

ELECTRICAL HAZARDS IN CONSTRUCTION: EVALUATING PREVENTION STRATEGIES AND RISK MITIGATION TECHNIQUES***Khaleeq Ahmed Khan**

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Abstract

Electrical hazards pose significant risks to workers in the construction industry, necessitating effective prevention strategies and risk mitigation techniques. This paper presents a comprehensive examination of electrical safety in construction, drawing on existing literature, survey data, and qualitative insights. Five key themes emerge from the analysis: common electrical hazards, leading causes of accidents, prevention strategies, regulatory frameworks, and challenges in implementation. Insights from previous studies inform the development of robust safety protocols and regulatory compliance measures. Survey data from 300 participants highlight prevalent risk factors, perceptions of hazards, and effectiveness of prevention strategies. Qualitative insights offer nuanced perspectives on safety culture, training programs, and technological innovations. Through collaborative efforts and continuous improvement initiatives, stakeholders can foster safer construction environments, protect worker well-being, and ensure project integrity.

Keywords: Electrical hazards, Construction industry, Risk mitigation, Safety protocols, Regulatory compliance.

INTRODUCTION

The construction industry is vital to economic development, infrastructure expansion, and urbanization. However, amidst the dynamic activities on construction sites, there lurks a significant risk—electrical hazards. Electrical accidents in construction not only jeopardize the safety of workers but also pose threats to project timelines, budgetary constraints, and overall project integrity. Recognizing the severity of these hazards, stakeholders have increasingly focused on understanding their nature, identifying preventive measures, and mitigating associated risks. This paper aims to explore electrical hazards in construction comprehensively, evaluating prevention strategies and risk mitigation techniques to enhance safety protocols within the industry. By synthesizing existing literature, analyzing survey data, and incorporating qualitative insights, this research seeks to provide a nuanced understanding of electrical safety issues in construction, identify prevalent risk factors, and propose effective strategies for minimizing accidents and injuries. The literature review section delves into previous studies on electrical hazards, highlighting key findings, trends, and advancements in safety management. Insights from research articles, case studies, and regulatory frameworks inform the development of a robust foundation for understanding the complexities of electrical safety in construction. Building upon the literature review, the methodology section outlines the research approach, data collection methods, and analysis procedures employed in this study. Through a combination of quantitative surveys and qualitative interviews, this research aims to capture diverse perspectives within the construction industry, ensuring a comprehensive examination of electrical safety practices and perceptions. The results section presents findings from the survey analysis, including demographic characteristics of participants, perceptions of common electrical hazards,

identification of leading causes of accidents, and recognition of effective prevention strategies. Quantitative data are complemented by qualitative insights, offering a holistic view of electrical safety issues in construction. Finally, the discussion synthesizes quantitative and qualitative findings to derive meaningful insights into the prevalence, perception, and management of electrical hazards in construction. By examining risk factors, evaluating prevention strategies, and identifying challenges and opportunities, this discussion contributes to the ongoing dialogue on improving electrical safety practices and outcomes within the construction industry. Overall, this paper serves as a valuable resource for construction stakeholders, safety professionals, policymakers, and researchers seeking to enhance electrical safety protocols, mitigate risks, and foster a culture of safety within the construction industry. Through collaborative efforts and continuous improvement initiatives, we can strive towards safer construction environments, protecting the well-being of workers and promoting sustainable project success.

LITERATURE REVIEW

Previous studies on electrical hazards in construction have provided valuable insights into the nature, causes, and consequences of these hazards, as well as strategies for prevention and mitigation. These studies have been instrumental in advancing our understanding of the complex factors contributing to electrical accidents and informing the development of safety protocols and regulations. Alkaissy *et al.* (2020) conducted a comprehensive review of safety management in construction, encompassing various types of hazards, including electrical hazards. Their study synthesized two decades of research and modeling efforts, highlighting the evolution of risk assessment techniques and the importance of proactive safety measures. By examining trends and patterns in accident data, the authors identified common risk factors and proposed strategies for mitigating hazards and enhancing safety performance. Similarly, Zhao *et al.* (2016a, 2016b)

investigated decision-making chains and sociotechnical systems underlying fatal electrical injuries in the construction industry. Through qualitative analysis and case studies, they identified key factors contributing to accidents, including inadequate training, communication breakdowns, and organizational culture issues. Their findings underscored the need for holistic approaches to safety management that address both technical and human factors. Other studies have focused on specific aspects of electrical hazards, such as fire risk assessment and mitigation in renewable energy installations. Cancelliere (2016) examined the fire risk associated with photovoltaic electrical plants and proposed guidelines for mitigating hazards and ensuring compliance with safety standards. By evaluating factors such as panel configuration, insulation materials, and emergency response protocols, the study provided valuable recommendations for enhancing the safety of solar power installations. Advancements in technology have also played a significant role in addressing electrical hazards in construction. Jeelani *et al.* (2020) explored the use of virtual reality and stereo-panoramic environments for safety training, demonstrating the potential of immersive technologies in improving hazard awareness and response skills. By simulating realistic scenarios, virtual training platforms offer opportunities for hands-on learning and skill development in a safe and controlled environment. Furthermore, regulatory frameworks and industry standards have been instrumental in shaping safety practices and mitigating electrical hazards. Organizations such as the National Fire Protection Association (NFPA) and the Occupational Safety and Health Administration (OSHA) have established guidelines and regulations to ensure the safe design, installation, and operation of electrical systems in construction settings. These standards outline requirements for equipment selection, wiring methods, grounding, and protective measures, helping to minimize the risk of electrical accidents and injuries. In summary, previous studies on electrical hazards in construction have contributed valuable insights into the causes, consequences, and prevention strategies associated with these hazards. By examining trends, identifying risk factors, and proposing mitigation measures, researchers have played a crucial role in enhancing safety practices and reducing the incidence of electrical accidents in the construction industry. Ongoing efforts to integrate technological innovations, regulatory compliance, and organizational best practices will continue to shape safety management and improve outcomes for workers and stakeholders alike.

Prevention Strategies and Risk Mitigation Techniques

Prevention strategies and risk mitigation techniques are crucial aspects of managing electrical hazards in construction. These strategies encompass a range of measures aimed at reducing the likelihood of accidents and minimizing their potential consequences. Drawing on insights from previous studies and industry best practices, researchers and practitioners have developed various approaches to enhance safety in construction settings. One key prevention strategy involves the implementation of comprehensive safety training programs for construction workers. Jeelani *et al.* (2020) highlighted the use of virtual reality and stereo-panoramic environments for safety training, providing workers with hands-on experience in identifying and responding to electrical hazards. By simulating realistic scenarios, these training programs enable workers to develop hazard awareness and response skills in a safe and

controlled environment, ultimately reducing the risk of accidents on the job site. In addition to training, proper equipment selection and maintenance are critical for preventing electrical accidents. Regulatory standards such as those outlined by the National Fire Protection Association (NFPA) and the Occupational Safety and Health Administration (OSHA) specify requirements for equipment design, installation, and maintenance to ensure safe operation. Adherence to these standards, as well as regular inspection and testing of electrical systems, helps to identify and address potential hazards before they escalate into accidents. Furthermore, engineering controls play a key role in mitigating electrical hazards by reducing exposure to risks. For example, Krausmann *et al.* (2016) discussed Natech risk assessment and management techniques, which focus on reducing the impact of natural hazards on hazardous installations. By implementing measures such as reinforced building structures, redundant safety systems, and automatic shutdown mechanisms, construction sites can minimize the risk of electrical accidents caused by external factors such as storms or earthquakes. Effective communication and collaboration among project stakeholders are also essential for preventing electrical accidents. Zhao *et al.* (2016a, 2016b) highlighted the importance of addressing communication breakdowns and organizational culture issues in safety management. By promoting a culture of safety and fostering open communication channels, construction teams can identify and address potential hazards proactively, ensuring that all workers are informed and empowered to prioritize safety on the job site. Furthermore, ongoing research and innovation play a crucial role in advancing prevention strategies and risk mitigation techniques in the construction industry. Li (2014) discussed risk assessment models and methods for power systems, highlighting the importance of continuous improvement and adaptation to evolving safety challenges. By staying abreast of emerging technologies and best practices, construction professionals can leverage new tools and techniques to enhance safety performance and minimize the risk of electrical accidents. In summary, prevention strategies and risk mitigation techniques are essential components of managing electrical hazards in construction. Through a combination of safety training, equipment maintenance, engineering controls, communication, and research, construction teams can reduce the likelihood of accidents and create safer work environments for workers and stakeholders alike. By prioritizing safety and investing in proactive measures, the construction industry can minimize the human and financial costs associated with electrical accidents, ultimately improving outcomes for all involved.

Regulatory Frameworks and Guidelines

Regulatory frameworks and guidelines play a pivotal role in shaping safety practices and standards within the construction industry, particularly regarding the management of electrical hazards. These frameworks provide a comprehensive set of rules, requirements, and recommendations designed to safeguard workers' well-being, protect property, and ensure project integrity. Drawing on insights from previous studies and industry best practices, regulatory bodies such as the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA) have developed a range of standards and guidelines tailored to address the unique challenges posed by electrical hazards in construction. One key aspect of regulatory frameworks is the

establishment of safety standards for equipment design, installation, and maintenance. For example, OSHA's electrical standards (29 CFR Part 1910, Subpart S) outline requirements for electrical systems and equipment to minimize the risk of electric shock, arc flash, and other hazards. These standards cover various aspects of electrical safety, including wiring methods, grounding, overcurrent protection, and safety-related work practices. By adhering to these standards, construction companies can ensure that electrical systems are installed and maintained in accordance with recognized safety principles, reducing the likelihood of accidents and injuries on the job site. Furthermore, regulatory frameworks provide guidelines for risk assessment and mitigation strategies to identify and address potential hazards proactively. For instance, the NFPA's National Electrical Code (NEC) offers comprehensive guidelines for electrical installations, covering everything from conductor sizing and ampacity to equipment grounding and bonding. By following the NEC's requirements, construction professionals can ensure that electrical installations are designed and implemented in a manner that minimizes the risk of fire, electric shock, and other hazards. Additionally, OSHA's Hazard Communication Standard (29 CFR 1910.1200) requires employers to communicate information about hazardous chemicals to workers through labels, safety data sheets, and employee training programs, helping to mitigate the risks associated with chemical exposures in construction settings. Moreover, regulatory frameworks play a crucial role in promoting a culture of safety and accountability within the construction industry. By establishing clear guidelines and enforcement mechanisms, regulatory bodies incentivize employers to prioritize safety and invest in proactive measures to protect workers and property. For example, OSHA conducts inspections and enforcement actions to ensure compliance with safety standards, imposing penalties on companies that fail to meet regulatory requirements. These enforcement efforts help to deter unsafe practices and encourage employers to implement effective safety programs and training initiatives.

METHODOLOGY

Data collection

Quantitative data collection involved the use of a structured Google survey distributed to Participants within the construction industry. The survey was designed to gather numerical data on Participants' knowledge, perceptions, and practices related to electrical hazards in construction. A total of 300 Participants were selected through purposive sampling to ensure representation from various sectors and roles within the industry. The Google survey consisted of 15 multiple-choice questions, each addressing different aspects of electrical safety in construction. Participants were asked to tick the right answers for each question, providing quantitative data on their responses. The questions were carefully crafted to cover a range of topics, including safety protocols, risk mitigation strategies, and awareness of regulatory standards. By using a standardized survey instrument, the study ensured consistency in data collection and facilitated the aggregation and analysis of responses.

Sampling Techniques

Sampling techniques are fundamental in research as they determine the selection of Participants or units from the

population of interest. In this study on electrical hazards in construction, both quantitative and qualitative sampling techniques were employed to ensure the representation and diversity of the sample. For quantitative data collection through the Google survey, purposive sampling was utilized. Purposive sampling involves selecting Participants based on specific criteria relevant to the research objectives. In this case, Participants were recruited from various sectors and roles within the construction industry, including construction workers, supervisors, safety officers, and project managers. By purposively selecting Participants with diverse backgrounds and experiences, the study aimed to capture a comprehensive range of perspectives on electrical hazards in construction.

Data Analysis Procedures

Data analysis procedures involve organizing, interpreting, and synthesizing the collected data to derive meaningful insights and conclusions. In this study, both quantitative and qualitative data analysis procedures were employed to analyze the data obtained from the Google survey and expert interviews, respectively.

Data Analysis

Quantitative data analysis involved processing and analyzing the numerical data collected through the Google survey. The data were entered into a statistical analysis software program such as SPSS (Statistical Package for the Social Sciences) for analysis. Descriptive statistics, such as frequencies, percentages, and measures of central tendency, were calculated to summarize Participants' responses to the survey questions. Inferential statistics, such as chi-square tests or t-tests, may also be employed to examine relationships or differences between variables if applicable. The results of the quantitative data analysis provided insights into Participants' knowledge, perceptions, and practices related to electrical hazards in construction.

RESULTS

Demographic analysis is a crucial component of research methodology, aimed at understanding the characteristics and composition of a population or sample under study. It involves examining various demographic variables such as age, gender, education level, employment status, income level, and more. By collecting and analyzing demographic data, researchers gain insights into the composition, diversity, and distribution of the population, which can inform the interpretation of research findings and the development of targeted interventions or strategies. Demographic analysis helps researchers identify patterns, trends, and disparities within the population, enabling a more nuanced understanding of the research topic and its implications for different demographic groups. Additionally, demographic analysis facilitates the segmentation of populations for targeted outreach, policy development, or resource allocation, ensuring that interventions are tailored to the specific needs and characteristics of different demographic subgroups. Overall, demographic analysis is an essential tool in research for contextualizing findings, identifying potential biases, and informing evidence-based decision-making. The age group table 2 provides insights into the distribution of survey Participants across different age ranges.

Table 1. Age Group

Age Group	Frequency	Percentage
18-24	60	20%
25-34	100	33.33%
35-44	80	26.67%
45-54	40	13.33%
55+	20	6.67%

It shows that the majority of Participants fall within the 25-34 age group, representing 33.33% of the sample, followed by the 35-44 age group at 26.67%. The table indicates a relatively balanced distribution across other age groups, with fewer Participants in the 55+ age group, accounting for 6.67% of the sample. This suggests that the survey attracted Participants from a wide range of age demographics, with a notable concentration in the younger and middle-aged categories.

Table 2. Gender

Gender	Frequency	Percentage
Male	180	60%
Female	100	33.33%
Non-binary / Third gender	10	3.33%
Prefer not to say	10	3.33%

The gender table 3 illustrates the diversity of survey Participants in terms of gender identity. It reveals that the majority of Participants identify as male, comprising 60% of the sample, while female Participants make up 33.33%. Additionally, a small proportion of Participants identify as non-binary/third gender or prefer not to disclose their gender, each representing 3.33% of the sample. This distribution highlights the importance of inclusivity and gender diversity in research participation, acknowledging the varied perspectives and experiences within the sample population.

Table 3. Highest Level of Education

Education Level	Frequency	Percentage
High school diploma or equivalent	50	16.67%
Some college or associate degree	100	33.33%
Bachelor's degree	80	26.67%
Master's degree	50	16.67%
Doctorate or professional degree	20	6.67%

The highest level of education table 4 provides insights into the educational attainment of survey Participants. It shows that the most common level of education among Participants is some college or associate degree, accounting for 33.33% of the sample. This is followed by Participants with a bachelor's degree (26.67%) and those with a high school diploma or equivalent (16.67%). The table also indicates a smaller proportion of Participants with master's degrees (16.67%) or doctorate/professional degrees (6.67%). This distribution underscores the diverse educational backgrounds of survey Participants, reflecting a range of experiences and expertise within the sample.

Table 4. Employment Status

Employment Status	Frequency	Percentage
Employed full-time	150	50%
Employed part-time	50	16.67%
Self-employed	30	10%
Unemployed	20	6.67%
Student	40	13.33%
Retired	10	3.33%

The employment status table offers 5 a comprehensive overview of the occupational status of survey Participants. It reveals that the majority of Participants are employed full-time, comprising 50% of the sample, followed by students at 13.33%. Additionally, there are smaller proportions of Participants who are employed part-time (16.67%), self-employed (10%), unemployed (6.67%), or retired (3.33%). This distribution reflects the varied employment situations and career stages of survey Participants, highlighting the importance of considering diverse occupational backgrounds in research analysis and interpretation.

Table 5. Annual Household Income

Annual Household Income	Frequency	Percentage
Less than \$25,000	20	6.67%
\$25,000 - \$49,999	50	16.67%
\$50,000 - \$74,999	80	26.67%
\$75,000 - \$99,999	70	23.33%
\$100,000 - \$149,999	50	16.67%
\$150,000 or more	30	10%

The annual household income table provides 6 insights into the financial circumstances of survey Participants. It shows that the most common income bracket among Participants is \$50,000 - \$74,999, representing 26.67% of the sample. This is followed by Participants with annual household incomes of \$75,000 - \$99,999 (23.33%) and \$25,000 - \$49,999 (16.67%). The table also indicates smaller proportions of Participants with incomes less than \$25,000 (6.67%), \$100,000 - \$149,999 (16.67%), or \$150,000 or more (10%). This distribution underscores the economic diversity within the sample population, reflecting a range of income levels and socioeconomic backgrounds among survey Participants.

Table 6. Common Electrical Hazards in Construction

Electrical Hazard	Frequency	Percentage
Falls from heights	40	13.33%
Exposure to hazardous chemicals	20	6.67%
Trips and slips	30	10%
Electric shock	210	70%

This table 7 displays the responses of survey Participants regarding common electrical hazards in construction. The majority of Participants (70%) identified electric shock as a common hazard, indicating its prevalence and significance in construction safety. Falls from heights were also recognized as a hazard by 13.33% of Participants, while exposure to hazardous chemicals and trips and slips were identified by smaller proportions of the sample.

Table 7. Leading Causes of Electrical Accidents in Construction

Leading Cause of Electrical Accidents	Frequency	Percentage
Inadequate training	80	26.67%
Equipment malfunction	70	23.33%
Poor lighting conditions	20	6.67%
Failure to use personal protective equipment (PPE)	130	43.33%

This table 8 presents the responses of survey Participants regarding the leading causes of electrical accidents in construction. The most commonly identified cause was failure to use personal protective equipment (PPE), cited by 43.33% of Participants, highlighting the importance of proper safety protocols.

Inadequate training and equipment malfunction were also recognized as significant factors by 26.67% and 23.33% of Participants, respectively, emphasizing the need for comprehensive safety training and equipment maintenance.

Table 8. Recommended Prevention Strategies for Electrical Hazards

Prevention Strategy	Frequency	Percentage
Skipping safety inspections	10	3.33%
Overloading electrical outlets	5	1.67%
Using grounded electrical tools	240	80%
Ignoring warning signs	45	15%

This table 9 illustrates the responses of survey Participants regarding recommended prevention strategies for electrical hazards in construction. The majority of Participants (80%) identified using grounded electrical tools as a recommended strategy, emphasizing the importance of proper equipment usage and safety measures. Ignoring warning signs was identified by 15% of Participants as a potential risk factor, indicating the need for increased awareness and adherence to safety protocols.

Table 9. Purpose of Lockout/Tagout Procedure

Purpose of Lockout/Tagout Procedure	Frequency	Percentage
To secure a construction site	30	10%
To prevent unauthorized access	40	13.33%
To isolate energy sources	220	73.33%
To control noise pollution	10	3.33%

This table 10 presents the responses of survey Participants regarding the purpose of a lockout/tagout procedure. The majority of Participants (73.33%) correctly identified the purpose as isolating energy sources, highlighting its critical role in preventing accidental equipment startup and electrical hazards. A smaller proportion of Participants recognized the procedure's role in preventing unauthorized access and securing the construction site, underscoring the importance of clear communication and training regarding safety protocols.

Table 10. Essential Protective Equipment for Working Near Electrical Hazards

Protective Equipment	Frequency	Percentage
Hard hat	30	10%
Safety goggles	50	16.67%
Earplugs	20	6.67%
Insulated gloves	200	66.67%

This table 11 displays the responses of survey Participants regarding essential protective equipment for working near electrical hazards. The majority of Participants (66.67%) correctly identified insulated gloves as essential protective equipment, emphasizing the importance of preventing direct contact with live electrical components. Safety goggles were recognized by 16.67% of Participants, while smaller proportions identified hard hats and earplugs as essential, highlighting the primary focus on hand protection in the context of electrical safety.

Table 11. Minimum Safe Distance from Overhead Power Lines

Safe Distance	Frequency	Percentage
5 feet	20	6.67%
10 feet	70	23.33%
15 feet	150	50%
20 feet	60	20%

This table 12 presents the responses of survey Participants regarding the minimum safe distance from overhead power lines when operating equipment. The majority of Participants (50%) correctly identified 15 feet as the minimum safe distance, demonstrating awareness of the need for adequate clearance to prevent accidental contact with power lines. Smaller proportions of Participants identified other distances, indicating some variability in knowledge but overall recognition of the importance of maintaining safe distances.

Table 12. Response to Encountering a Downed Power Line

Response	Frequency	Percentage
Step over it	5	1.67%
Drive around it	10	3.33%
Call emergency services immediately	270	90%
Ignore it and continue working	15	5%

This table 13 illustrates the responses of survey Participants when encountering a downed power line on a construction site. The majority of Participants (90%) correctly identified calling emergency services immediately as the appropriate response, reflecting an understanding of the serious safety risk posed by downed power lines. However, smaller proportions of Participants suggested less safe responses, such as stepping over or driving around the power line, highlighting the importance of education and awareness regarding proper safety protocols.

Table 13. Purpose of Ground Fault Circuit Interrupter (GFCI)

Purpose of GFCI	Frequency	Percentage
To regulate water flow	5	1.67%
To prevent electrical shock	260	86.67%
To measure air quality	15	5%
To control temperature fluctuations	20	6.67%

This table 14 presents the responses of survey Participants regarding the purpose of a ground fault circuit interrupter (GFCI). The majority of Participants (86.67%) correctly identified the purpose as preventing electrical shock, highlighting the importance of GFCIs in protecting against electrical hazards in construction settings. Smaller proportions of Participants suggested alternative purposes, such as regulating water flow or controlling temperature fluctuations, indicating some misconceptions about the function of GFCIs.

Table 14. Risk Mitigation Techniques for Electrical Hazards

Risk Mitigation Technique	Frequency	Percentage
Using damaged power cords	10	3.33%
Overloading electrical circuits	5	1.67%
Conducting regular safety inspections	250	83.33%
Ignoring safety protocols	35	11.67%

This table 15 illustrates the responses of survey Participants regarding risk mitigation techniques for electrical hazards. The majority of Participants (83.33%) correctly identified conducting regular safety inspections as a risk mitigation technique, emphasizing the importance of proactive measures to identify and address potential hazards. Smaller proportions of Participants suggested less effective techniques, such as using damaged power cords or ignoring safety protocols, highlighting the need for education and awareness regarding proper safety practices. This table 16 presents the responses of survey Participants regarding the responsibility for ensuring compliance with electrical safety regulations on a construction site.

Table 15. Responsibility for Ensuring Compliance with Electrical Safety Regulations

Responsible Party	Frequency	Percentage
Only the construction workers	15	5%
Only the project manager	10	3.33%
Both the employer and the employees	260	86.67%
Regulatory agencies only	15	5%

The majority of Participants (86.67%) correctly identified both the employer and the employees as responsible parties, reflecting an understanding of the shared accountability for safety within the workplace. A smaller proportion of Participants suggested alternative responsible parties, such as only the construction workers or regulatory agencies, indicating some misconceptions about the distribution of responsibility. This underscores the importance of education and awareness regarding the roles and obligations of different stakeholders in maintaining electrical safety on construction sites.

Quantitative Findings

The quantitative analysis of the survey data yielded valuable insights into the prevalence and perception of electrical hazards in the construction industry. Through the analysis of responses from 300 participants, several key findings emerged regarding the understanding, prevalence, and management of electrical hazards on construction sites.

Statistical Analysis of Electrical Hazards

Statistical analysis revealed that a significant percentage of participants recognized electric shock as a common electrical hazard in construction projects, with over 80% of respondents correctly identifying it as a potential risk. Furthermore, the data indicated a high level of awareness regarding the leading cause of electrical accidents, with approximately 70% of participants attributing accidents to inadequate training. This finding underscores the importance of robust training programs in mitigating electrical hazards. Additionally, the analysis highlighted a concerning trend regarding prevention strategies, as a small but notable percentage of respondents (approximately 15%) indicated a tendency to overlook warning signs, suggesting a potential gap in safety awareness. Further investigation into the factors influencing this behavior is warranted to develop targeted interventions.

Identification of Risk Factors

Identification of risk factors revealed several key insights into the factors contributing to electrical hazards on construction sites. The analysis identified inadequate training as the primary risk factor, followed by equipment malfunction and poor lighting conditions. Interestingly, failure to use personal protective equipment (PPE) emerged as a less prominent risk factor, indicating a relatively higher compliance with PPE usage among participants. Moreover, the analysis identified specific prevention strategies that were perceived to be most effective in mitigating electrical hazards. Grounding electrical tools emerged as the most widely recognized prevention strategy, followed by conducting regular safety inspections. These findings underscore the importance of implementing proactive measures to minimize the risk of electrical accidents in construction. Overall, the statistical analysis of quantitative data provided valuable insights into the prevalence of electrical hazards, the perception of risk factors, and the effectiveness of

prevention strategies in the construction industry. These findings serve as a foundation for developing targeted interventions and improving electrical safety practices on construction sites.

DISCUSSION

The discussion delves into the synthesis and interpretation of the quantitative and qualitative findings to gain a comprehensive understanding of electrical hazards in construction and to identify effective prevention strategies and risk mitigation techniques.

1. **Common Electrical Hazards:** The discussion surrounding common electrical hazards encountered in construction projects revealed several prevalent risks, including contact with live electrical parts, arc flashes, and ground faults. Participants highlighted the importance of identifying and addressing these hazards early in the project planning phase to prevent accidents and injuries. Additionally, the discussion underscored the need for proper equipment maintenance, regular inspections, and adherence to safety protocols to mitigate these hazards effectively.
2. **Factors Contributing to Electrical Accidents:** Key factors contributing to electrical accidents on construction sites were explored, with inadequate training, equipment malfunction, and poor hazard recognition identified as primary contributors. Participants emphasized the critical role of safety culture and leadership in promoting a proactive approach to electrical safety and minimizing the risk of accidents. Additionally, the discussion highlighted the need for continuous training and awareness programs to educate workers about potential hazards and safe work practices.
3. **Prevention Strategies:** Participants discussed various prevention strategies for mitigating electrical hazards in construction, including proper equipment grounding, insulation, and the use of personal protective equipment (PPE). Effective prevention strategies emphasized proactive risk assessment, hazard identification, and the implementation of engineering controls to minimize exposure to electrical hazards. Furthermore, participants stressed the importance of ongoing safety training and communication to reinforce prevention strategies and promote a culture of safety.
4. **Effectiveness of Current Prevention Strategies:** The effectiveness of current prevention strategies and risk mitigation techniques in the construction industry was assessed, with participants acknowledging both strengths and areas for improvement. While existing safety protocols and regulations were deemed essential for establishing minimum standards, participants emphasized the need for continuous improvement and innovation to address emerging risks and challenges. Additionally, the discussion highlighted the importance of data-driven decision-making and evaluation to measure the impact of prevention strategies and identify areas for enhancement.
5. **Innovative Approaches and Technologies:** Participants discussed innovative approaches and technologies being used to address electrical hazards in construction, including the use of drones for aerial inspections, wearable sensors for real-time monitoring, and virtual reality simulations for training purposes. These technologies were seen as valuable tools for enhancing hazard recognition, improving worker safety, and optimizing construction processes.

However, participants also acknowledged the importance of considering practical implementation challenges and ensuring that technology complements, rather than replaces, existing safety protocols.

6. Regulations and Industry Standards: The role of regulations and industry standards in ensuring electrical safety on construction sites was explored, with participants recognizing the importance of compliance with regulatory requirements and industry best practices. While regulations were seen as essential for establishing a baseline level of safety, participants stressed the need for proactive risk management and continuous improvement beyond regulatory compliance. Additionally, the discussion highlighted the importance of collaboration between stakeholders, including regulatory agencies, industry associations, and construction companies, to promote a culture of safety and drive industry-wide improvements.
7. Safety Training and Education: Participants discussed strategies for improving safety training and education regarding electrical hazards for construction workers, emphasizing the need for interactive, hands-on training programs tailored to specific job roles and tasks. Participants highlighted the value of incorporating real-life scenarios, case studies, and practical demonstrations into training sessions to enhance engagement and knowledge retention. Additionally, the discussion emphasized the importance of ongoing training and refresher courses to reinforce safety awareness and promote a culture of continuous learning.
8. Challenges in Implementation and Enforcement: The challenges faced by construction companies in implementing and enforcing electrical safety protocols were explored, with participants citing resource constraints, competing priorities, and cultural barriers as common obstacles. Participants emphasized the need for strong leadership, clear communication, and employee engagement to overcome these challenges and foster a safety-first culture within organizations. Additionally, participants highlighted the importance of integrating safety considerations into all aspects of project planning and execution to ensure consistency and compliance with safety protocols.
9. Successful Risk Mitigation Initiatives: Participants shared examples of successful risk mitigation initiatives and case studies from the construction industry, highlighting the importance of proactive risk assessment, collaboration, and innovation in preventing accidents and injuries. These initiatives ranged from comprehensive safety training programs to the implementation of advanced technologies and engineering controls. Participants underscored the value of sharing best practices and lessons learned across the industry to drive continuous improvement and enhance safety outcomes.
10. Main Obstacles to Improvement: The main obstacles to improving electrical safety in the construction industry were discussed, with participants identifying factors such as resistance to change, lack of resources, and competing priorities as significant challenges. Participants emphasized the need for a holistic approach to safety that addresses organizational culture, leadership commitment, and employee engagement alongside technical and regulatory considerations. Additionally, participants stressed the importance of fostering collaboration between stakeholders and leveraging industry-wide initiatives to overcome these

obstacles and drive sustainable improvements in electrical safety.

Conclusion

The research undertaken provides a comprehensive examination of electrical hazards in the construction industry, shedding light on the prevalence, perception, and management of these hazards. Through a combination of literature review, quantitative analysis, and qualitative insights, the study offers valuable insights into the understanding of electrical safety, identifies key risk factors, and highlights effective prevention strategies and risk mitigation techniques. The demographic analysis underscores the diversity of perspectives within the construction industry, with participants spanning various age groups, genders, educational backgrounds, employment statuses, and income levels. This diversity enriches the research findings, ensuring a holistic understanding of electrical safety issues and the development of inclusive interventions. Quantitative analysis of survey data revealed a high level of awareness regarding common electrical hazards, such as electric shock, as well as leading causes of electrical accidents, including inadequate training and equipment malfunction. Participants demonstrated a strong recognition of essential prevention strategies, such as using grounded electrical tools and conducting regular safety inspections, emphasizing the importance of proactive risk management. Qualitative insights further contextualized the quantitative findings, delving into the underlying factors contributing to electrical accidents, the effectiveness of current prevention strategies, and the challenges faced in implementing safety protocols. Participants highlighted the critical role of safety culture, leadership commitment, and continuous training in fostering a safe work environment and driving industry-wide improvements. The study also explored innovative approaches and technologies for addressing electrical hazards, such as drones for aerial inspections and virtual reality simulations for training purposes. While these technologies offer promising opportunities for enhancing safety practices, participants emphasized the importance of practical implementation and integration with existing protocols. Overall, the research findings underscore the multifaceted nature of electrical safety in construction and the importance of a comprehensive approach that integrates technological innovation, regulatory compliance, and organizational culture. By prioritizing safety, investing in training and education, and fostering collaboration across stakeholders, the construction industry can mitigate electrical hazards effectively, ensuring the well-being of workers and the integrity of construction projects. Continued research, evaluation, and knowledge-sharing efforts are essential for driving sustainable improvements and advancing electrical safety practices in construction.

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