in most construction sites. However, 5.8% of respondents feel that supervisors lack adequate training, which can pose a risk to worker safety. Ensuring that all supervisors receive continuous and updated safety training is crucial for maintaining a safe work environment. Construction companies should conduct regular training sessions and refresher courses to reinforce hazard identification and mitigation strategies, ultimately reducing the likelihood of workplace accidents.

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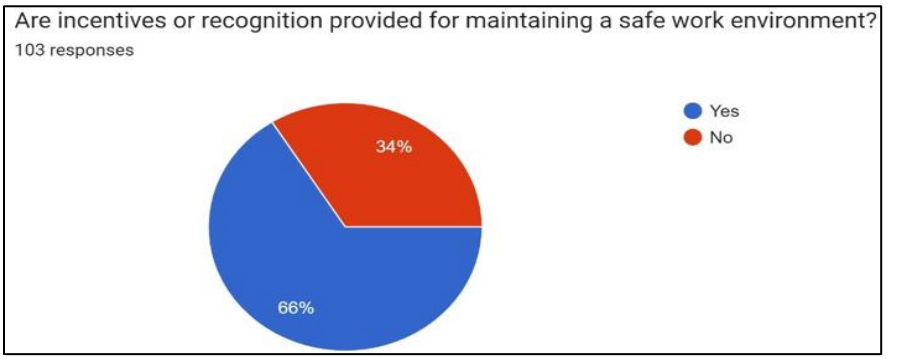
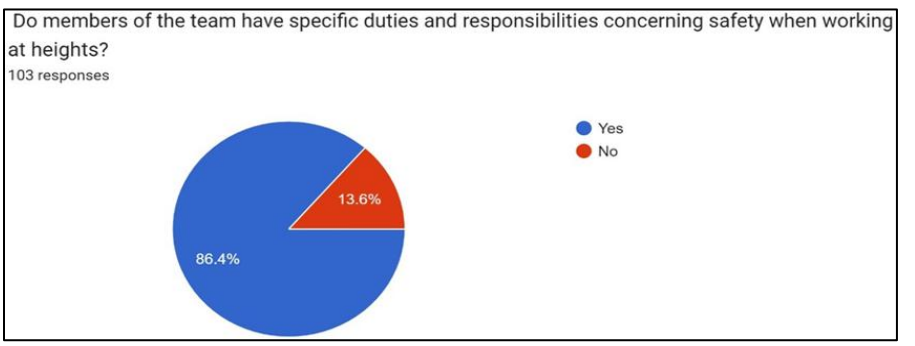
Figure 9: Provision of Incentives or Recognition for Maintaining a Safe Work Environment



The survey results show that 66% of respondents confirm the presence of incentives or recognition programs for maintaining a safe work environment, indicating that many organizations acknowledge and reward safety compliance. However, 34% of respondents report a lack of such programs, suggesting room for improvement in motivating workers to prioritize safety. Implementing structured incentive programs, such as safety awards or bonuses, can encourage employees to adopt safer work practices. Recognizing and rewarding safety-conscious behavior fosters a proactive safety culture, ultimately reducing workplace accidents and enhancing overall construction site safety.

Figure 10: Team Members' Specific Safety Duties and Responsibilities When Working at Heights



The survey results indicate that 86.4% of respondents confirm that team members have specific duties and responsibilities related to safety when working at heights, demonstrating a structured approach to workplace safety. However, 13.6% of respondents report that such

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responsibilities are not clearly assigned, which could lead to confusion and potential safety risks. Clearly defining and enforcing safety roles ensures accountability and enhances hazard prevention measures. Organizations should implement detailed safety protocols, assign responsibilities effectively, and conduct regular safety briefings to strengthen compliance and minimize risks associated with working at heights.

5.0 Conclusion

The critical importance of implementing effective safety measures to mitigate risks and improve construction site safety is underscored by the study on Safety and Risk Management in Construction Projects with Special Reference to Building Projects in Pune. The results suggest that, despite the increasing awareness of safety regulations and training, there are still voids in risk assessment methodologies, compliance, and implementation.

The construction industry in Pune, characterized by rapid urban expansion and increasing high-rise developments, faces significant hazards such as falls from heights, inadequate fall protection, and unsafe working conditions. The survey conducted among 103 respondents from 36 construction organizations provided valuable insights into safety practices. While most respondents reported regular safety training and toolbox talks, a notable percentage still lack access to structured risk assessment methodologies and compliance monitoring. Key concerns include the lack of proper guidelines for working at heights in adverse weather, inadequate incentives for maintaining a safe environment, and challenges in hazard identification. Furthermore, research gaps indicate the need for a holistic safety approach, integrating advanced technology such as IoT-based real-time hazard detection, systematic risk assessment models, and enhanced stakeholder involvement. The study suggests that construction companies, policymakers, and regulatory authorities must work collaboratively to enforce safety policies, provide adequate training, and develop risk mitigation strategies. Investing in a strong safety culture, incorporating modern safety technologies, and ensuring strict adherence to regulations will significantly reduce workplace accidents and improve overall construction efficiency in Pune's rapidly growing building sector.

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