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Enhancing Occupational Safety and Health Using Online Interactive Risk Assessment (OIRA) in Small to Medium – Scale Construction Companies in the City of San Fernando, Pampanga: Strategies, Challenges, and Best Practices

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Abstract:

Occupational safety and health (OSH) are important concerns in the construction industry, especially for small and medium-sized enterprises (SMEs), where insufficient resources frequently make comprehensive implementation challenging. This study focuses on enhancing occupational safety and health standards in the construction industry in the City of San Fernando, Pampanga, by strategically using an Online Interactive Risk Assessment (OIRA) tool. The study aims to identify current obstacles, develop user-friendly OIRA applications tailored to the needs of small to medium-scale construction companies, evaluate the accuracy of the implemented tools, and offer continuous enhancement approaches. This study investigates the complex landscape of OSH practices in SMEs, utilizing a thorough methodology that includes preliminary assessments, OIRA tool implementation, website development, and accuracy evaluations. The research uses thematic analysis and statistical approaches to shed light on common occupational hazards, such as falling objects and equipment malfunctions, emphasizing the significance of proactive risk management. The findings show the effectiveness of the OIRA tools in facilitating risk assessments, improving user engagement, and fostering a safety culture within small to medium companies. Furthermore, the study underlines the importance of ongoing monitoring, stakeholder participation, and user feedback channels in maintaining and enhancing occupational safety and health standards. This study contributes to the continuing efforts to improve workplace safety and promote the well-being of construction workers in San Fernando, Pampanga, and elsewhere by providing actionable insights and practical recommendations.

Keywords **—Occupational Safety and Health (OSH), Construction Industry, Small and Medium-scale companies, Online Interactive Risk Assessment (OIRA), Safety Culture**

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I. INTRODUCTION

In the dynamic and high-risk realm of construction, success hinges on unwavering dedication to safety. Vigilance in establishing a secure work environment surpasses regulatory compliance, involving meticulous development and implementation of comprehensive safety protocols. Stringent adherence to guidelines ensures each construction facet aligns with high safety standards, integrating preventive measures against potential hazards. This proactive approach, ingrained in the organizational culture, empowers every team member to be vigilant guardians of their safety and colleagues.

Prioritizing safety is crucial for overall project success, fostering a culture that lays the foundation for a harmonious work environment, translating into timely projects with heightened quality and precision. Safety is not merely a regulatory obligation; it represents an investment in workforce welfare and seamless project goal realization. Across industries, health and safety are paramount, especially in construction, where common accidents like tool cuts and falls occur. The International Labor Organization (ILO) highlights construction's highest rate of fatal workplace accidents, occurring twice as often and being more severe. Effective health and safety management acknowledges inherent construction risks, reduces injuries, and mitigates stress associated with the labour-intensive nature of the work.

Globally prioritizing workplace safety is critical for employee protection and increased productivity. Organizations implement ISO 45001, an international standard guiding the development of robust occupational safety and health management systems. Regular training promotes awareness, equips staff to address risks, and keeps employees updated on safety practices. Thorough risk assessments detect and minimize potential dangers, resulting in a safer workplace. Employee responses are more informed when safety rules, especially emergency procedures, are clearly communicated. This holistic strategy, incorporating international standards, training, risk assessments, and effective processes, is crucial for a safe global workplace, protecting people and contributing to company success [1].

Executive Order 307 established the Philippine National Occupational Safety and Health (OSH) system to protect workers from risks impacting their health, safety, and well-being. Key contributors include the Department of Labor and Employment, employers, workers' organizations, and government agencies. The order aims to enhance the government's capacity to prevent work-related injuries, illnesses, and deaths, reduce economic losses, and address social costs. Its declared policies focus on the effective implementation of occupational safety and health programs to improve Filipino workers' quality of life, boost productivity, and align with national development goals. Additionally, EO 307 mandates the maintenance of an expert center for industrial illnesses and occupational safety to support outlined objectives in relevant legislation [2].

Occupational Safety and Health (OSH) is a comprehensive discipline focused on ensuring workplace well-being, involving identifying, assessing, and controlling risks associated with work activities to prevent injuries, illnesses, and fatalities. OSH aims to create a work environment that prioritizes employees' physical, mental, and social well-being. The field encompasses formulating and implementing regulations, policies, and practices to establish and sustain safe workplaces, including strategies for hazard control, employee training, and providing necessary safety equipment.

Construction Occupational Safety and Health (COSH) Training, a crucial 40-hour program for safety officers in construction, is mandated by the Occupational Safety and Health Standards and DOLE Department Order 13. All construction companies must employ enough trained safety

officers, the quantity dependent on the workers per shift. The training includes lectures on Occupational Safety and Health programming, policies, and guidelines implementation, emphasizing the importance of safety in construction sites, covering areas like excavation, demolition, roles of safety officers, toolbox meetings, job hazard analysis, accident investigation, OSH legislation, Employees Compensation Program, and Emergency Preparedness.

The Yellow Book in safety and health is often a reference to the Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. This manual, jointly published by NIOSH, OSHA, USCG, and EPA, is a crucial resource for safeguarding workers involved in hazardous waste site activities. It aims to inform workers about potential hazards like chemical, physical, and biological risks, providing them with suitable safety measures to mitigate these dangers. The Yellow Book delineates comprehensive safety protocols, including personal protective equipment (PPE) requirements, decontamination procedures, and emergency response actions, thereby establishing a cornerstone for health and safety standards in hazardous waste management.

The guidelines in the Yellow Book underscore the importance of a systematic approach to safety and health, necessitating the development of a site-specific safety and health plan (SSHP) to address unique site conditions and hazards. This plan includes hazard identification, risk assessment, and the implementation of control measures. Additionally, the manual emphasizes the significance of training and education to ensure workers are adept at recognizing hazards, using PPE correctly, and responding effectively to emergencies. By fostering a culture of safety and vigilance, the Yellow Book aims to reduce the incidence of occupational injuries and illnesses in hazardous waste operations.

Furthermore, the Yellow Book serves a crucial role in regulatory compliance and promoting industry best practices. It aligns with standards set by OSHA's Hazardous Waste Operations and Emergency Response (HAZWOPER) regulations, providing practical guidance for their implementation. The recommendations in the Yellow Book assist organizations in maintaining compliance with federal safety regulations, thereby avoiding legal penalties, and fostering safer work environments. Additionally, by adhering to the Yellow Book's guidelines, companies can improve operational efficiency, reduce downtime due to accidents, and establish a reputation for safety and responsibility. Ultimately, the Yellow Book stands as an indispensable tool for protecting workers' health and well-being while ensuring the safe and effective management of hazardous waste sites.

In small to medium-scale enterprises (SMEs) in the Philippines, Occupational Safety and Health (OSH) encounters significant challenges stemming from limited resources. This constraint affects the comprehensive implementation of OSH measures, leading to issues like inadequate training, informal work structures fostering a lax attitude toward safety, and the multitasking nature of roles contributing to distractions and increased accident risks. Financial limitations hinder access to safety equipment, and inconsistent regulatory compliance poses legal challenges. Limited staffing results in excessive workloads, causing stress and fatigue, compromising safety adherence. Inadequate emergency response plans and oversight of workplace ergonomics underscore the need for concerted efforts from authorities and businesses. Prioritizing OSH, allocating resources, and fostering a safety culture through training and compliance are crucial for creating healthier working environments, especially in SMEs.

The integration of Online Interactive Risk Assessment (OIRA) tools in Europe, developed by the European Agency for Safety and Health at Work (EU-OSHA), is a strategic measure to improve occupational safety and health (OSH) practices, especially within small and medium-sized enterprises (SMEs). These tools are customized to address the specific challenges SMEs face, providing an accessible and cost-effective online

platform for conducting risk assessments. By enhancing accessibility and affordability, these tools encourage SMEs to prioritize their employees' well-being, fostering a culture of safety in workplaces. This implementation is aligned with the broader goal of ensuring compliance with European Union regulations and directives related to OSH. Actively promoted by the EU-OSHA, OIRA tools play a vital role in increasing awareness of workplace risks, promoting a proactive approach to accident prevention, and improving working conditions across the European Union.

Figure. 1 Online Interactive Risk Assessment Tool
Source: European Agency for Safety and Health at Work

This study emphasizes the importance of ensuring occupational safety and health (OSH) in small to medium-scale enterprises (SMEs) in the Philippines. Vital for both employee welfare and business sustainability, despite progress in awareness, challenges persist in implementing robust safety measures. The key to improvement involves strengthening regulatory frameworks, providing accessible training, and fostering a safety-centric culture. OSH measures aim to safeguard workers' well-being, prevent accidents, injuries, and exposure to harmful substances, fostering a health-conscious work environment.

1.2 REVIEW OF RELATED LITERATURE

1.2.1 Occupational Safety and Health Practices inConstruction Companies

Occupational Safety and Health (OSH) management is widely recognized as an essential way of addressing poor OSH performance, but empirical information on OSH management by construction companies in Sub-Saharan Africa is sparse. This study investigated into OSH management by construction-related companies (i.e., contractors) in Malawi to determine obstacles to implementation that needed to be addressed. Materials and procedures. A survey of contractors was used to examine 46 OSH management practices [3].

The construction industry is considered high-risk, as it involves dangerous and challenging work, such as excavation, the erection of structural steel, and working at substantial heights. The construction sector is regarded as high risk since it entails difficult and hazardous tasks including excavation, the erection of structural steel, and working at great heights [4].

The top industries in any country that significantly contribute to the survival and advancement of the economy and infrastructure are those in the construction sector. The economic success of any country contributes to the rapid growth of construction activities. The construction industry has a long history of poor performance in terms of health and safety. The complexity, numerous stakeholders, changeable operational environment, and organizational structures of building projects have all been blamed for this which have regularly resulted in accidents and injuries to workers [5].

1.2.2 EvaluatingWorkplace SafetyMeasuresinSmall and Medium-Scale Construction Companies

Small and medium-sized construction firms (SMSCF) must understand the factors that influence their growth for policy guidelines to be developed to improve their effective participation in the construction industry[6].

Lean construction (LC) and building information modelling (BIM) are two important concepts that are challenging established construction management approaches. Small and medium-sized firms (SMEs) are frequently the most numerous in construction supply chains. Increasing BIM and LC adoption among SMEs is a critical requirement for achieving BIM and LC transformation of the construction industry. Most countries' construction

industries are divided into two categories: huge corporations and small and medium-sized enterprises (SMEs). In many circumstances, larger corporations prefer to outsource work to smaller subcontractors rather than keep a large employment base. As a result, a small company has fewer than 50 people, whereas a medium-sized corporation has between 50 and 249 employees [7].

The effectiveness of small and medium-sized construction enterprises in Nigeria's Oyo State is examined in this study. These companies, according to the authors, are crucial to the construction industry, but they also confront a variety of difficulties, including a lack of access to capital and equipment, a lack of technical know-how, and competition from larger companies [8].

Small-scale contractor development in the construction sector by the International Labor Organization (ILO): In the construction industry, small-scale contractors confront both opportunities and problems, which are summarized in this paper. A few policies and programs that governments might employ to aid in the expansion and development of small contractors are also covered [9].

Any firm must carefully manage its occupational health and safety (OHS) concerns. Numerous studies have demonstrated that small-to-medium-sized businesses (SMEs) are disproportionately affected by work-related accidents and fatalities and that this is attributable to poor OHS risk management. The primary objective of this work is to create a foundation of indicators useful for assessing the maturity of OHS risk management in industrial SMEs [10].

1.2.3 Challenges and Best Practices in Occupational Safety within the Construction Industry

The construction industry is an intricate sector in which many stakeholders must work together to maintain occupational health and safety. Workers are the most important actors in maintaining a safe environment. As a result, workers' perceptions of workplace safety are substantial on a construction site [11].

The construction industry has one of the most dangerous working environments in any field of work. Workers in construction investment projects account for a significant portion of the costs, and there are many risks to labour safety. As a result, ensuring worker safety and aiming for zero labour accidents is a significant imperative and challenge for project managers and construction employees. Ensured safety throughout construction activity leads to project success [12].

Resilient safety culture attempts to create a sustained increase in safety performance by addressing the changing and unanticipated safety risks related to the complexity of building projects. As previously stated, companies may be better able to manage safety risk in construction projects with higher levels of resilient safety culture, reducing the negative effects of project complexity on safety performance. The sector continues to experience a high rate of casualties despite significant efforts to increase overall safety. In fact, dynamic and intricate construction processes may cause on-site dangers and safety plans to be disregarded, which is likely to result in several safety accidents [13].

A system to estimate the status of scaffoldings, including safe, over-turning, uneven settlement, and over-loading, by fitting strain sensors onto the scaffoldings. They developed a model to distinguish different safety conditions of scaffolds through the combination of finite element analysis and machine learning. The system has the potential to estimate the status of reinforced concrete structures by introducing material performance and structural behaviour. With the help of workers' safety experience and behaviour, some methods have been proposed to identify unpredictable, dangerous situations and hazard areas to fill the gap between the safety plan and real construction situation [14].

It offered a critical assessment of the wearable apps' state of the art for construction safety and health. Signal artifacts and noise in wearable sensors' field measurements, varying standards for personal safety and health risks in construction, users' reluctance to adopt new technology, and

uncertainty concerning the form of investment are identified as challenges that are preventing the further development and deployment of wearable applications. Opportunities exist for the field to advance, particularly in the areas of building a business case, conducting sensor fusion for wearable applications, and utilizing wearables for risk assessment and post-injury compensability evaluation [15].

Construction sectors have made significant contributions to global economic, business, and physical structural growth. The implementation and materialization of construction projects will inevitably benefit the people, thus achieving the desire of national progress and expansion and improving the nation's economic standing. Until now, some research has been conducted to improve the performance of construction projects [16].

Minor accidents without absence from work have other reasons (cuts or damage to the lumbar spine, eyes, or shoulder/arms/hands) compared to fatalities, which usually are caused by falls from height, electric shocks, crushing, or that the worker is hit by an object. Based on accident statistics, the risk of accidents with serious consequences is higher in small companies. The risk for accidents is higher among subcon166 tractors. Slips and trip accidents constitute a large part of 168 the number of accidents. Environmental conditions like dust, snow, ice, mud, and weather are identified as important contributing factors to accidents [16].

Small and medium-sized enterprises (SMEs) play an important role in the worldwide construction sector, accounting for 90% of all businesses and contributing to economic growth, employment creation, and support for bigger firms. Despite this, construction SMEs confront several important issues, including weak managerial control and growth in non-value-added activities (NVAA), which leads to poor output quality. These quality management issues can have a substantial influence on production, resulting in time and expense overruns as well as disagreements [17].

The prevalence of accidents and incurred illnesses in the construction industry is high due to its unique characteristics. Because of this, construction businesses build and implement occupational health and safety management systems (OHSMS) to safeguard the health of their employees [18].

It explains how the construction sector might use the Training Within Sector (TWI) program, which was developed from manufacturing procedures, to increase occupational safety. The TWI program's beginnings, goals, and connection to the lean management school of thought are also discussed. It demonstrates how safety has evolved to include a preventative strategy. It has been established that human mistakes, not technical issues, have the biggest influence on the likelihood of accidents. The key root causes of human errors were identified, and they are as follows: a lack of or improperly conducted training, poorly created and specified job standards, and an absence of staff monitoring [19].

1.2.4 Online Interactive Risk Assessment Tools

Online interactive risk assessment gives mostly micro and small organizations the tools and knowledge they need to evaluate risks with their resources [20].

The European Agency for Safety and Health at Work (EU-OSHA) is assisting small- and medium-sized enterprises by providing the "OIRA" tool, a web-based platform for evaluating sector-specific hazards [21].

OIRA - online interactive risk assessment is a freely available web application designed for micro and small businesses to perform a step-by-step risk assessment, from preparation, through identification and evaluation, and development of an action plan to reporting. However, the EU does not explicitly specify that states use the OIRA tool to assess occupational risks. It also supports the initiative of other Member States in developing such tools [21].

Organizations regarded the OIRA Tool to be clear, relevant, and user-friendly when assessing their readiness for leading and sustaininginnovations (with a high S-CVI index of 0.92 and I-CVI indices ranging from 0.82 to 1.0). Following expert consensus, the final version of the tool included 22 of the original 25 competencies. A

usability test proved the web-based OIRA Tool's usability and efficiency, demonstrated by above-average conversion rates (14%) and comparable bounce (51.81%) and exit rates (15.44%) when compared to industry standards [22].

Figure 2 OIRA tool EU-OSHA – The OIRA Team
Source: Ginger Lewis, 2019

1.3 STATEMENT OF THE PROBLEM

This paper aims to answer the following research questions:

a. What are the existing occupational safety and health challenges within small to medium-scale construction companies in the City of San Fernando, Pampanga, requiring assessment during the initial phase of the Online Interactive Risk Assessment (OIRA)?

b. How can effective tools and a user-friendly website be developed to address the identified occupational safety and health challenges in small to medium-scale construction companies, as part of the Online Interactive Risk Assessment (OIRA) initiative?

c. In what ways can the accuracy of implemented methods be evaluated, and what strategies can be devised to continually improve occupational safety and health measures within small to medium-scale construction companies in the City of San Fernando, Pampanga, following the implementation of the Online Interactive Risk Assessment (OIRA)?

1.4 OBJECTIVES

1.4.1 General Objective

This research aims to enhance occupational safety and health in small to medium-scale construction companies in the City of San Fernando, Pampanga, by effectively implementing an Online Interactive Risk Assessment (OIRA) tool. Throughout the initial assessment phase, the research seeks to identify and prioritize existing challenges, followed by the development of a user-friendly OIRA application and website specifically targeted to the needs of these construction companies. Consequently, the focus goes to ensuring the accuracy of the implemented OIRA tools and promoting continual improvement, as well as bolstering proactive solutions to address occupational safety and health concerns in the targeted industry. Eventually, this research intends to provide significant insights, concepts, and best practices to enhance the overall well-being and safety of workers in the specified region's construction industry.

1.4.2 Specific Objective

Specifically, the research study aimed to:

a. To conduct an extensive assessment of occupational safety and health strategies in small to medium-scale construction companies in San Fernando, Pampanga, to identify and prioritize existing challenges.

b. To develop an Online Interactive Risk Assessment (OIRA) tool and website that effectively addresses the identified occupational safety and health challenges while ensuring user-friendliness and adapted relevance to the context of small to medium-scale construction companies.

c. To evaluate the accuracy of the implemented Online Interactive Risk Assessment (OIRA) methods and develop strategies for continuous improvement, with a focus on enhancing occupational safety and health measures in small to medium-scale construction companies in San Fernando, Pampanga.

1.5 SCOPE AND LIMITATIONS

The study focuses on analyzing small to medium-scale construction companies situated in

the City of San Fernando, Pampanga, with a specific emphasis on identifying the diverse risks and hazards inherent in vertical construction. These risks encompass various potential incidents such as falls from elevated positions, structural collapses, electrical dangers, equipment-related risks, and other hazards particular to tall structures. This investigative approach is designed to conduct a thorough evaluation of the local regulatory framework and contextual factors influencing occupational safety and health within the construction industry. While acknowledging the prevailing methodologies employed by construction firms, the research endeavors to achieve a nuanced understanding of the sector's safety and health concerns. Additionally, the study introduces an innovative online interactive risk assessment tool (OIRA) aimed at enhancing safety practices within construction operations. Through a meticulous analysis of strategies, challenges, and best practices adopted by these companies, the research aims to provide valuable insights for improving workplace safety and health standards within the construction sector.

This study is delimited to specific small to medium-scale companies and defined geographical regions, which may limit its generalizability to other industries or locations. Horizontal construction hazards, such as those encountered in roadways, bridges, highways, tunnels, and pipelines, are not within the scope of this investigation. When extrapolating the findings to a broader community, careful consideration must be given to the impact of sample size and representation. Furthermore, legislative amendments or technological advancements in subsequent research may influence the relevance and timeliness of this study. Moreover, the efficacy of the online interactive risk assessment tool may be contingent upon the technological infrastructure and accessibility within the target companies. Despite diligent efforts to ensure data integrity, privacy, and participant transparency, it is important to acknowledge that resource constraints, including financial and temporal limitations, may impose constraints on the depth and scope of the research.

II. METHODOLOGY

2.1 Research Design

In this study, the qualitative research method was utilized to provide deeper insights into existing issues. This approach is renowned for its ability to define difficult-to-analyze patterns and processes of human behavior effectively.

Furthermore, researchers employed a data collection method recognized for its pivotal role in the overall success and internal validity of a study. The collected data was interpreted to either support or refute research hypotheses and draw conclusions on the study's subject matter. To gather the data, a survey questionnaire was utilized to collect primary data that was previously unavailable but was asserted through the research process, in conjunction with interviews.

The choice of qualitative research was necessitated by the need to conduct interviews with participants regarding existing challenges in occupational safety and health (OSH) within small to medium-scale construction companies. Through qualitative research, researchers assessed and evaluated inadequacies or gaps in OSH measures among construction companies. Interviews were considered the most efficient method for gathering information, enabling researchers to collect data within variables and providing an additional concept for further development of online interactive risk assessment tools, thereby enhancing accuracy for small to medium-scale construction companies.

2.2 Methodological Framework

The following procedures were undertaken to accomplish the intended results and, ultimately, to meet the specified goals. Preliminary Assessment, OIRA Implementation and WebsiteDevelopment,

Tool Accuracy and Continuous Improvement are the three phases in the methodology.

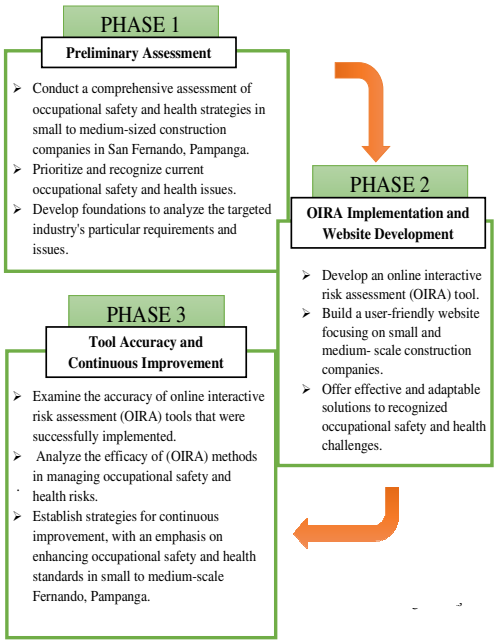

Figure 3 Flow of Process in Obtaining Results

2.3 Phase 1: Preliminary Assessment

In this study, researchers aim to conduct a comprehensive assessment to understand the strategies, challenges, and best practices encountered by small to medium-scale construction companies specifically in the City of San Fernando, Pampanga. The research endeavors to delve into the intricate landscape of these companies, shedding light on the approaches employed, the risks faced, and the exemplary practices that contribute to their overall operational framework.

The researchers executed better understanding and enhanced Occupational Safety and Health (OSH) procedures in small to medium-sized construction companies. Also, the researchers' geographic focus is on San Fernando, Pampanga, a thriving center for these kinds of industries. A fundamental methodological choice modified the researchers' approach; they used simple random sampling, which involves picking every company in the study at random.

A simple random selection ensures a neutral portrayal of San Fernando's small to medium-scale construction companies. With this approach, potential biases were eliminated, and more broadly applicable findings can be drawn because every organization was given an equal chance of being chosen. This method becomes important as researchers explore the complexities of occupational safety and health, allowing them to understand the subtle problems and strengths present in these varied organizations.

Based on the provided list of municipalities in the City of San Fernando, Pampanga, it has been determined that there are only 188 registered construction companies. Researchers aim to provide a thorough and accurate depiction of Occupational Safety and Health (OSH) practices within this industry through the utilization of basic random sampling techniques. The conclusions drawn from this study are intended not only to augment the existing body of knowledge in the field but also to furnish practical recommendations for small- to medium-scale construction companies in the City of San Fernando, Pampanga, with the objective of promoting a safer and healthier workplace environment.

Selecting a suitable sample size is significant to the investigation of this study into the complexities of enhancing occupational safety and health (OSH) in small to medium-scale construction companies in the City of San Fernando, Pampanga. To do this, researchers used Cochran's formula, a statistical technique that is essential to determining how robust the study is. By using Cochran's formula, researchers may achieve a compromise between

accuracy and usefulness. By considering a 10 percent margin of error, the researchers are admitting the permissible range that results could fall within. The z-score, which is set at 1.645, represents the 90 percent confidence level. This shows how confident researchers are in their ability to capture the genuine traits of the population under study.

Cochran's formula helps determine the sample size required for a representative study, which is relevant to this research since the goal of this study is to reveal the complex landscape of OSH practices. An increased sample size guarantees a more precise portrayal of the strategies, challenges, and industry best practices common to small and medium-sized construction firms. In addition to upholding statistical rigor, researchers are also bringing their research into compliance with the pragmatic requirements of the context they have selected by carefully implementing Cochran's formula. The sample size that is obtained serves as a dependable basis for deriving significant conclusions and providing perceptive suggestions, which in turn aids in improving occupational safety and health in the City of San Fernando, Pampanga's construction sector.

To verify the findings of Cochran's formula in calculating the overall sample size for the study, the researchers used Raosoft's sample size calculator as an additional tool. By ensuring a strong and cross-validated methodology, this approach improves the dependability of the research findings. Raosoft's sample size calculator probably provided more information and validation, enhancing the study's methodological rigor. Using that, the sample size was calculated to be 50 out of 188 registered construction companies, with one respondent representing each company.

The classification of construction projects into small to medium-scale categories depends on various factors such as project size, budget, and complexity. Small-scale construction projects typically involve endeavors like individual houses, small shops, or community facilities with budgets ranging from a few hundred thousand pesos to a few million pesos. These projects are manageable in terms of workforce, duration, and resources required. Medium-scale construction projects, on the other hand, encompass larger undertakings such as bigger commercial buildings or mid-sized housing developments, with budgets typically ranging from a few million to tens of millions of pesos. These projects often require a more extensive workforce, longer completion times, and a higher level of coordination and resources compared to small-scale endeavors.

The distinction between small and medium-scale construction companies in this context lies in their capacity to handle projects within these budget ranges. Small companies typically specialize in projects at the lower end of the budget spectrum, while medium-sized firms demonstrate the ability to manage larger and more complex endeavors within the specified financial limits.

The main research instruments in this study, which examined risk understanding and mitigation in small- to medium-sized construction companies in San Fernando, Pampanga, are a combination of survey questionnaires and interviews.

Survey Questionnaire: To methodically collect qualitative data, researchers used a structured questionnaire. This tool is made up of a series of pre-written questions about various aspects of the risks associated with occupational safety and health (OSH) and it is an open-ended question. The respondents, in this case the important employees of the companies, provide qualitative answers, which enable them to express their experiences, opinions, or insights in their own words. Because the questionnaire guarantees a uniform methodology, researchers can effectively compare responses from various companies.

Interviews: To further explore the subtleties of risks within each company, researchers used qualitative interviews in addition to the structured questionnaire. Comprehensive insights are sought by letting respondents elaborate on their experiences, perceptions, and the contextual nuances of occupational safety and health (OSH) risks through open-ended questions. Interviews give

the researcher's overall analysis more depth by allowing us to understand the challenges that each company faces in more detail.

The researchers' goal in combining these two research tools is to produce thorough and integrated knowledge of the risk environment. Interviews and structured questionnaires offer rich qualitative data, the interview captures the contextual and human aspects of occupational safety and health risks, while the structured questionnaire offers qualitative data for statistical analysis. The implementation of a dual-method approach guarantees a comprehensive investigation of the obstacles encountered by small to medium-sized construction firms in the City of San Fernando, Pampanga, and establishes the foundation for the formulation of efficacious risk mitigation tactics.

To examine the gathered qualitative data, thematic analysis was utilized. Thematic analysis serves as a technique for recognizing, examining, and presenting patterns (themes) inherent within data. It facilitates the systematic coding of data, its organization into coherent themes, and the interpretation of various facets of the research subject. In this study, the application of thematic analysis will aid in the identification of crucial themes concerning Occupational Safety and Health (OSH) practices, associated challenges, and best practices within the construction firms under scrutiny. Employing this method will empower researchers to acquire a comprehensive comprehension of the risk landscape and derive actionable insights conducive to the formulation of targeted OSH strategies for these enterprises.

2.4 Phase 2: OIRA Implementation and Website Development

Initiating the development of an Online Interactive Risk Assessment (OIRA) tool and a web application requires a methodical and goal-oriented approach. The process commences with a clear definition of the tool's purpose, establishing a solid foundation for a systematic approach. Thorough identification of workplace risks follows necessitating comprehensive analysis to encompass a wide range of scenarios. Adherence to regulatory standards takes precedence, guiding the design and functionality of the tool. Attention to detail and alignment with occupational health principles remain pivotal throughout this structured process, fostering the development of a robust OIRA tool and web application.

The creation of content for an Online Interactive Risk Assessment (OIRA) tool follows a systematic process. It starts with defining the tool's objectives, identifying workplace hazards using real-world examples, and ensuring compliance with regulations. Next, the chosen risk assessment methodology, user-friendly instructions, and specific risk factors for assessing likelihood and severity are outlined. Interactive quizzes on the website enhance user engagement, allowing users to test their knowledge while navigating the content and receive immediate feedback. Comprehensive training materials support implementation, integrated into broader safety procedures. A feedback mechanism allows for updates based on user input, resulting in a comprehensive and user-friendly tool for effective workplace risk assessment and management.

The development of a web application is a systematic process that commences with defining specific objectives. This involves outlining the purpose, identifying the target audience, and specifying key features. The subsequent crucial step is to gather pertinent data while considering user experience and design preferences to ensure the application meets user expectations.

In front-end development, Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript are commonly utilized tools. HTML provides the structural framework of the web pages, CSS enhances visual presentation, and JavaScript facilitates interactivity. Backend languages like Hypertext Preprocessor (PHP) can be employed for tasks such as user authentication and data storage.
The structure and layout of the application are integral components of the development process. This encompasses designing a user-friendly

interface and ensuring responsiveness across various platforms to guarantee a consistent user experience regardless of the device used to access the web application.

Overall, this systematic approach contributes to the successful creation of a comprehensive and efficient web application. It involves progressing from defining objectives to implementing front-end and back-end technologies, all aimed at delivering a seamless and gratifying user experience.

Figure 4: Workflow within the website for OIRA tool implementation

Figure: 11-24 OIRA Website Content

2.5 Phase 3: Tool Accuracy and Continuous Improvement

Improving the OIRA tool's effectiveness in managing occupational safety and health by enhancing its ability to identify various risks within the construction industry. This phase involves evaluating the tool's user-friendliness and accessibility to ensure that individuals with varying

levels of expertise can navigate it proficiently for effective risk assessments. Additionally, the accuracy of the data collected through OIRA assessments will be scrutinized.

To elevate safety and health standards in small to medium-scale construction companies in the City of San Fernando, Pampanga, researchers will conduct comprehensive training sessions for both employees and management. These sessions will emphasize the proficient use of the OIRA tool for risk assessments, understanding its functionalities, and ensuring accurate data entry. A structured schedule will be implemented for regular updates to align with changes in local safety regulations and industry standards, ensuring the tool's continued relevance and effectiveness. Encouraging active involvement from management in the OIRA risk assessment process will be a key focus. Routine safety audits will be conducted to validate the tool's efficacy in identifying and mitigating risks. Through these initiatives, construction companies can leverage the OIRA tool to consistently enhance occupational safety and health standards, thereby fostering a safer work environment.

Researchers will also assess user feedback to gauge the accuracy of the OIRA tool. Feedback will be gathered through questionnaires, interviews, and user comments during tool or website usage. This feedback will offer valuable insights into users' experiences and interactions with OIRA, aiding in identifying the tool's strengths and areas for improvement.

III. RESULTS AND DISCUSSIONS

This chapter illustrates the data collected and organized following the 3 phases of methodology particularly: (1) Preliminary Assessment; (2) OIRA Implementation and Website Development; (3) Tool Accuracy and Continuous Improvement.

3.1 Preliminary Assessment

This section presents the results and discussions of the Thematic Analysis performed. The findings are displayed in tables and structured based on the sequence of the survey questionnaire. The data collection involved both a survey questionnaire and interviews with small to medium-scale construction companies in the City of San Fernando, Pampanga. The questionnaire sought to delve into different facets of workplace safety, risk management, and strategies for mitigating hazards utilized by these companies.

Table1 Question #1. Could you please provide details regarding the safety personnel or officers responsible for ensuring workplace safety in your company, including any designated safety officer? Describe their roles and responsibilities.

Theme	Sub-themes	Theme Description	Respondents	No. of Respondents Mentioning Theme
Safety Officer Responsibilities	Enforcement of safety protocols, conducting inspections, providing training, ensuring compliance	Safety officers are responsible for enforcing safety protocols, conducting inspections, providing training, and ensuring compliance to maintain a safe working environment.	2, 3, 4, 6, 7, 8, 9, 10, 13, 16, 22, 23, 24, 26, 27, 28, 31, 32, 34, 35, 37, 38, 39, 40, 41, 42, 43, 46, 48, 49	28
Collaboration with Employers	Developing and refining safety policies	Safety personnel collaborate with employers to develop and refine safety policies aiming to minimize accidents and mitigate financial losses.	8, 20	2
Training and Education	Providing safety instructions and precautions, conducting safety training sessions	Safety officers provide safety instructions, and precautions, and conduct training sessions to educate employees on safety measures.	3, 7, 13, 16, 20, 26, 37	7
Workplace Safety Oversight	Overseeing safety policies, ensuring compliance, conducting inspections	Safety officers oversee safety policies, ensure compliance, and conduct inspections to maintain workplace safety standards.	1, 5, 7, 10, 14, 15, 17, 18, 19, 21, 22, 23, 25, 27, 28, 29, 30, 33, 34, 35, 38, 39, 41, 42, 43, 44, 45, 47, 50	27
Safety Officer Qualifications	Background, training	Safety officers often have backgrounds in occupational	11, 13, 22, 23, 28, 48, 50	7

		safety and health (OSH) and undergo specific training to fulfill their roles effectively.		
Emergency Preparedness	Creating emergency action plans, handling crises	Safety officers create emergency action plans and handle crises to ensure the safety of employees in case of emergencies.	27	1

Safety Officer Responsibilities

The primary responsibilities of safety officers, as highlighted by 28 respondents, include enforcing safety protocols, conducting inspections, providing training, and ensuring compliance. These duties align closely with the standards outlined in the Yellow Book, which emphasizes proactive safety management and continuous monitoring to maintain a safe working environment.

Workplace Safety Oversight

Ensuring workplace safety oversight emerges as another notable element, as highlighted by 27 participants. Safety officers are designated to enforce safety protocols, ensure adherence to regulations, and perform inspections aimed at identifying and rectifying potential hazards. This mirrors the principles delineated in the Yellow Book, emphasizing the importance of stringent oversight and adherence to safety regulations to mitigate workplace accidents and injuries.

Training and Education

Seven respondents underscored the importance of training and education provided by safety officers. These activities include safety instructions, precautions, and training sessions to enhance employee awareness and adherence to safety protocols. These practices are consistent with the guidelines in occupational safety and health standards, which emphasize the need for comprehensive safety training programs to equip employees with the knowledge and skills necessary to maintain a safe workplace.

Safety Officer Qualifications

The qualifications and training of safety officers were noted by seven respondents, highlighting the value of professionalism and competency in safety management. Safety officers with backgrounds in OSH and specific training fulfill their roles effectively, which aligns with the qualifications specified in safety and health standard manuals.

Collaboration with Employers and Emergency Preparedness

Although mentioned by fewer respondents, collaboration with employers (2 respondents) and emergency preparedness (1 respondent) are fundamental components of safety management. The partnership between safety personnel and employers in developing and refining safety policies aligns with the best practices recommended in safety manuals. Similarly, the creation of comprehensive emergency action plans and regular training drills for handling crises reflect the guidelines in safety standards, emphasizing preparedness for unforeseen events.

In summary, the thematic analysis highlights the broad and interrelated nature of safety management within organizations. By adhering to the standards and guidelines in the Yellow Book and other safety and health manuals, organizations can create safer and healthier work environments for their employees, ultimately enhancing productivity and well-being. Focusing on enforcement, oversight, training, and collaboration ensures compliance with established safety protocols and promotes a culture of continuous improvement in safety management procedures.

Table2 Question #2. What specific risks and hazards have you encountered in your vertical construction projects?

Theme	Sub-themes	Theme Description	Respondents	No. of Respondents Mentioning Theme
Falling Objects	Falling debris, falling objects, falling objectives	Risks associated with objects falling from height or being dropped within the construction site.	2, 3, 4, 6, 9, 10, 11, 14, 16, 18, 20, 21, 23, 25, 26, 27, 28, 29, 30, 31, 33, 34, 38, 39, 40, 43, 44, 46, 47, 48	29

Injuries	Injuries, crane accidents, fatality	Risks related to physical harm, including accidents involving heavy machinery or other equipment.	2, 3, 5, 7, 8, 10, 11, 13, 14, 15, 17, 20, 21, 22, 25, 26, 30, 31, 32, 35, 36, 37, 40, 41, 42, 43, 45, 46, 47, 48, 49, 50	32
Equipment Malfunction	Equipment malfunction, struck-by incidents, equipment hazards	Risks associated with machinery malfunction or failure, including incidents where workers are struck by equipment or machinery.	2, 13, 16, 26, 32, 36, 40, 42, 48	9
Tripping	Tripping, slippery surfaces	Risks related to slips, trips, and falls due to uneven or slippery surfaces.	3, 6, 9, 11, 20, 23, 24, 27, 29, 30, 36, 39, 47, 49	14
Uncovered Sharp Objects	Uncovered sharp objects	Risks associated with sharp objects left exposed within the construction area, potentially causing injury to workers.	3, 11, 27, 39	4
Structural Collapse	Structural collapse	Risks associated with the failure of structural components, potentially leading to injuries or fatalities.	4, 5, 16, 17, 18, 31, 32, 37, 42	9
Electrical Hazards	Electrical hazards	Risks associated with electrical installations or systems within the construction site, posing a threat of electrical shock or fire.	5, 13, 24, 34	4
Health Hazards	Manpower sickness, health hazard, chemical hazard	Risks related to exposure to harmful substances or activities that may result in health issues for workers.	1, 10, 12, 22, 25, 29, 38, 44, 49	9
Weather Hazards	Weather changes	Risks associated with adverse weather conditions, such as strong winds or storms, affect work safety.	21, 29	2
Noise	Noise	Risks associated with excessive noise levels in construction areas, potentially leading to hearing damage or other health issues.	50	1

Falling Objects

The most frequently mentioned hazard, highlighted by 29 respondents, involves falling objects, including debris and tools. This risk underscores the importance of compliance with safety standards such as those in the Yellow Book, which mandates measures like securing tools and materials at heights, using safety nets, and enforcing the wearing of hard hats to prevent injuries from falling objects.

Injuries

Injuries were reported by 32 respondents and encompass accidents with heavy machinery, crane incidents, and fatalities. The Yellow Book and other safety manuals emphasize the need for rigorous safety training, proper use of personal protective equipment (PPE), and adherence to operational protocols to mitigate these risks.

Equipment Malfunction

Nine respondents cited equipment malfunction as a significant risk. This includes machinery failure and struck-by incidents. Adhering to regular maintenance schedules, conducting pre-operation checks, and training operators as recommended by safety standards can significantly reduce these hazards.

Tripping

Tripping hazards were noted by 14 respondents, often due to uneven surfaces or spills. The Yellow Book and safety manuals advocate for maintaining clean and organized workspaces, promptly addressing spills, and marking uneven areas to prevent tripping incidents.

Uncovered Sharp Objects

Four respondents highlighted the risks associated with uncovered sharp objects. Safety standards require that all sharp tools and materials be properly stored and covered when not in use to prevent accidental injuries.

Structural Collapse

The potential for structural collapse was mentioned by nine respondents. Compliance with engineering standards, thorough inspections, and proper scaffolding are crucial measures outlined in safety manuals to prevent such catastrophic events.

Electrical Hazards

Electrical hazards, mentioned by four respondents, pose risks of shock and fire. Ensuring that electrical systems are installed and maintained according to national electrical codes and safety standards can mitigate these risks.

Health Hazards

Health hazards, including exposure to chemicals and other harmful substances, were noted by nine respondents. Safety standards recommend the use of PPE, proper ventilation, and adherence to handling guidelines to protect workers' health.

Weather Hazards

Two respondents mentioned weather hazards, such as strong winds or storms. Safety manuals recommend monitoring weather forecasts, implementing weather-related safety plans, and halting work during severe weather conditions to ensure worker safety.

Noise

Excessive noise, as mentioned by one respondent, poses a risk of hearing damage. Safety standards advocate for the use of hearing protection and regular monitoring of noise levels in the workplace.

The analysis of hazards in vertical construction projects reveals a wide range of risks that need to be managed to ensure worker safety. By adhering to the Yellow Book and other safety and health standards, companies can implement effective measures to mitigate these risks. Prioritizing the identification and management of common hazards such as falling objects, injuries, and equipment malfunctions can lead to safer construction environments and better protection for workers.

Table 3 Question #3. Among the risks and hazards, you have faced, which one was the most challenging, and how did your company address or cope with it?

Theme	Sub-themes	Theme Description	Respondents	No. of Respondents Mentioning Theme
Equipment Malfunction	Equipment malfunction	Challenges related to malfunctioning equipment and company strategies to address it, such as proactive maintenance schedules and employee training.	2, 4, 13, 40	5
Falling Objects	Falling debris, falling objects	Challenges related to falling objects and strategies to address them, such as securing objects before leaving the site and ensuring proper PPE usage.	3, 5, 8, 9, 11, 14, 16, 19, 20, 26, 27, 28, 30, 34, 36, 39, 47	16
Injuries	Injuries	Challenges related to injuries and strategies to address them, such as providing training and first aid kits.	4, 8, 15, 16, 17, 18, 29, 30, 33, 37, 38, 41, 44, 47, 48, 49	15
Health Hazards	Health hazard	Challenges related to health hazards and strategies to address them, such as monitoring proper PPE usage and providing training.	1, 10, 12, 22, 25, 29, 43	7
Weather Changes	Weather changes	Challenges related to weather changes and strategies to address them, such as being prepared for unpredictable weather conditions.	21	1
Structural Collapse	Structural collapse	Challenges related to structural collapse and strategies to address them, such as immediate action to prevent further damage.	31, 32, 35, 37, 48	5
Electrical Hazards	Electrical hazards	Challenges related to electrical hazards and strategies to address them, such as training on hazard mitigation.	24, 45	2
Tripping	Tripping	Challenges related to tripping hazards and strategies to address them, such as maintaining a clean workspace.	6, 23, 29, 30	4
Falls	Falls	Challenges related to falls and strategies to address them, such as fall prevention systems and safety gear.	7, 15, 16, 17, 19, 20, 30, 38, 39, 41, 47	11
Fatality	Fatality	Challenges related to fatalities and strategies to address them, such as thorough investigations and accountability.	32, 35, 37, 41, 47	5

Falling Objects

Falling objects emerged as the most challenging hazard, as noted by 16 respondents. This hazard poses immediate threats to worker safety and requires swift mitigation strategies. Companies addressed this by implementing measures such as securing objects before leaving the site and enforcing strict PPE protocols.

Injuries

Injuries were identified as the second most challenging hazard, affecting 15 respondents. Beyond impacting individual well-being, injuries disrupt operations and incur significant costs. Companies addressed this by prioritizing safety training and ensuring fully stocked first aid kits on-site.

Health Hazards

Seven respondents highlighted health hazards as challenging, emphasizing the need for ongoing monitoring and adherence to safety protocols. Strategies such as health screenings, PPE monitoring, and training were implemented to maintain a healthy work environment.

Collective Mitigation Strategies

Addressing these hazards collectively reflects a commitment to prioritizing worker safety and fostering a prevention-oriented culture within the workplace. Each hazard presents unique challenges, but a concerted effort to address them reflects the company's commitment to safety.

The analysis of the most challenging hazards faced by respondents underscores the importance of proactive risk management and mitigation strategies in the construction industry. By addressing hazards such as falling objects, injuries, and health risks, companies demonstrate a commitment to ensuring worker safety and fostering a culture of prevention in the workplace.

Table4 Question #4. What strategies does your company use to mitigate the risks and hazards in vertical construction projects?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Safety Equipment	Proper PPE usage	Ensuring workers use appropriate Personal Protective Equipment (PPE)	1, 2, 5, 7, 8, 9, 10, 13, 14, 15, 19, 21, 24, 25, 27, 29, 30, 31, 32, 33, 35, 41, 42, 43, 49	25
	Training and Education	Providing education and training sessions to workers on safety protocols	2, 3, 9, 10, 11, 12, 14, 15, 16, 17, 18, 22, 24, 25, 26, 28, 30, 31, 32, 33, 34, 36, 39, 40, 45, 48	25
	Compliance with Safety Protocols	Ensuring strict adherence to safety protocols	6, 8, 9, 10, 16, 17, 18, 20, 20, 23, 24, 26, 27, 28, 30, 31, 32, 33, 35, 36, 37, 38, 42, 44, 45, 47, 48, 50	27
Risk Assessment	Identification of Risks	Identifying potential risks and hazards in the construction site	1, 2, 10, 12, 16, 17, 18, 22, 24, 25, 26, 27, 28, 29, 31, 34, 35, 36, 37, 38, 39, 41, 42, 44, 46, 47, 48, 49, 5	28
	Mitigation Plans	Creating plans to mitigate identified risks and hazards.	1, 2, 10, 12, 16, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 34, 35, 36, 37, 38, 39, 40, 42, 44, 45, 46, 47, 48, 49, 50	29
Communication	Safety Meetings	Holding regular safety meetings to discuss hazards and suggest solutions	11, 12, 14, 16, 17, 23, 26, 27, 28, 29, 30, 34, 35, 37, 38, 39, 44, 47	18
	Open Communication	Encouraging open communication among workers to address safety concerns.	29, 30, 33, 39, 40, 47, 49	7
Construction Site Management	Inspection and Monitoring	Regular inspection and monitoring of construction sites to ensure safety compliance	29, 32, 34, 36, 38, 39, 41, 49	8
	Emergency Response Planning	Developing plans and practicing drills for emergency responses	27, 29, 35, 36, 47	5
Regulatory Compliance	Collaboration with Regulatory Organizations	Collaborating with regulatory bodies to ensure adherence to safety standards and regulations	28	1

Safety Equipment

Twenty-five respondents emphasized the importance of proper PPE usage. This proactive measure demonstrates a commitment to worker safety by providing essential protective gear.

Training and Education

An equal number of respondents highlighted the significance of ongoing education and training sessions. By providing workers with thorough safety training, companies develop a culture of accountability and increase risk awareness.

Compliance with Safety Protocols

Twenty-seven respondents emphasized strict adherence to safety protocols. This ensures consistency in risk management initiatives and fosters a sense of accountability among workers.

Risk Assessment and Mitigation Plans

Twenty-eight and twenty-nine respondents, respectively, highlighted the importance of risk assessment and the creation of mitigation plans. These proactive measures enable companies to anticipate and mitigate potential hazards effectively.

Communication

Regular safety meetings and open communication channels were mentioned by eighteen and seven respondents, respectively. This fosters a collaborative environment where workers can discuss hazards and suggest solutions, enhancing overall safety culture.

Construction Site Management

Eight respondents emphasized the importance of regular inspection and monitoring of construction sites to ensure safety compliance. This proactive approach helps identify and address potential hazards promptly.

Emergency Response Planning

Five respondents highlighted the importance of developing plans and practicing drills for emergency responses. This ensures preparedness and swift action in the event of emergencies.

Regulatory Compliance

One respondent emphasized collaboration with regulatory organizations to ensure adherence to safety standards and regulations, demonstrating a commitment to regulatory compliance.

The analysis of risk mitigation strategies underscores the importance of proactive risk management in vertical construction projects. By prioritizing safety equipment, training, compliance, and proactive risk assessment and mitigation, companies can establish a strong framework to ensure the security and success of projects.

Table 5 Question #5. How do you ensure that subcontractors and other project partners adhere to the same high standards of risk management and safety practices as your company during vertical construction projects?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Contracts and Agreements	Clear Safety Expectations	Establishing clear contractual agreements outlining safety requirements and expectations	2, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 43, 44, 47, 48, 49	31
	Compliance Monitoring	Monitoring subcontractors and partners to ensure adherence to safety standards	1, 4, 5, 6, 7, 8, 9, 10, 20, 22, 25, 26, 27, 28, 29, 30, 31, 32, 33, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 47, 48, 49, 50	32
Training and Education	Safety Training Sessions	Conducting regular safety training sessions for subcontractors and partners	2, 9, 11, 12, 23, 24, 26, 28, 29, 30, 31, 36, 37, 38, 41, 42, 46, 47, 48	19
	Communication and Collaboration	Maintaining open communication channels and establishing collaborative environments for addressing safety concerns and ensuring compliance	2, 12, 22, 23, 26, 28, 30, 32, 33, 36, 37, 38, 39, 40, 41, 42, 43, 46, 47	19
Safety Monitoring and Inspections	Regular Site Inspections	Conducting regular site inspections to monitor safety compliance	5, 6, 7, 9, 20, 25, 26, 28, 29, 30, 32, 33, 35, 37, 39, 41, 44, 46, 50	19
	On-site Monitoring	Implementing on-site monitoring to ensure adherence to safety protocols	3, 7, 9, 10, 22, 26, 27, 29, 31, 33, 35, 36, 39, 40, 41, 46, 47	17
Performance Evaluation and Accountability	Evaluation of Compliance	Holding subcontractors and partners accountable for adherence to safety protocols through performance evaluations and incentives	2, 3, 9, 13, 16, 17, 19, 24, 26, 28, 29, 31, 32, 33, 35, 36, 39, 41, 44, 45, 46, 47, 48, 49, 50	24
	Accountability Mechanisms	Implementing mechanisms to hold subcontractors	2, 3, 9, 13, 16, 17, 19, 24, 26, 28, 29, 31, 32, 33, 35, 36, 39,	24

		and partners accountable for safety compliance	41, 44, 45, 46, 47, 48, 49, 50	
Quality Control	Compliance Verification	Verifying subcontractors' compliance with safety standards through quality control measures	3, 4, 8, 11, 23, 24, 25, 26, 30, 32, 33, 34, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 49, 50	24
	Pre-qualification Process	Implementing a pre-qualification process to ensure subcontractors have a history of safety compliance.	2, 22, 23, 24, 26, 30, 34, 37, 39, 43, 44, 45, 46, 47, 48, 49	16
Compliance Documentation	Proof of Safety Training	Requesting proof of safety training and certificates from subcontractors and project partners	2, 9, 11, 12, 23, 24, 26, 28, 29, 30, 31, 36, 37, 38, 41, 42, 46, 47, 48	19

Contracts and Agreements

Thirty-one respondents emphasized the importance of establishing clear contractual agreements outlining safety requirements and expectations. This ensures that all parties involved are aware of and committed to maintaining high safety standards throughout the project.

Compliance Monitoring

Thirty-two respondents highlighted the necessity of monitoring subcontractors and partners to ensure adherence to safety standards. Regular monitoring helps identify any deviations from safety protocols and allows for prompt corrective actions.

Training and Education

Nineteen respondents emphasized the significance of conducting regular safety training sessions for subcontractors and partners. This ensures that all individuals involved are equipped with the necessary knowledge and skills to maintain safety standards.

Communication and Collaboration

Nineteen respondents stressed the importance of maintaining open communication channels and establishing collaborative environments for addressing safety concerns and ensuring compliance. This fosters a culture of shared responsibility and accountability for safety.

Safety Monitoring and Inspections

Nineteen respondents highlighted the importance of conducting regular site inspections to monitor safety compliance. On-site monitoring further reinforces the commitment to safety and allows for immediate corrective actions when necessary.

Performance Evaluation and Accountability

Twenty-four respondents emphasized the importance of holding subcontractors and partners accountable for adherence to safety protocols through performance evaluations and accountability mechanisms. This ensures that safety standards are consistently upheld throughout the project.

Quality Control

Twenty-four respondents stressed the importance of verifying subcontractors' compliance with safety standards through quality control measures and implementing a pre-qualification process to ensure subcontractors have a history of safety compliance. This proactive approach reduces the risk of safety incidents and ensures that only qualified subcontractors are engaged.

Compliance Documentation

Nineteen respondents highlighted the importance of requesting proof of safety training and certificates from subcontractors and project partners. Compliance documentation serves as evidence of commitment to safety standards.

The analysis of strategies for ensuring subcontractor and partner adherence to high safety standards highlights the importance of clear contractual agreements, compliance monitoring, training and education, communication and collaboration, safety monitoring and inspections, performance evaluation and accountability, quality control, and compliance documentation. By implementing these strategies, companies can maintain a culture of safety and ensure the success of vertical construction projects.

Table 6 Question #6. Have there been any instances where unexpected risks and hazards emerged during vertical construction projects?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Unforeseen Risks and Hazards Preparedness and Readiness	Worker Non-compliance	Risks and hazards arise due to workers not adhering to safety protocols.	1, 6, 10, 12, 21, 24, 26, 30, 35, 41	10

	Weather-related Hazards	Risks and hazards arising from unpredictable weather conditions.	16, 27	2
	Ground Conditions	Risks and hazards arising from unexpected ground conditions.	13, 17, 19, 27	4
	Lack of Maintenance	Risks and hazards due to lack of maintenance of heavy equipment	13	1
	Mitigation Efforts	Preparedness and readiness among workers to mitigate unforeseen risks and hazards	5, 9, 14, 15, 20, 33, 38, 39, 48, 50	10
Environmental Factors	Thorough Planning and Risk Assessment	Risks and hazards despite thorough planning and risk assessment	4, 15, 28, 32, 39	5
	Complexity of the Project	Risks and hazards due to the complexity of the construction project	39	1
	Weather-related Hazards	Risks and hazards arising from unpredictable weather conditions	16, 27	2
Worker Compliance	Ground Conditions	Risks and hazards arising from unexpected ground conditions	13, 17, 19, 27	4
	Unpredictable Events	Risks and hazards due to unpredictable events during construction	20, 26, 36	3
	Adherence to Safety Protocols	Risks and hazards when workers do not follow safety protocols	1, 3, 4, 5, 8, 10, 11, 12, 14, 15, 16, 22, 23, 25, 28, 29, 31, 33, 34, 35, 37, 39, 40, 43, 44, 45, 46, 47, 48, 49, 50	29

Unforeseen Risks and Hazards

- Worker Non-compliance: Ten respondents highlighted the risk of accidents and injuries due to workers not adhering to safety protocols. This underscores the importance of strict adherence to safety regulations and effective monitoring systems.
- Weather-related Hazards: Two respondents identified weather-related hazards as a major concern, emphasizing the need for effective mitigation and early planning to minimize risks and project delays.
- Ground Conditions: Four respondents mentioned significant issues related to unexpected ground conditions, highlighting the importance of careful site inspections and engineering solutions to ensure worker safety and structural integrity.
- Lack of Maintenance: One respondent noted risks and hazards due to the lack of maintenance of heavy equipment, indicating the importance of regular equipment maintenance to prevent accidents.

Preparedness and Readiness

- Mitigation Efforts: Ten respondents emphasized the importance of preparedness and readiness among workers to mitigate unforeseen risks and hazards, highlighting the need for proactive measures and effective risk management strategies.
- Thorough Planning and Risk Assessment: Five respondents mentioned risks and hazards despite thorough planning and risk assessment, underscoring the need for flexibility and adaptive approaches to address changing project dynamics.
- Complexity of the Project: One respondent highlighted risks and hazards due to the complexity of the construction project, emphasizing the need for efficient risk mitigation techniques to ensure project success.

Environmental Factors

- Weather-related Hazards: Two respondents identified weather-related hazards as a major concern, emphasizing the need for effective mitigation and early planning to minimize risks and project delays.
- Ground Conditions: Four respondents mentioned significant issues related to unexpected ground conditions, highlighting the importance of careful site inspections

and engineering solutions to ensure worker safety and structural integrity.

- Unpredictable Events: Three respondents highlighted risks and hazards due to unpredictable events during construction, emphasizing the need for proactive measures and contingency plans to address unexpected situations.

Worker Compliance

- Adherence to Safety Protocols: Twenty-nine respondents emphasized the importance of workers adhering to safety protocols to prevent accidents and injuries, highlighting the need for continuous training and reinforcement of safety procedures.

The analysis of instances where unexpected risks and hazards emerged during vertical construction projects reveals the complexity and challenges involved in ensuring project continuity and safety. Key themes include worker non-compliance, environmental factors, preparedness and readiness, and the complexity of the project. Effective risk management strategies, including thorough planning, proactive mitigation efforts, and continuous monitoring, are essential to address these challenges and ensure the safety and success of vertical construction projects.

Table 7 Question #7. How does your company communicate and address safety concerns or risks with team members and subcontractors on-site?

Theme	Sub-themes	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Meetings	Safety meetings	Regularly scheduled meetings specifically focused on safety issues and protocols	2, 4, 8, 11, 12, 14, 15, 20, 23, 30, 31, 35, 37, 38, 39, 41, 43, 45, 47, 48, 49	20
	Toolbox Meetings	Meetings where specific safety issues are discussed and addressed among team members and subcontractors.	6, 9, 10, 13, 20, 30, 32, 41, 43	9
Clear Communication	Briefings/Instructions	Clear instructions and briefings were provided to ensure an understanding of safety protocols	1, 4, 7, 8, 12, 13, 16, 17, 18, 19, 24, 25, 28, 31, 32, 33, 34, 38, 40, 42, 44, 46, 47, 48, 50	24
	Open communication channels	Establishing channels where safety concerns can be openly discussed and addressed.	2, 8, 9, 16, 17, 18, 19, 20, 24, 26, 27, 31, 35, 36, 37, 39, 40, 42, 43, 46, 47, 49	22
Safety Protocols	Adherence to protocols	Ensuring that all team members and subcontractors follow established safety protocols	2, 8, 9, 11, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 31, 34, 35, 37, 40, 42, 46, 48, 49, 50	28
	Regular Training	Continuous training is provided to team members and subcontractors to keep them updated on safety protocols.	2, 5, 9, 11, 14, 15, 19, 20, 21, 22, 24, 25, 26, 28, 29, 30, 32, 34, 38, 40, 42, 43, 47, 48, 49	25
Risk Management	Risk identification and management	Identifying and managing potential risks and hazards on-site to ensure the safety of all workers	2, 3, 4, 5, 9, 10, 12, 13, 15, 16, 17, 19, 20, 21, 23, 24, 25, 26, 27, 28, 31, 33, 36, 39, 40, 41, 43, 45, 46, 47, 48, 49	31
	Reporting and addressing concerns	Establishing a system for reporting safety concerns and taking prompt action to address them.	2, 8, 9, 13, 14, 17, 18, 19, 20, 24, 26, 27, 28, 31, 33, 36, 37, 38, 40, 41, 42, 43, 44, 46, 47, 48, 49	26
Personal Protective Equipment	Provision of PPE	Ensuring that all workers have access to and use appropriate personal protective equipment (PPE)	2, 9, 14, 19, 20, 23, 26, 29, 42	9
Safety Culture	Emphasis on safety culture	Fostering a culture where safety is prioritized and valued among all team members and subcontractors	2, 9, 13, 14, 15, 19, 20, 24, 26, 27, 28, 33, 34, 35, 37, 39, 40, 41, 42, 43, 45, 47, 48, 49	25

Meetings

- Safety meetings: Regularly scheduled meetings specifically focused on safety issues and protocols. These meetings provide a dedicated forum for discussing safety concerns and ensuring alignment on safety protocols among team members and subcontractors.
- Toolbox Meetings: Meetings where specific safety issues are discussed and addressed among team members and subcontractors. These meetings allow for more targeted discussions on safety topics and promote collaboration in addressing safety concerns.

Clear Communication

- Briefings/Instructions: Clear instructions and briefings are provided to ensure understanding of safety protocols. These briefings ensure that all team members and subcontractors are aware of safety procedures and expectations.
- Open communication channels: Establishing channels where safety concerns can be openly discussed and addressed. Open communication channels foster transparency and collaboration in addressing safety issues and promote a proactive approach to safety management.

Safety Protocols

- Adherence to protocols: Ensuring that all team members and subcontractors follow established safety protocols. This ensures consistency in safety practices and minimizes the risk of accidents or incidents on-site.
- Regular Training: Continuous training is provided to team members and subcontractors to keep them updated on safety protocols. Regular training helps reinforce safety practices and ensures that all personnel are equipped with the necessary knowledge and skills to work safely.

Risk Management

- Risk identification and management: Identifying and managing potential risks and hazards on-site to ensure the safety of all workers. Proactive risk management strategies help mitigate potential hazards and minimize the risk of accidents or incidents.
- Reporting and addressing concerns: Establishing a system for reporting safety concerns and taking prompt action to address them. This encourages a culture of reporting and ensures that safety issues are addressed promptly to prevent potential accidents or incidents.

Personal Protective Equipment

- Provision of PPE: Ensuring that all workers have access to and use appropriate personal protective equipment (PPE). Providing PPE is essential for safeguarding the health and well-being of workers and minimizing the risk of injuries on-site.

Safety Culture

- Emphasis on safety culture: Fostering a culture where safety is prioritized and valued among all team members and subcontractors. A strong safety culture promotes collective responsibility for safety and ensures that safety is integrated into all aspects of the work environment.

Effective communication and proactive safety management are essential for addressing safety concerns and risks on construction sites. Key strategies include holding regular safety meetings, providing clear communication channels, ensuring adherence to safety protocols, conducting regular training, implementing risk management measures, providing personal protective equipment, and fostering a strong safety culture. These strategies contribute to creating a safe work environment and minimizing the risk of accidents or incidents on-site.

Table 8 Question #8. What safety protocols and procedures does your company have in place to ensure a safe working environment for employees?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Personal Protective Equipment (PPE)	PPE Usage	Ensuring the use of Personal Protective Equipment (PPE)	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 41, 42, 44, 46, 47, 50	28
	Visibility of Safety Signs	Ensuring the presence of construction signs to alert workers of potential hazards	6, 8, 9, 12, 13, 14, 18, 20, 22, 24, 27, 28, 40, 47	13
	Safety Training	Providing regular safety training covering hazard recognition, PPE usage, and emergency procedures	2, 5, 7, 9, 12, 13, 14, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 42, 48, 49, 50	32
	Enforcement of Safety Rules	Enforcing safety rules and regulations to ensure compliance.	9, 13, 16, 17, 18, 20, 28, 30, 31, 38, 39, 41, 43, 49, 50	15
	Maintenance of Workplace	Regular maintenance of	47	1

		the workplace and equipment, including materials		
	Incident Resolution	Promptly resolving safety incidents and issues	16, 17, 18, 19, 47, 48, 50	7
Training and Education	Safety Training	Providing regular safety training covering hazard recognition, PPE usage, and emergency procedures	2, 5, 7, 9, 12, 13, 14, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 42, 48, 49, 50	32
	Monitoring and Evaluation	Continuous monitoring of workplace safety and performance	31, 32, 33, 36, 37, 38, 39, 40, 46	9
Workplace Safety	Adherence to Safety Protocols	Ensuring adherence to safety protocols and procedures	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	45

Personal Protective Equipment (PPE)

- PPE Usage: Ensuring the use of Personal Protective Equipment (PPE) is a fundamental aspect of workplace safety. According to the Yellow Book standards and other safety manuals, workers must use PPE appropriate for the tasks they are performing. PPE usage was mentioned by 28 respondents, highlighting its critical role in protecting workers from hazards such as falling objects, chemical exposures, and electrical hazards. Companies ensure that PPE is provided and worn consistently, as mandated by safety standards.
- Visibility of Safety Signs: Ensuring the presence of construction signs to alert workers of potential hazards is another key protocol. According to safety standards, such signs must be visible and understandable to alert workers to potential risks. Thirteen respondents emphasized the importance of safety signs, which serve as constant reminders of workplace hazards and encourage vigilance.

Safety Training and Education

- Safety Training: Providing regular safety training covering hazard recognition, PPE usage, and emergency procedures is crucial for maintaining a safe work environment. As per the Yellow Book standards, regular training sessions are required to keep workers informed about the latest safety protocols and hazard prevention techniques. This theme was mentioned by 32 respondents, indicating a strong emphasis on continuous education and training to enhance workers' safety awareness and skills.
- Enforcement of Safety Rules: Enforcing safety rules and regulations to ensure compliance is necessary to maintain workplace safety. Safety standards mandate strict enforcement of these rules to minimize risks. Fifteen respondents highlighted the importance of enforcement, reflecting the need for robust supervisory and disciplinary measures to ensure adherence to safety protocols.

Workplace Maintenance and Incident Resolution

- Maintenance of Workplace: Regular maintenance of the workplace and equipment, including materials, is essential for preventing accidents and ensuring smooth operations. This was highlighted by one respondent but remains a critical aspect of safety protocols as per safety standards.
- Incident Resolution: Promptly resolving safety incidents and issues is critical for preventing recurrences and improving safety practices. Safety standards emphasize the importance of a systematic approach to incident resolution, including investigation, root cause analysis, and corrective actions. Seven respondents mentioned the importance of prompt incident resolution, underlining its role in enhancing overall safety.

Monitoring and Evaluation

- Continuous Monitoring: Continuous monitoring of workplace safety and

performance is essential for identifying potential hazards and ensuring ongoing compliance with safety protocols. This was mentioned by nine respondents and aligns with safety standards that require regular audits, inspections, and performance evaluations to maintain a safe working environment.

Adherence to Safety Protocols

- Adherence to Safety Protocols: Ensuring adherence to safety protocols and procedures is the most frequently mentioned theme, with 45 respondents highlighting its importance. This involves making sure all team members and subcontractors follow established safety guidelines, which is a fundamental requirement in safety standards. Adherence to protocols minimizes the risk of accidents and ensures a consistent approach to safety across all levels of the organization.

Safety Culture

- Emphasis on Safety Culture: Fostering a culture where safety is prioritized and valued among all team members and subcontractors is crucial for long-term safety performance. Although not explicitly mentioned in Table 3.8, developing a strong safety culture is an underlying theme in all safety practices. Encouraging a culture of safety involves leadership commitment, employee engagement, and continuous improvement, which are essential components of safety standards.

Safety protocols and procedures are essential to ensure a safe working environment in vertical construction projects. The emphasis on Safety Training, Adherence to Safety Protocols, PPE Usage, and Visibility of Safety Signs reflects a strong alignment with safety standards like those outlined in the Yellow Book and other safety manuals. These protocols and procedures help minimize risks, prevent accidents, and foster a culture of safety awareness and accountability. By prioritizing safety training, enforcing adherence to safety rules, ensuring visibility of safety signs, and providing necessary PPE, companies demonstrate their commitment to protecting the health and safety of their employees. Prompt incident resolution and continuous monitoring further enhance workplace safety, contributing to the successful and safe completion of construction projects.

Table 9 Question #9. How does your company stay compliant with relevant safety regulations and standards in the vertical construction industry?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Compliance with Safety Regulations and Standards	Compliance Measures	Measures taken to ensure compliance with safety regulations and standards	2, 4, 6, 7, 8, 9, 13, 14, 15, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	38
	Training and Education	Providing ongoing training and education to ensure awareness and understanding of safety regulations and standards	2, 13, 14, 15, 16, 17, 18, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 45, 46, 47, 49, 50	31
	Internal Audits	Conducting internal audits to assess compliance with safety regulations and standards	2, 13, 14, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 45, 46, 47, 49, 50	32
	Collaboration with Regulatory Agencies	Collaborating with regulatory agencies and industry organizations to address safety concerns.	2, 14, 15, 19, 26, 27, 28, 31, 32, 38, 39, 40, 46, 48, 50	15
	Monitoring and Inspection	Regular monitoring and inspection of workplace safety practices to ensure compliance with regulations and standards	5, 20, 22, 23, 24, 25, 26, 30, 33, 34, 35, 36, 37, 38, 40, 41, 43, 45, 46, 47	20
	Communication and Documentation	Establishing open communication channels and documentation procedures to ensure adherence to safety regulations and standards	29, 30, 31, 32, 38, 39, 40, 41	8
	Risk Awareness and Prevention	Promoting risk awareness and prevention measures among employees to ensure compliance with safety regulations and	3, 4, 6, 7, 9, 11, 13, 14, 16, 19, 20, 21, 22, 29, 31, 36, 41, 43, 47, 48, 50	20

		standards		
	Legal Compliance	Ensuring compliance with legal requirements through agreements, policies, and background checks	4, 14, 18, 19, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 39, 40, 41, 42, 43, 44, 46, 47, 48, 49, 50	25

Compliance Measures

The most predominant approach, supported by 38 respondents, is the implementation of comprehensive compliance measures. These measures involve rigid adherence to safety controls and guidelines throughout all stages of a construction project. By meticulously following established guidelines, companies demonstrate a commitment to maintaining safety protocols, mitigating risks, and safeguarding the well-being of their workforce.

Training and Education

Regular training and education sessions, emphasized by 31 respondents, play a crucial role in promoting awareness and understanding of safety regulations among employees. These sessions equip workers with the necessary knowledge and skills to identify potential hazards, comply with safety protocols, and respond effectively in emergencies. Through ongoing educational initiatives, companies empower their workforce to prioritize safety, fostering a culture of vigilance and responsibility on construction sites.

Internal Audits

Internal audits emerged as a critical strategy, mentioned by 32 respondents. By conducting regular audits, companies assess their compliance with safety regulations, identify areas for improvement, and implement corrective actions as needed. These internal assessments serve as a proactive measure to ensure alignment with regulatory requirements and promote continuous improvement in safety practices.

Collaboration with Regulatory Agencies

Collaboration with regulatory agencies and industry organizations also plays a crucial role, adopted by 15 respondents. By engaging with external stakeholders, companies stay informed about evolving safety standards, industry best practices, and regulatory updates. This collaborative approach enables companies to align their practices accordingly, maintain compliance with relevant regulations, and uphold the highest standards of safety within the vertical construction industry.

Monitoring and Inspection

Regular monitoring and inspection of workplace safety practices are essential to ensure compliance with regulations and standards. Twenty respondents mentioned this approach, reflecting its importance in maintaining a safe working environment. Ongoing monitoring allows companies to promptly identify and address any deviations from safety protocols, ensuring consistent adherence to safety regulations.

Communication and Documentation

Establishing open communication channels and documentation procedures is another key strategy to ensure adherence to safety regulations and standards. Eight respondents emphasized the significance of effective communication and proper documentation in maintaining safety compliance. Clear communication channels facilitate the reporting of safety concerns, while thorough documentation ensures that safety practices are recorded and can be reviewed as needed.

Risk Awareness and Prevention

Promoting risk awareness and prevention measures among employees is critical for ensuring compliance with safety regulations and standards. Twenty respondents highlighted this approach, emphasizing the need for proactive risk management. By raising awareness about potential hazards and encouraging preventive measures, companies can significantly reduce the likelihood of accidents and injuries.

Legal Compliance

Ensuring compliance with legal requirements through agreements, policies, and background checks was mentioned by 25 respondents. This approach underscores the importance of aligning company practices with legal standards to avoid penalties and ensure a safe working environment. Legal compliance involves creating and enforcing policies that meet regulatory requirements and conducting background checks to ensure that all

personnel are qualified and compliant with safety standards.

In examining how companies ensure compliance with safety regulations and standards within the vertical construction industry, several key strategies emerge. The most predominant approach is the implementation of comprehensive compliance measures, emphasizing rigid adherence to established safety controls and guidelines. Regular training and education, internal audits, and collaboration with regulatory agencies are also critical strategies. These efforts help companies stay informed about evolving safety standards, assess their compliance, and promote continuous improvement in safety practices. Additionally, regular monitoring and inspection, effective communication and documentation, risk awareness and prevention measures, and legal compliance are essential components of a comprehensive safety compliance strategy. By prioritizing these strategies, companies demonstrate their commitment to maintaining the highest standards of safety and protecting the well-being of their workforce.

Table 10 Question #10. Can you share any examples of successful safety initiatives or programs implemented within your company?

Theme	Sub-theme	Theme Description	Respondents	Number of Respondents Mentioning this Theme
Successful Safety Initiatives and Programs	PPE Requirements	Implementation of personal protective equipment (PPE) requirements as a safety initiative	6, 9, 10, 12, 13, 20, 21, 22, 24, 25, 26, 27, 28, 30, 31, 36, 40, 41, 42, 47, 50	21
	Safety Training Programs	Development and implementation of safety training programs for employees	2, 8, 9, 13, 14, 15, 22, 23, 31, 32, 33, 34, 38, 39	13
	Safety Awareness Programs	Implementation of safety awareness programs to promote safe practices among employees	2, 16, 17, 18, 19, 20, 26, 28, 29, 46	10
	Safety Incentive Programs	Introduction of safety incentive programs to encourage safe behavior and reduce incidents	23	1
	Routine Safety Checks	Conducting routine safety checks and audits to identify and address workplace hazards	24, 32, 40, 46	4
	Communication and Reporting	Encouraging open communication and reporting of safety concerns among employees	28	1
	Emergency Preparedness	Implementation of emergency preparedness measures such as emergency exit signs, first aid kits, and fire extinguishers	25, 30	2
	Safety Committees	Formation of safety committees to oversee safety programs and address safety issues	26, 37	2
	Continuous Improvement	Commitment to continuous improvement in safety standards and protocols	35, 38	2
	Employee Involvement	Involvement of employees in health and safety initiatives	44, 45	2
	Management Training	Introduction of training programs for management on health and safety interactions	48	1
	Ethical Responsibility	Encouraging management to view health and safety as an ethical responsibility	49	1

PPE Requirements

The most prominently mentioned initiative, supported by 21 respondents, is the implementation of PPE requirements. This initiative underscores the commitment to equipping employees with the necessary personal protective equipment to safeguard their well-being in hazardous work environments. By mandating the use of PPE and providing adequate training on its proper usage, companies ensure that their workforce remains protected against potential risks and hazards, fostering a safe working environment.

Safety Training Programs

Safety training programs are crucial in educating employees about safety protocols, hazard recognition, and emergency procedures. As mentioned by 13 respondents, these programs empower the workforce with the knowledge and skills necessary to identify potential risks and respond effectively in various scenarios. This proactive approach not only enhances safety awareness among employees but also demonstrates a commitment to prioritizing their well-being.

Safety Awareness Programs

The implementation of safety awareness programs was highlighted by 10 respondents. These programs aim to cultivate a safety-conscious culture where employees actively engage in promoting and maintaining safe practices in the workplace. By reinforcing the importance of safety as a core value within the organization, these initiatives drive continuous improvement and foster a collaborative approach toward risk mitigation.

Safety Incentive Programs

Safety incentive programs, mentioned by one respondent, are introduced to encourage safe behavior and reduce incidents. These programs reward employees for adhering to safety protocols and contribute to a safer work environment by motivating positive behavior.

Routine Safety Checks

Routine safety checks and audits, supported by four respondents, are conducted to identify and address workplace hazards. Regular inspections ensure that potential risks are promptly recognized and mitigated, maintaining a safe working environment.

Communication and Reporting

Encouraging open communication and reporting of safety concerns, as mentioned by one respondent, is vital for maintaining a safe workplace. Establishing clear communication channels allows employees to report hazards and concerns, fostering a culture of transparency and continuous safety improvement.

Emergency Preparedness

Emergency preparedness measures, such as emergency exit signs, first aid kits, and fire extinguishers, were highlighted by two respondents. These measures ensure that employees are prepared to respond effectively to emergencies, enhancing overall workplace safety.

Safety Committees

The formation of safety committees, mentioned by two respondents, involves establishing groups to oversee safety programs and address safety issues. These committees play a crucial role in ensuring that safety protocols are followed and continuously improved.

Continuous Improvement

A commitment to continuous improvement in safety standards and protocols, as mentioned by two respondents, reflects the ongoing efforts to enhance safety measures. This approach ensures that safety practices evolve to meet emerging challenges and standards.

Employee Involvement

Involving employees in health and safety initiatives, supported by two respondents, emphasizes the importance of engaging the workforce in safety practices. Employee involvement leads to a more comprehensive approach to safety and fosters a culture of shared responsibility.

Management Training

The introduction of training programs for management on health and safety interactions, mentioned by one respondent, highlights the importance of equipping leaders with the knowledge and skills to manage safety effectively.

Ethical Responsibility

Encouraging management to view health and safety as an ethical responsibility, as mentioned by one respondent, emphasizes the moral obligation of leaders to prioritize the well-being of their employees.

In examining successful safety initiatives and programs implemented within companies, several key strategies stand out. The most prominently mentioned initiative is the implementation of PPE requirements, emphasizing the importance of equipping employees with necessary protective gear. Safety training programs and safety awareness programs also play crucial roles in educating employees and fostering a safety-conscious culture. Routine safety checks, safety incentive programs, and emergency preparedness measures are vital for maintaining a safe workplace. Additionally, fostering open communication, forming safety committees, committing to continuous

improvement, involving employees in safety initiatives, and providing management training highlight the multifaceted approach companies take to ensure workplace safety. Encouraging management to view health and safety as an ethical responsibility further underscores the commitment to protecting the well-being of employees. These initiatives collectively contribute to creating a safer and more resilient work environment in the vertical construction industry.

Table 11 Question #11. What are the best strategies and practices that construction teams can employ to proactively identify, assess, and mitigate risks in high-risk areas or phases, aiming to improve risk identification, assessment, and management in vertical construction projects?

Themes	Sub-Themes	Theme Descriptions	Respondents	Number of Respondents Mentioning this Theme
Risk Assessment	Thorough Risk Assessment	Conducting comprehensive risk assessments to identify potential hazards and evaluate their likelihood and impact.	2, 5, 9, 16, 20	5
	Early Warning Systems	Implementing systems to identify and address emerging risks before they escalate into serious problems.	26	1
Communication	Open Communication	Fostering an environment of open communication among team members to discuss safety concerns and share solutions.	2	1
	Collaboration with Stakeholders	Involving stakeholders in risk assessment and management processes to ensure comprehensive understanding and cooperation.	16	1
Education	Training and Education	Providing comprehensive training and education to workers to enhance their awareness of safety protocols and risk mitigation strategies.	2, 12, 13, 15, 32, 33, 35, 39, 50	9
Technology	Utilization of Technology	Leveraging technology such as sensors, drones, and building information modeling (BIM) for real-time risk monitoring and data collection		
Safety Culture	Promoting Safety Culture	Establishing a culture of safety through continuous instruction, dialogue, and reinforcement of safety procedures among all project parties.	29	1
	Toolbox Meetings	Conducting regular toolbox meetings to reinforce safety reminders and policies, including the use of personal protective equipment (PPE).	1, 43, 44	3
Identification	Hazard Identification	Identifying potential hazards and risks at all project phases, including planning, execution, and ongoing monitoring.	22, 23, 24, 25, 45	5
	Central Risk Registry	Maintaining a central risk registry to record identified hazards, evaluate their likelihood and impact, and monitor mitigation strategies.	24	1
Mitigation	Mitigation Strategies	Implementing practical measures and protocols to mitigate identified risks and ensure safe working conditions for all employees.	8, 17, 18, 19, 26, 27, 28, 30, 46, 47, 48, 49	12
Policy	Policy Implementation	Enforcing strict policies and protocols, including pre-assessments, rules, and safety protocols, to ensure compliance and risk mitigation.	4, 7, 8, 10, 18, 21, 31, 38, 41, 42, 49, 50	12

Risk Assessment

The most frequently mentioned strategy is conducting thorough risk assessments, emphasized by 5 respondents. This involves identifying potential hazards and evaluating their likelihood and impact, enabling construction teams to gain a comprehensive understanding of project risks and implement targeted mitigation measures.

Education

Providing comprehensive training and education to workers, mentioned by 9 respondents, enhances awareness of safety protocols and equips employees

with the skills needed to identify and address risks proactively. Continuous learning initiatives foster a culture of safety and empower personnel to prioritize risk mitigation in their daily operations.

Mitigation

Implementing practical measures and protocols to mitigate identified risks, highlighted by 12 respondents, ensures safe working conditions for all employees. This proactive approach, supported by strict policies and protocols, prevents potential hazards from escalating into serious problems and enhances safety outcomes across all project phases.

Identification

Identifying potential hazards and risks at all project phases, including planning, execution, and ongoing monitoring, is essential for proactive risk management. This strategy, mentioned by 5 respondents, allows construction teams to systematically assess and address risks throughout the project lifecycle.

Technology

Leveraging technology for real-time risk monitoring and data collection enhances risk assessment capabilities. This includes the use of sensors, drones, and building information modeling (BIM), mentioned by 2 respondents, which provide valuable insights for informed decision-making.

Communication

Fostering open communication among team members and collaboration with stakeholders, highlighted by 1 respondent each, promotes transparency and cooperation in risk assessment and management processes. Regular toolbox meetings serve as platforms for reinforcing safety reminders and policies, fostering a safety-conscious culture.

Policy

Enforcing strict policies and protocols, including pre-assessments, rules, and safety protocols, ensures compliance and risk mitigation. This proactive approach, mentioned by 12 respondents, establishes clear guidelines for risk management across all project phases.

Construction teams can employ various strategies and practices to proactively identify, assess, and mitigate risks in high-risk areas or phases of vertical construction projects. Prioritizing thorough risk assessments, comprehensive training and education, and practical mitigation measures enhances safety outcomes and fosters a culture of safety. Leveraging technology for real-time monitoring, fostering open communication, and enforcing strict policies further contributes to proactive risk management. By systematically identifying, assessing, and mitigating risks, construction teams can ensure safe working conditions for all employees and enhance project success.

Table 12 Question #12. Why is it necessary to comprehend how the company handles risk and risk management?

Themes	Sub-themes	Theme Descriptions	Respondents	Number of Respondents Mentioning this Theme
Safety and Well-being	Workplace Safety, Employee Health	Understanding risk management ensures workplace safety and the health of employees.	1, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	43
Operational Efficiency	Informed Decision-making, Regulatory Compliance	Knowing risk management enhances informed decision-making and regulatory compliance, maintaining operational efficiency.	2, 7, 8, 22, 23, 24, 25, 26, 27, 32, 35, 36, 37, 38, 39, 40, 45, 46, 47, 49, 50	21
Risk Identification and Control	Proactive Risk Identification, Control Measures	Comprehending risk management aids in identifying and controlling threats, preventing potential hazards.	3, 4, 9, 10, 11, 13, 16, 17, 18, 19, 20, 28, 29, 30, 31, 33, 34, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50	29
Organizational Alignment	Strategic Decision-making, Goal Alignment	Understanding risk management aligns strategic decisions with organizational goals.	2, 22	2
Stakeholder Confidence	Transparency, Trust	Demonstrating effective risk management builds stakeholder trust and confidence.	26, 27	2
Continuous Improvement	Performance Evaluation, Future Preparedness	Assessing risk management facilitates continuous improvement and future readiness.	23, 30, 31, 35, 36, 37, 38, 39, 40, 47, 48	11

Financial Stability	Risk Mitigation, Financial Security	Risk management contributes to financial stability by mitigating risks and ensuring financial security.	2, 23, 24, 25, 26, 27, 48	7

Safety and Well-being

Understanding risk management is crucial for ensuring workplace safety and the health of employees. This theme was most frequently mentioned by respondents, highlighting the importance of safeguarding workers from workplace dangers and promoting a culture of safety.

Operational Efficiency

Comprehending risk management enhances informed decision-making and regulatory compliance, thereby maintaining operational efficiency. By making well-informed decisions and adhering to regulations, stakeholders can ensure that business operations align with the aims and objectives of the organization.

Risk Identification and Control

A thorough understanding of risk management aids in identifying and controlling threats, preventing potential hazards. Proactive risk identification and effective control measures are essential for mitigating risks and maintaining a safe working environment.

Organizational Alignment

Understanding risk management aligns strategic decisions with organizational goals, promoting coherence and consistency in decision-making processes. This ensures that risk management practices are integrated into the broader strategic framework of the organization.

Stakeholder Confidence

Demonstrating effective risk management builds stakeholder trust and confidence in the organization's ability to manage risks effectively. Transparency and trust are essential for fostering positive relationships with stakeholders and maintaining support for business initiatives.

Continuous Improvement

Assessing risk management facilitates continuous improvement and future preparedness. By evaluating current practices and identifying areas for improvement, organizations can enhance their resilience and adaptability to changing circumstances.

Financial Stability

Risk management contributes to financial stability by mitigating risks and ensuring financial security. By effectively managing risks, organizations can protect their assets and resources, thereby safeguarding their financial stability and long-term viability.

Comprehending how the company handles risk and risk management is essential for various reasons, including ensuring workplace safety and employee well-being, maintaining operational efficiency, and promoting stakeholder confidence. It also facilitates proactive risk identification and control, aligns strategic decisions with organizational goals, fosters continuous improvement, and contributes to financial stability. Overall, a solid understanding of risk management is fundamental for the success and sustainability of an organization.

Table 13 Question #13. What typical dangers are associated with building sites, and in your opinion, how can they be effectively controlled?

Themes	Sub-themes	Theme Descriptions	Respondents	Number of Respondents Mentioning this Theme
Falls	Falls from Heights, Slips, Trips, Falls	Effective controls include safety training, barriers, safety equipment, and regular inspections.	2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50	45
Falling Objects	Debris, Moving Objects	Controls involve safety nets, barriers, and proper storage of materials.	1, 3, 4, 6, 13, 14, 21, 27, 30, 31, 36, 43, 44	13
Electrical Hazards	Electrocution, Wiring Issues	Proper insulation, grounding, and safety training mitigate risks.	5, 23, 25, 26, 33	5
Structural Collapse	Building Failure, Collapse Risks	Adherence to standards, regular structural evaluations, and quick action upon degradation are key.	3, 7, 8, 21, 22, 24, 41, 42	8
Hazardous	Chemicals,	Proper handling,	5, 29, 34, 47	4

Materials	Flammable Materials	storage, and PPE usage are essential controls.		
Noise and Vibration	Noise, Vibration Hazards	Controls include barriers, sound-absorbing materials, and limiting exposure time.	48, 49	2
Manual Handling	Heavy Lifting, Manual Labor	Reduce load risk through lighter weights and stable containers.	50	1
Safety Protocols	Adherence to Rules, Safety Procedures	Following company protocols and safety regulations is crucial.	2, 26, 46, 47, 41, 42	6
Comprehensive Training	Safety Training, Education	Providing comprehensive training ensures awareness and preparedness.	2, 4, 5, 13, 14, 15, 35	7
Personal Protective Equipment (PPE)	Safety Gear, Dress Code	Proper PPE usage mitigates various risks on construction sites.	2, 26, 29, 46	4
Regulatory Compliance	Safety Standards, Compliance	Adherence to safety regulations and standards is necessary.	2, 8, 9, 22, 23, 24, 25, 34, 41, 42	10

Falls

Falls, including falls from heights, slips, trips, and stumbles, are the most common dangers associated with building sites. Effective controls include safety training, barriers, safety equipment, and regular inspections to prevent falls and ensure worker safety.

Falling Objects

Falling objects, such as debris and moving objects, pose a serious threat to construction workers. Controls involve the use of safety nets, barriers, and proper storage of materials to prevent injuries caused by falling objects.

Electrical Hazards

Electrical hazards, including electrocution and wiring issues, are significant risks on construction sites. Proper insulation, grounding, and safety training are essential controls to mitigate these risks and ensure worker safety.

Structural Collapse

Structural collapse, resulting from building failure or degradation, is a critical risk on construction sites. Adherence to standards, regular structural evaluations, and quick action upon degradation are key controls to prevent structural collapse and protect worker safety.

Hazardous Materials

Exposure to hazardous materials, including chemicals and flammable materials, is a concern on construction sites. Proper handling, storage, and personal protective equipment (PPE) usage are essential controls to minimize risks associated with hazardous materials.

Other Dangers

Other common dangers on construction sites include noise and vibration hazards, manual handling risks, adherence to safety protocols, comprehensive training, personal protective equipment (PPE) usage, and regulatory compliance. Effective controls for these risks include barriers, sound-absorbing materials, lighter weights for manual handling, following safety protocols, providing comprehensive training, proper PPE usage, and adherence to safety regulations and standards.

Construction sites pose various dangers to workers, including falls, falling objects, electrical hazards, structural collapse, exposure to hazardous materials, noise and vibration hazards, and manual handling risks. Effective controls for these risks include safety training, barriers, safety equipment, regular inspections, proper storage of materials, insulation, grounding, structural evaluations, hazard handling procedures, PPE usage, and regulatory compliance. By implementing these controls, construction companies can enhance safety on building sites and minimize the risks associated with construction work.

Table 14 Question #14. What do you consider a risk assessment's objectives in construction to be?

Themes	Sub-Themes	Theme Descriptions	Respondents	Number of Respondents Mentioning this Theme
Objective of Risk Assessment	- Preventing accidents and minimizing their impact - Identifying potential hazards and	The objectives of a risk assessment in construction encompass preventing accidents, identifying hazards, implementing	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43,	50

	risks - Implementing control measures - Ensuring a safe working environment	controls, and ensuring workplace safety.	44, 45, 46, 47, 48, 49, 50	
Prioritizing Safety	- Making safety a priority - Integrating risk assessment into project design and implementation	Prioritizing safety involves making it a primary concern and integrating risk assessment into all phases of a project.	14, 15	2
Hazard Identification	-Identifying potential hazards and risks	Identifying potential hazards and risks associated with a construction project.	2, 7, 9, 13, 19, 20, 22, 24, 25, 26, 28, 29, 31, 32, 34, 37, 43, 46	18
Risk Mitigation	- Developing actionable solutions to mitigate risks. - Implementing control measures - Minimizing the likelihood of accidents or incidents	Risk mitigation involves developing solutions to reduce the likelihood of accidents and implementing control measures to minimize risks.	2, 4, 5, 7, 9, 13, 19, 20, 22, 23, 26, 27, 28, 31, 32, 33, 34, 38, 39, 40, 42, 43, 44, 46, 47, 48, 49	27
Ensuring Workplace Safety	- Providing a safe working environment - Ensuring the safety of workers and projects	Ensuring workplace safety involves providing a safe environment for workers and projects.	2, 4, 5, 8, 9, 13, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 33, 35, 39, 41, 42, 43, 44, 45, 47, 49	28
Ensuring Workplace Safety	- Providing a safe working environment - Ensuring the safety of workers and projects	Ensuring workplace safety involves providing a safe environment for workers and projects.	2, 4, 5, 8, 9, 13, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 33, 35, 39, 41, 42, 43, 44, 45, 47, 49	28
Knowledge and Awareness	- Prioritizing safety through knowledge and awareness - Identifying risks and knowing how to mitigate them	Knowledge and awareness play a crucial role in prioritizing safety and identifying risks for mitigation.	10, 11, 12	3
Continuous Improvement	Continuously assessing and revising risk reduction strategies - Implementing revisions as necessary	Continuous improvement involves ongoing assessment and revision of risk reduction strategies throughout a project.	30	1
Communication and Collaboration	- Sharing risks and mitigation strategies with project teams, subcontractors, and regulatory agencies	Communication and collaboration involve sharing risks and mitigation strategies with relevant stakeholders	29	1
Cost and Time Management	- Minimizing negative impacts on - Project performance in relation to cost, time, and quality objectives	Cost and time management aim to minimize negative impacts on project performance.	50	1

Objective of Risk Assessment

The primary objectives of risk assessment in construction include preventing accidents, identifying potential hazards, implementing control measures, and ensuring a safe working environment. By prioritizing these objectives, construction teams can effectively manage risks and ensure the safety of all workers and projects.

Prioritizing Safety

Prioritizing safety involves making it a primary concern throughout all phases of a construction project. Integrating risk assessment into project design and implementation ensures that safety considerations are addressed from the outset, minimizing risks, and promoting a safe working environment.

Hazard Identification

Identifying potential hazards and risks associated with a construction project is crucial for effective risk management. By identifying hazards, construction teams can implement targeted control measures to mitigate risks and ensure the safety of all workers and projects.

Risk Mitigation

Risk mitigation involves developing actionable solutions to reduce the likelihood of accidents and incidents on construction sites. By implementing control measures and minimizing risks, construction teams can enhance safety and prevent accidents, ensuring the success of the project.

Ensuring Workplace Safety

Ensuring workplace safety involves providing a safe environment for all workers and projects. By prioritizing safety and implementing control measures, construction teams can minimize risks and ensure the safety of all personnel involved in the project.

Knowledge and Awareness

Prioritizing safety through knowledge and awareness is essential for effective risk management in construction. By identifying risks and knowing how to mitigate them, construction teams can enhance safety and prevent accidents on construction sites.

Continuous Improvement

Continuous improvement involves ongoing assessment and revision of risk reduction strategies throughout a construction project. By implementing revisions as necessary, construction teams can adapt to changing circumstances and ensure the success of the project.

Communication and Collaboration

Communication and collaboration involve sharing risks and mitigation strategies with relevant stakeholders, including project teams, subcontractors, and regulatory agencies. By promoting open communication and collaboration, construction teams can enhance safety and ensure the success of the project.

Cost and Time Management

Cost and time management aim to minimize negative impacts on project performance, including cost, time, and quality objectives. By prioritizing safety and implementing efficient risk management strategies, construction teams can minimize costs and delays, ensuring the success of the project.

The primary objectives of risk assessment in construction are to prevent accidents, identify hazards, implement control measures, and ensure a safe working environment. Prioritizing safety throughout all project phases involves integrating risk assessment into design and implementation, minimizing risks, and promoting safety awareness. Effective hazard identification enables targeted control measures to mitigate risks, while proactive risk mitigation strategies reduce the likelihood of accidents and incidents. Ensuring workplace safety includes providing a safe environment for workers and projects through continuous improvement and efficient risk management practices. Open communication and collaboration with stakeholders facilitate the sharing of risks and mitigation strategies, while cost and time management prioritize safety alongside project performance objectives, ultimately ensuring the success of construction projects.

3.1 OIRA Implementation and Website Development

This section states the implementation and development of the Online Interactive Risk Assessment (OIRA) tool and web application.

ASPECTS	DESCRIPTION
Purposeful Approach	In this phase implementation began with a clear definition of the OIRA tool's purpose, guiding the systematic development process to achieve specific goals.
Complete Risk Identification	A wide range of workplace risks were identified and classified using thorough analysis and real-world examples, ensuring the OIRA tool's ability to address a variety of hazards.
Regulatory Compliance	Regulatory standards were prioritized throughout development and incorporated into the tool's design and functionality to ensure compliance and reduce legal risks.
User Engagement and Learning Experiences	Interactive quizzes integrated into the web application increased user engagement and created a dynamic learning environment, encouraging active participation and knowledge retention.
Seamless Integration and Iterative Updates	Comprehensive training materials and a feedback mechanism were seamlessly integrated into the tool, allowing for easy implementation and iterative improvements based on user feedback.
Technical Implementation	The use of HTML, CSS, JavaScript, and backend languages such as PHP allowed for the creation of a responsive and functional web application that was accessible and usable across multiple platforms.
Consistent User Experience	The emphasis on creating a user-friendly interface and ensuring responsiveness resulted in a consistent and satisfying user experience across all devices and platforms.

Table 15 OIRA Tool Implementation and Web Development

The implementation and development of the OIRA tool and web application marked substantial progress towards research objectives. The deliberate approach ensured that each stage of the development process was geared towards attaining specific goals, establishing a robust foundation for

success. Through comprehensive identification of workplace risks and ensuring regulatory adherence, the OIRA tool has been adeptly equipped to assess and mitigate hazards effectively, thereby enhancing workplace safety. Furthermore, the integration of interactive quizzes has not only bolstered user engagement but also fostered a dynamic learning atmosphere, enabling active user participation in risk assessment procedures.

The seamless integration of training materials and feedback mechanisms enables continuous improvement and adaptation to change user needs. Furthermore, modern technologies have allowed for the creation of a user-friendly and responsive web application, ensuring accessibility and usability across multiple platforms. Moving forward, continuous monitoring, evaluation, and iterative improvements will be critical to ensuring the OIRA tool's relevance and effectiveness in improving workplace safety and risk management practices. Collaboration with stakeholders and the incorporation of user feedback will be critical in driving further advancements and ensuring the tool's long-term success in real-world applications.

3.1 Tool Accuracy and Continuous Improvement

This section determines the accuracy and continuous improvement of the Online Interactive Risk Assessment (OIRA) tool in enhancing occupational safety and health practices in the construction industry.

ASPECTS	DESCRIPTION
Effectiveness of OIRA Tool in Risk Identification	The OIRA tool was evaluated and found to be effective in identifying a wide range of occupational health and safety risks in the construction industry.
Usability and Accessibility	The assessment found that the OIRA tool's user-friendly interface and intuitive design made it easy for both experts and non-experts to navigate, resulting in more efficient risk assessments.
Data Accuracy	OIRA assessments provided valuable insights into workplace hazards and supported informed decision-making processes.
Comprehensive Training and Regular Updates	Employee and management training sessions, as well as regular updates to reflect changes in safety provisions, ensured that the OIRA tool was used effectively and remained relevant over time.
Evaluation of User Feedback	User feedback collected via various channels provided valuable insights into the OIRA tool's accuracy and usability, guiding continuous improvement efforts.
Continuous Improvement in Occupational Safety and Health Standards	The implementation of strategies to leverage the OIRA tool resulted in significant improvements in occupational safety and health standards within construction companies, creating a safer working environment.

Table 16 OIRA Tool Evaluation and Improvement

The findings emphasize several key points. For starters, the tool's ability to identify a wide range of workplace risks enables organizations to manage occupational hazards proactively, resulting in a safer workplace. Second, its user-friendly interface and accessibility features allow users of all levels of expertise to easily navigate the tool, promoting widespread adoption and utilization.

Furthermore, the accurate and reliable data collected through OIRA assessments allows for informed decision-making and proactive risk mitigation strategies. Comprehensive training sessions and regular updates provide users with the necessary knowledge and tools to effectively use the OIRA and adapt to changing safety standards. Management's active participation in the risk assessment process, combined with regular safety audits, strengthens an organizational culture of safety and accountability.

Continuous evaluation of user feedback enables iterative improvements to the OIRA tool, addressing user concerns while improving overall user experience. By leveraging the OIRA tool, construction companies can drive continuous improvement in occupational safety and health standards, resulting in a safer and more secure working environment for all workers.

In short, the results demonstrate the OIRA tool's significant impact on advancing occupational safety and health practices, emphasizing its importance as a critical tool for risk management in the construction industry. Ongoing efforts to monitor, evaluate, and improve the tool will be required to

ensure that it remains effective and relevant in addressing changing workplace challenges.

IV. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Findings

The researchers conducted this study to enhance occupational safety and health (OSH) using online interactive risk assessment (OIRA) in small to medium-scale construction companies in the City of San Fernando, Pampanga: strategies, challenges, and best practices. Thematic analysis of the preliminary assessment provided significant information into the challenges that these companies encounter, specifically falling objects, equipment malfunctions, and injuries as key hazards in vertical construction works. These findings addressed the stated challenges, underscoring the vital need for necessary risk management strategies.

Throughout the following phases, the study focused on accomplishing its objectives. The development and implementation of the OIRA tool and user-friendly website were intended to address the identified OSH obstacles while remaining adaptive to the context of small to medium-sized construction companies. The tools proved effective in facilitating risk assessment methods and fostering proactive risk management practices among users.

The evaluation of the implemented OIRA procedures demonstrated their accuracy in acknowledging workplace risks and gathering accurate data. This is with the objective of assessing the accuracy of the OIRA approaches and developing strategies for continuous enhancement. User feedback procedures and gradual adjustments were important for growing the effectiveness and relevance of the OIRA tool in improving workplace safety standards.

As a result of these findings, the study provides helpful insights and practical recommendations to enhance occupational safety and health standards in the construction industry. By aligning with the study's problem statement and objectives, the research facilitates accomplishing the overall objective of building a culture of proactive risk management and ensuring workers' well-being in small to medium-sized construction businesses.

4.2 Conclusion

The main objective of this study is to enhance occupational safety and health using Online Interactive Risk Assessment (OIRA) in small to medium-scale construction companies.

Based on the results of the study, the following conclusions can be drawn:

- The assessment of occupational safety and health challenges in small to medium-scale construction companies, specifically in the City of San Fernando, Pampanga, encountered several types of serious concerns, including falling objects, mishaps, and health hazards. These findings correspond with the intended objective of identifying existing challenges within the target company.
- The Online Interactive Risk Assessment (OIRA) tool and website have effectively addressed the identified occupational safety and health risks and hazards. The OIRA platform's user-friendly interface and comprehensive features are tailored specifically to the needs of small to medium-sized construction companies, achieving the objective of developing effective risk assessment and mitigation tools.
- An evaluation of the accuracy of the adopted OIRA procedures indicated a high level of fidelity and efficiency in identifying workplace risks and implementing control protocols It aims to ensure the accuracy of OIRA tools while also promoting the continuous improvement of occupational safety and health standards in the construction industry.
- The study's findings emphasize the significance of continuous monitoring,

assessment, and collaboration in maintaining and enhancing occupational safety and health standards. Construction companies can enhance workplace safety procedures gradually by engaging stakeholders and implementing user feedback, which aligns with the wider objective of improving occupational safety and health in the targeted industry.

4.3 Recommendations

After concluding the study, the researchers offer the following specific recommendations to enhance security protocols and promote environmental responsibility in the construction industry:

1. Horizontal Construction Optimization:
   - Future Researchers: Expand the study's scope to include both horizontal and vertical risk variables during construction to provide a more comprehensive understanding of safety concerns across various projects.
   - Others: Construction industry stakeholders, policymakers, and safety regulators can utilize this recommendation to advocate for comprehensive risk assessment approaches that consider both horizontal and vertical factors in construction projects.
2. Leveraging Existing Tools for Risk Assessment in the City of San Fernando, Pampanga:
   - Future researchers: Should explore leveraging existing tools for enhanced risk assessment in San Fernando. Collaborating with tech-driven companies specializing in urban risk assessment provides access to advanced methodologies, fostering innovation and enriching research endeavors.
   - Others: Stakeholders interested in advancing risk assessment in San Fernando should consider leveraging existing tools available in the field. Partnering with tech-driven companies offers access to integrated platforms, remote sensing, GIS technologies, and big data analytics. By maximizing these tools, stakeholders can improve decision-making and resilience against urban challenges.
3. Upgrade Technology for Data Protection:
   - Future Researchers: Utilize advances in technology to improve the data protection method, expanding beyond conventional methods, including screenshotting. This step fosters a safer research environment and encourages innovation in protecting sensitive information.
   - Others: Stakeholders should prioritize technology upgrades to improve data security measures. This involves using encryption, access controls, and data anonymization systems. By investing in modern technology, stakeholders can mitigate the risks associated with data breaches while maintaining confidentiality and integrity.
4. Continuous Enhancement of Risk Assessment and Management:
   - Future Researchers: Ensure ongoing enhancements in risk assessment and management procedures for all construction projects, regardless of size or type.
   - Others: Industry stakeholders, policymakers, and safety regulators should prioritize investments in innovative strategies, regular training programs, and technological improvements to mitigate potential hazards and enhance safety standards across construction projects.
5. Consideration of Mobile Application Transition:
   - Future Researchers: Evaluate the potential transition to mobile applications for risk assessment and management processes in construction, considering the benefits of flexibility, real-time data collection, and accessibility offered by mobile apps.
   - Others: Industry stakeholders and technology providers can collaborate to develop and implement mobile applications tailored to the construction industry's needs,

considering variations in technological infrastructure and accessibility levels.

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