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# Implementation and Performance Evaluation of Occupational Health and Safety Management Systems in a Building Construction Project

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## Abstract

Occupational Health and Safety Management Systems represent a managerial approach designed to protect workers from occupational accidents and work-related diseases, thereby creating a safe, efficient, and productive working environment. Nevertheless, the increasing number of occupational accidents in Indonesia, as reported by the Social Security Administration for Employment, indicates that the implementation of such systems continues to face significant challenges in practice. The primary issue addressed in this study is the limited understanding of hazard potential, the level of occupational risk, and the effectiveness of risk supervision and control in building construction projects. Therefore, this research aims to analyze the implementation of the Occupational Health and Safety Management System, identify high-risk construction activities, and evaluate the factors contributing to potential workplace accidents in the Landmark BSI (Bank Syariah Indonesia) Building Construction Project in Aceh. This study employed a quantitative approach supported by statistical analysis. Primary data were collected through field observations, questionnaire surveys administered to respondents, and project documentation, while secondary data included project organizational structures and workforce information. The findings reveal that the implementation of occupational health and safety management practices in the Landmark BSI Aceh Building Construction Project can be categorized as relatively effective, as evidenced by the execution of hazard identification procedures, safety protocols, and risk control measures. Based on the Relative Importance Index analysis, the most dominant occupational accident risk was the potential of being struck by falling materials from height (mean score 4.58), while the highest-rated control measure was the availability of emergency evacuation routes (mean score 4.63). The validity and reliability tests confirmed that all research instruments were valid (r-count > r-table 0.404) and reliable (Cronbach's Alpha > 0.60). However, improvements are still required in terms of supervision, consistency of implementation, and the strengthening of safety culture to sustainably minimize the potential for workplace accidents.

**Keywords:** Occupational Health and Safety, Construction, Risk, Workplace Accidents, Risk Control

## *Introduction*

The Occupational Health and Safety Management System is a systematic managerial approach designed to control workplace risks through the integration of policies, planning, implementation, and evaluation within an organization [1]. The implementation of this system is particularly crucial in the construction sector, which is characterized by high-risk activities such as the operation of heavy equipment, working at elevated heights, and unpredictable workplace conditions. Occupational accident data in Indonesia reported by the Social Security Administration for Employment indicate an increasing trend in recent years, reflecting that the implementation of workplace safety practices continues to encounter various challenges [2]. This condition highlights the necessity of evaluating the implementation of Occupational Health and Safety Management Systems, particularly in building construction projects such as the Landmark BSI Aceh Building Project, which involves a large workforce and various activities with diverse potential hazards.

From a theoretical perspective, a construction project is defined as a temporary, unique, and complex undertaking aimed at producing a physical structure within specified constraints of time, cost, and quality [3]. According to project management theory, project success is not solely measured by the achievement of technical objectives, but also by the ability to effectively manage risks, including occupational safety risks [4]. The characteristics of construction projects, which involve multiple stakeholders with diverse backgrounds and are influenced by external factors such as weather conditions and the surrounding environment, make occupational safety management an integral component of the overall project process. Furthermore, the high mobility of the workforce, combined with the presence of less experienced workers, may further increase the potential for workplace accidents [5].

In the field of occupational safety studies, several theories have been developed to explain the causes of workplace accidents. One of the classical theories that remains relevant is the Domino Theory, which states that accidents occur as a result of a chain of interrelated factors, ranging from individual background characteristics and human error to unsafe actions, ultimately leading to accidents and resulting losses [6,7]. In addition, modern accident causation theories emphasize the importance of a systems approach, in which accidents are not solely attributed to individual errors, but also to deficiencies within the management system [8]. These two theoretical perspectives complement each other in building construction projects by providing a comprehensive analytical framework: the Domino Theory enables the identification of proximal causes and individual behavioral sequences that lead to accidents, while modern systems theory addresses the broader organizational, environmental, and managerial failures that may create the conditions for such sequences to occur. The integration of both approaches allows for a more complete understanding of accident causation, recognizing that unsafe acts by workers are often influenced by latent organizational weaknesses, such as inadequate safety supervision, poor communication, or insufficient risk assessment practices, which are particularly prevalent in dynamic and high-pressure construction environments.

In general, the factors contributing to workplace accidents can be classified into human factors, work-related factors, and environmental factors [9]. Human factors include age, educational background, work experience, as well as the physical and psychological conditions of workers. Work-related factors are associated with the type of work, work methods, work systems such as shift arrangements, and workload conditions that may lead to fatigue. Meanwhile, environmental factors encompass physical conditions such as lighting, noise, temperature, and exposure to chemical and biological substances. These three factors interact with one another and may increase the risk of workplace accidents if they are not properly managed through an effective control system [10].

Risk management practices in occupational safety commonly recognize the hierarchy of risk control as a core framework for hazard mitigation. Within this framework, control measures are categorized into several levels, namely elimination, substitution, engineering controls, administrative controls, and personal protective equipment. Priority is generally given to controlling hazards at their source through the removal or replacement of hazardous conditions before dependence is placed on individual protective measures as the last layer of protection. In construction project environments, the application of this hierarchy can be reflected through the implementation of safer construction techniques, the establishment and enforcement of operational safety procedures, and the provision of protective equipment that is specifically suited to the nature of the work activities being carried out [11].

Furthermore, the establishment of a strong safety culture is widely regarded as a crucial factor in ensuring the effective implementation of Occupational Health and Safety Management Systems. Within an organization, workplace safety is reflected through the collective values, perceptions, attitudes, and level of commitment demonstrated by all individuals toward maintaining safe working conditions [12,13]. Organizations that possess a well-developed safety culture are commonly identified through the presence of effective communication systems, leadership commitment toward occupational safety, and active involvement of workers in safety-related programs. Greater awareness of workplace hazards is generally promoted through the establishment of such a culture, while stronger compliance with safe working procedures is encouraged among employees during the execution of work activities [14].

The Occupational Health and Safety Management System is generally regarded as an integrated component of the overall organizational management structure, in which the processes of planning, organizing, implementation, and supervision are systematically incorporated [15]. Within the regulatory framework in Indonesia, the implementation of Occupational Health and Safety Management Systems has been regulated through various legal provisions, whereby companies are required to apply these systems in a systematic and integrated manner. The primary objectives of implementing an Occupational Health and Safety Management System are to enhance the effectiveness of workforce protection, prevent occupational accidents and work-related diseases, and establish a safe and productive working environment. Therefore, the implementation of this system is not merely administrative in nature, but also constitutes an essential component of organizational risk management strategy [16–18].

The problems addressed in this study focus on the inadequate identification of high-risk activities, the lack of comprehensive mapping of factors contributing to workplace accidents, and the limited effectiveness of risk supervision and control in the Landmark BSI Aceh Building Construction Project. This study is intended to identify work activities associated with high-risk levels, examine the factors contributing to workplace accidents, and assess the implementation of occupational safety control and supervision systems within the project environment. The research employed a quantitative approach, with data collected through field observations, questionnaires, and documentation, which were subsequently analyzed using statistical techniques to obtain objective and measurable results.

The novelty of this study is reflected in the analytical approach employed, in which activity-based risk identification, analysis of accident causation factors, and assessment of risk control effectiveness are integrated within a comprehensive research framework. In addition, the implementation of the hierarchy of risk control and safety culture principles is examined specifically within the context of building construction projects in the Aceh region, where relatively limited attention has been given in previous research.

This study is expected to contribute both theoretically and practically. From a theoretical standpoint, the understanding of Occupational Health and Safety Management System implementation within the construction sector may be further enriched through the findings of this research. From a practical perspective, the results obtained may be utilized as a reference by contractors, project managers, and other related stakeholders to improve the effectiveness of occupational safety practices. Moreover, continuous efforts toward the prevention of workplace accidents are expected to be supported through this study, thereby contributing to the development of a safer, healthier, and more productive work environment.

## Materials and Methods

This section provides a detailed and systematic description of the research procedures, including the processes of data collection, data processing, and data analysis undertaken to obtain accurate research findings. The sequence of research procedures is described in several section.

### Research Object

The object of this study was the Landmark BSI Aceh Building Construction Project situated on Teuku Moh. Daud Beureueh Street, Kampung Keuramat, Kuta Alam District, Banda Aceh City, Aceh Province. The selection of this project location was made based on the consideration that a high degree of work complexity was involved in the construction activities, with various

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parties participating in different types of work operations, thereby resulting in considerable potential risks related to occupational health and safety.

The study location is situated at approximately 5°33’15.6”N latitude and 95°19’22.1”E longitude, within the central business district of Banda Aceh. The project site is bordered by Teuku Moh. Daud Beureueh Street to the south, residential areas to the north, public facilities to the east, and office buildings to the west. These surrounding conditions contribute to the complexity of occupational safety management due to high traffic activity and the proximity to community activities.

In this study, the implementation of occupational health and safety practices within the project environment was examined comprehensively. Particular attention was given to the identification of potential hazards, the evaluation of occupational risk levels, and the assessment of the effectiveness of the control and supervision systems applied throughout the construction process.

### *Data Collection Methods*

The data collection process in this study was carried out as a crucial stage for obtaining relevant and reliable information. Both primary and secondary data were utilized in this research, and the data were systematically gathered in accordance with the analytical requirements of the study.

Data collection was carried out through several structured stages, beginning with the preparation of research instruments, followed by field observations, and subsequently the collection of information through questionnaires and interviews. Through this approach, the data obtained were expected to accurately represent the actual conditions in the field.

Primary data were directly acquired from the principal sources through questionnaire administration, interview sessions, and on-site observations conducted within the project area. The collection of research data was carried out within an estimated period of two weeks after the research instruments had been provided to the respondents participating in the project.

The questionnaire instrument was designed in the form of structured questions aimed at obtaining information related to risk factors, potential occupational accidents, and the implementation of occupational safety control systems. In addition, field observations were conducted to directly examine working conditions, the use of personal protective equipment, and the implementation of safety procedures at the project site. Visual documentation was also collected as supporting data to strengthen the observational findings. Furthermore, interviews were carried out with individuals who were considered to possess adequate competence and relevant knowledge, so that more comprehensive and detailed information could be obtained.

Secondary data were collected as supporting information obtained from various relevant sources. These data include a map of Aceh Province, a map of Banda Aceh City, a map of the research location, as well as data on the project organization and workforce obtained from the project implementing agency. The availability of secondary data was intended to complement the primary data and to provide contextual information regarding the research location and object. As a result, a more comprehensive and systematic analysis could be carried out.

### *Research Stages*

In this study, several supporting tools were utilized to facilitate the data collection process in the field. Writing instruments were used to record observations and interview results conducted throughout the research period. Questionnaires were employed as the primary instrument for obtaining data from respondents.

In addition, documentation devices such as digital cameras or smartphones were used to capture field conditions as visual evidence. Computers or laptops were employed to process the collected data, including data entry and statistical analysis using relevant software. The utilization of these tools was intended to improve the accuracy and effectiveness of the research process.

The stages of the research were systematically arranged to ensure that the overall research process could be carried out in a structured manner and in accordance with the predetermined objectives. The process of data collection was conducted through direct observation, questionnaire administration, and interviews with parties involved in the project activities.

This approach was applied to obtain an overview of the implementation of occupational safety and health systems conducted by the contractor as part of the efforts to reduce the occurrence of workplace accidents in the field.

### *Research Variables*

The variables in this study were determined based on aspects related to occupational safety and health. These variables included respondent characteristics, types of high-risk work activities, factors contributing to occupational accidents, and the implementation of risk control and supervision measures. Each variable was further operationalized into several indicators measured through a questionnaire instrument. The formulation of these variables was carried out to obtain more focused and representative data reflecting the actual conditions in the field.

Questionnaires were distributed to respondents consisting of workers, contractors, and supervising consultants involved in the project. The questionnaire instrument was structured into several sections, namely respondent identity, instructions for completion, and research questions. The questions were designed in a closed-ended format to facilitate respondents in providing answers and to simplify the data analysis process. The distribution of questionnaires was carried out directly at the project site.

Interviews were carried out with respondents who possessed work experience in the construction sector, particularly in matters related to occupational safety and health. Respondents with a minimum of five years of professional experience were selected for this study. More detailed information regarding

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the implementation of occupational safety systems, along with the challenges encountered during project execution, was intended to be obtained through the interview process.

### *Sampling Technique*

The population in this study was defined as all parties involved in the building construction project, including both workers and project management personnel. The research sample was determined based on specific criteria aligned with the objectives of the study. The selection of respondents was carried out by considering their work experience, job position, and level of involvement in the implementation of the construction project.

A purposive non-probability sampling technique was employed in this study. The application of this method enabled respondents to be selected according to criteria that had previously been established by the researcher. Through this sampling approach, individuals considered to have relevant knowledge and practical experience related to the research subject were expected to be included in the study. The specific criteria used for selecting the 30 respondents included: (1) employment in a job role directly involved in construction activities, such as skilled laborers, foremen, site supervisors, safety officers, and project engineers; (2) a minimum of one year of work experience on construction projects to ensure familiarity with site operations; and (3) direct engagement in high-risk activities, including working at heights, operating heavy machinery, or handling construction materials, to ensure that respondents had firsthand knowledge of potential occupational hazards.

Several methods were applied in the process of collecting research data, including field observations, the distribution of questionnaires, and interviews with respondents involved in the study. Observation was conducted to examine the actual conditions in the field, while questionnaires were used to obtain quantitative data from respondents. Interviews were conducted to complement the data obtained from questionnaires and observations, thereby providing more comprehensive and in-depth information.

### *Validity and Reliability Test*

The validity test was performed to evaluate the capability of the research instrument in measuring the variables that had been established in the study accurately and appropriately. The test was performed using statistical software, in which the calculated values were compared with predetermined standard values. When the obtained values satisfied the predetermined criteria, the research instrument was regarded as valid and appropriate to be utilized in the study. The r-table value of 0.404 was selected based on the degrees of freedom ($df = n - 2 = 30 – 2 = 28$) at a significance level of $\alpha = 0.05$ (two-tailed test), which corresponds to the critical value for a sample size of 30 respondents as obtained from standard statistical tables. This threshold is conventionally used in exploratory social science research to determine the minimum correlation coefficient required for an item to be considered valid, ensuring that the instrument adequately measures the intended constructs.

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The reliability test was performed to assess the consistency and stability of the research instrument in producing measurement results throughout the study. The test was carried out using a specific coefficient value as a reference for assessing instrument reliability. The instrument was considered reliable if the obtained value met the predetermined minimum threshold, indicating that it could be trusted to produce consistent data.

### Descriptive Analysis

Descriptive analysis was applied to explain the characteristics of the respondents and the distribution of responses obtained from the questionnaires. The collected data were processed using statistical software so that frequency distributions, percentage values, and mean scores could be generated. Subsequently, the analytical results were presented in the form of tables and diagrams to simplify the interpretation process. The mean values obtained from the analysis were utilized to determine the dominant factors affecting the implementation of occupational safety and health practices in construction projects.

## Results and Discussion

The research data were systematically processed and subsequently presented in the form of tables and graphical illustrations, so that various issues associated with the investigated project could be examined and discussed in a more structured and comprehensive manner.

### General Description of the Project

The implementation of research in construction projects represents a strategic stage in obtaining a realistic overview of field conditions. This phase not only serves as the execution of previously developed planning, but also as a means of evaluating the consistency between planned objectives and actual work implementation. During the construction process, various field dynamics are inevitable. Discrepancies between actual conditions and initial planning often occur due to both external and internal factors, such as environmental conditions, resource limitations, and other technical constraints. Therefore, a structured control mechanism and intensive coordination among involved parties are required to ensure that any emerging issues can be addressed without causing significant deviations from the project targets. Previous studies have also reported similar findings [19].

The primary emphasis of this study was placed on the implementation of an Occupational Safety and Health Management System. Such emphasis was based on the characteristics of construction activities, which are associated with high levels of risk to both workers and the surrounding environment. Consequently, the application of an integrated occupational safety and health management system was considered essential to ensure that potential hazards arising during the construction process could be identified, controlled, and minimized effectively.

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### General Project Data

General project data were presented to provide a comprehensive overview of the characteristics of the work that constituted the object of the study. This project is an integrated construction work using a design-build approach, which combines the planning and execution processes within a single system. This approach requires more intensive coordination between planners and contractors to ensure time and cost efficiency.

The planned structure is an eight-story office building with an additional two basement levels. The building structure is designed to accommodate modern banking operational needs; therefore, it requires high construction quality standards as well as adequate safety systems.

The project is scheduled to be implemented over a relatively long duration of 510 calendar days, with a maintenance period of 365 calendar days. The application of a lump sum and fixed-price contract system requires the contractor to manage resources optimally, as the risk of cost overruns is entirely borne by the implementing party. In addition, periodic payment based on work progress also demands accuracy in reporting and strict control of the project implementation schedule.

The participation of various parties, including the project owner, design consultant, construction management consultant, and quantity surveyor, indicated that the project possessed a considerable level of complexity. Consequently, the implementation of a well-structured management system, particularly in the aspect of occupational safety, was considered necessary to ensure that all activities could be conducted in accordance with the established standards. Previous studies have explained that project complexity increases with the number of stakeholders involved; thus, a systems approach is necessary to ensure effective coordination and proper risk control [20].

### Project Site and Environmental Conditions

The surrounding environmental conditions of the project are one of the factors influencing the level of construction risk. The project location, which is situated in an urban area with high traffic activity, presents potential accident risks that involve not only workers but also the surrounding community.

On the southern side, the presence of a main road increases the potential for traffic accidents as well as social disturbances. Meanwhile, on the northern side, which is adjacent to residential areas, there is a potential risk of environmental damage and falling construction materials. These conditions require additional safety measures, such as the installation of project fencing and the control of material transportation activities.

On the eastern and western sides, the presence of public facilities and office buildings creates additional risks in the form of noise, air pollution, and potential disturbances to institutional activities surrounding the project site. Therefore, the implementation of effective environmental management becomes an integral part of the occupational safety system. Overall, the site conditions

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indicate that external factors make a significant contribution to construction risks. Accordingly, a comprehensive risk management approach is essential to anticipate various possible occurrences. This is supported by previous studies stating that construction projects involve high levels of risk encompassing health, safety, and environmental aspects; thus, an integrated risk management approach is required to identify and control various sources of hazards [21].

### *Characteristics and Profile of Respondents*

An examination of respondent characteristics was carried out to provide a comprehensive description of the human resources engaged in the project activities. Based on the results of the data analysis, a predominance of male respondents was identified within the workforce composition. This finding may be associated with the general characteristics of the construction industry, where occupations involving intensive physical demands are more commonly undertaken by male workers.

From the age perspective, the majority of respondents were classified within the productive age category. This condition indicates that adequate physical endurance and mental capability were generally possessed by the workforce to carry out construction activities characterized by relatively high work demands. In addition, stronger adaptability toward technological developments and work procedures was commonly demonstrated within the productive age group.

In terms of educational background, the majority of respondents had completed senior high school education. This indicates that most construction workers come from vocational educational backgrounds with practical skills. Meanwhile, workers with higher education levels generally occupy managerial or technical positions.

The respondents' work experience indicates that most of them have more than five years of experience. This experience serves as an important indicator in understanding the level of worker competence, particularly in the implementation of occupational safety procedures. A higher level of work experience was generally associated with a better understanding of occupational risks and the corresponding preventive measures. In previous studies, workers with longer periods of service were reported to contribute positively to the implementation of occupational safety and health practices, as greater risk awareness and safer work behavior were commonly demonstrated by experienced personnel [22]. The distribution of respondents based on job position, highest level of education, and length of work experience is illustrated in Table 1, Table 2, and Table 3.

**Table 1.** Respondents' Job Positions

| No. | Educational Background | Number of Respondents | Percentage (%) |
|---|---|---|---|
| 1 | Elementary School | 6 | 20 |
| 2 | Junior High School | 6 | 20 |
| 3 | Senior High School | 12 | 40 |
| 4 | Diploma-3 | 0 | 0 |
| 5 | Bachelor's Degree | 6 | 20 |
| | **Total** | **30** | **100** |

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**Table 2.** Respondents' Highest Educational Background

| No. | Educational Background | Number of Respondents | Percentage (%) |
|---|---|---|---|
| 1 | Elementary School | 0 | 0 |
| 2 | Junior High School | 6 | 25 |
| 3 | Senior High School | 12 | 50 |
| 4 | Diploma-3 | 0 | 0 |
| 5 | Bachelor's Degree | 6 | 25 |
| | **Total** | | **100** |

**Table 3.** Respondents' Work Experience Data

| No. | Work Duration | Number of Respondents | Percentage (%) |
|---|---|---|---|
| 1 | < 1 Year | 0 | 0 |
| 2 | 1 – 5 Years | 6 | 25 |
| 3 | 5 – 10 Years | 13 | 54 |
| 4 | > 10 Years | 5 | 21 |
| | **Total** | **24** | **100** |

### *Validity and Reliability Analysis of the Research Instrument*

As presented in Table 4, the validity test was performed to evaluate whether each statement item within the questionnaire accurately reflected the variables examined in the research. The analysis results indicated that all questionnaire items obtained correlation coefficients above the established minimum criteria (r-table = 0.404). Based on these findings, the research instrument was regarded as valid and suitable for use in the study.

Subsequently, reliability testing was carried out to evaluate the consistency of respondents' answers to the questionnaire items. Based on the analysis results presented in Table 5, Cronbach's Alpha values exceeding 0.60 were obtained for all research variables, indicating that the instrument demonstrated a satisfactory level of reliability. These findings are in line with previous studies, in which a Cronbach's Alpha value of 0.60 has generally been regarded as the minimum acceptable criterion for reliability [23]. For further clarification, see Table 4 and Table 5.

With both of these aspects being satisfied, the collected data can be used as a reliable basis for accurate analysis. This is essential to ensure that the research findings are scientifically valid and accountable. The outcomes of the validity testing are illustrated in graphical form and are presented in Figure 1.

As shown in Figure 1, the validity test graph shows that all research variables have average calculated r-values (r-count) above the r-table threshold (approximately 0.40), indicating that all research instruments are valid. Variable X1 has the highest value (approximately 0.69), indicating that its indicators have the strongest correlation with the measured construct. Meanwhile, X2 (approximately 0.63) also demonstrates good validity, while X3 (approximately 0.51) and X4 (approximately 0.52) fall into the moderate category but still meet the required criteria. These differences reflect variations in the strength of relationships among items within each variable. Variables with lower values remain acceptable for use; however, they may require refinement through

**Table 4.** Respondents' Work Experience Data

| Variable | Item | r-table | r-count | Description |
|---|---|---|---|---|
| Occupational Accident Risk (X1) | X1.1 | 0.404 | 0.550 | Valid |
| | X1.2 | 0.404 | 0.605 | Valid |
| | X1.3 | 0.404 | 0.662 | Valid |
| | X1.4 | 0.404 | 0.647 | Valid |
| | X1.5 | 0.404 | 0.749 | Valid |
| | X1.6 | 0.404 | 0.826 | Valid |
| | X1.7 | 0.404 | 0.679 | Valid |
| | X1.8 | 0.404 | 0.808 | Valid |
| Work Accident Potential (X2) | X2.1 | 0.404 | 0.693 | Valid |
| | X2.2 | 0.404 | 0.433 | Valid |
| | X2.3 | 0.404 | 0.745 | Valid |
| | X2.4 | 0.404 | 0.477 | Valid |
| | X2.5 | 0.404 | 0.770 | Valid |
| | X2.6 | 0.404 | 0.810 | Valid |
| | X2.7 | 0.404 | 0.703 | Valid |
| | X2.8 | 0.404 | 0.422 | Valid |
| Implementation of Work Accident Control (X3) | X3.1 | 0.404 | 0.459 | Valid |
| | X3.2 | 0.404 | 0.446 | Valid |
| | X3.3 | 0.404 | 0.572 | Valid |
| | X3.4 | 0.404 | 0.491 | Valid |
| | X3.5 | 0.404 | 0.413 | Valid |
| | X3.6 | 0.404 | 0.455 | Valid |
| | X3.7 | 0.404 | 0.712 | Valid |
| | X3.8 | 0.404 | 0.580 | Valid |
| Supervision of Work Accident Control (X4) | X4.1 | 0.404 | 0.415 | Valid |
| | X4.2 | 0.404 | 0.458 | Valid |
| | X4.3 | 0.404 | 0.622 | Valid |
| | X4.4 | 0.404 | 0.444 | Valid |
| | X4.5 | 0.404 | 0.631 | Valid |
| | X4.6 | 0.404 | 0.486 | Valid |
| | X4.7 | 0.404 | 0.658 | Valid |
| | X4.8 | 0.404 | 0.451 | Valid |

**Table 5.** Reliability Test Results

| Variabel | Cronbach's Alpha | Description |
|---|---|---|
| Occupational Accident Risk (X1) | 0.841 | Reliable |
| Work Accident Potential (X2) | 0.799 | Reliable |
| Implementation of Work Accident Control (X3) | 0.632 | Reliable |
| Supervision of Work Accident Control (X4) | 0.633 | Reliable |

indicator evaluation to improve their representativeness. This result is consistent with findings reported in previous studies, where instrument validity has been regarded as a systematic evaluation process intended to confirm that each measurement item accurately represents the theoretical construct investigated in the research [24].

The lower r-count for variable X3 (Implementation of Work Accident Control) compared to X1 (Occupational Accident Risk) suggests that the constructs underlying control implementation are more multifaceted and may be more susceptible to subjective interpretation by respondents. This does not necessarily indicate that the instrument is inadequate, but rather that the measurement of implementation effectiveness inherently involves broader and more diverse operational aspects, such as the availability of safety facilities, enforcement of procedures, and workers' perceptions of managerial commitment. Therefore, while the current items are statistically valid, future research may benefit from refining the questionnaire by including more specific behavioral and observable indicators to enhance the precision of measuring this variable.

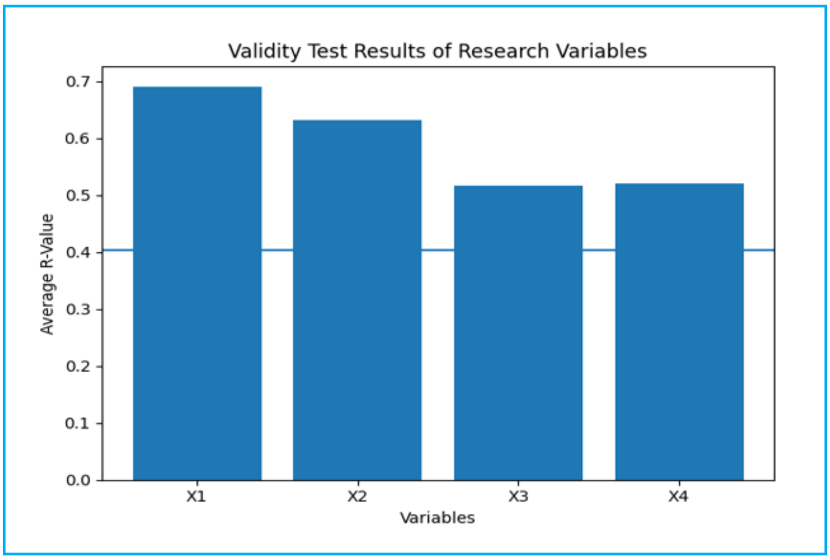


**Figure 1.** Results of the Validity Test

### *Relative Importance Index (RII) Analysis*

The determination of priority levels for each factor within the occupational safety and health management system was carried out using the Relative Importance Index analysis, a method grounded in the calculation of mean values and the weighting of respondent responses. Further details are presented in Table 6.

Based on the data presented in Table 6, the analysis results indicate that the most dominant occupational accident risk is the potential of being struck by falling materials from height. This is consistent with the characteristics of high-rise building construction, which involves vertical activities. Therefore, the implementation of strict control measures, such as the use of personal protective equipment and the installation of additional safety protections, is necessitated. This finding is consistent with those of previous studies, in which accidents caused by falling objects have been identified as one of the primary causes of injuries and fatalities within the construction industry [25]. Recent studies also indicate that this risk increases in high-rise building projects due to the intensity of material lifting and distribution activities [26].

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**Table 6.** Questionnaire Assessment Data of Respondents

| No | Questionnaire Items | Measurement Scale | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| **Occupational Accident Risk** | | | | | | |
| 1 | Struck by work equipment during work activities | 0 | 2 | 2 | 10 | 10 |
| 2 | Falling from height | 0 | 3 | 3 | 11 | 7 |
| 3 | Exposure to welding sparks during welding operations | 0 | 3 | 0 | 16 | 5 |
| 4 | Being hit by materials/equipment falling from height | 0 | 1 | 0 | 11 | 12 |
| 5 | Buried by soil during excavation work | 1 | 1 | 5 | 14 | 3 |
| 6 | Impact with hard materials/equipment | 1 | 0 | 0 | 16 | 7 |
| 7 | Exposure to sharp objects | 0 | 2 | 0 | 11 | 11 |
| 8 | Direct contact with heat, radiation, chemicals, and noise | 1 | 1 | 5 | 12 | 5 |
| **Work Accident Potential** | | | | | | |
| 1 | Workers' knowledge in operating work equipment | 0 | 1 | 0 | 16 | 7 |
| 2 | Failure to use personal protective equipment (PPE) | 0 | 0 | 0 | 8 | 16 |
| 3 | Unhealthy and hazardous working conditions | 0 | 1 | 2 | 15 | 6 |
| 4 | Workers' non-compliance with established regulations | 0 | 0 | 0 | 7 | 17 |
| 5 | Inadequate or poorly maintained work equipment conditions | 0 | 1 | 2 | 12 | 9 |
| 6 | Construction materials that do not meet quality standards | 0 | 1 | 2 | 17 | 4 |
| 7 | Inadequate work execution methods | 0 | 1 | 2 | 12 | 9 |
| 8 | Lack of occupational safety and health signage at the project site | 0 | 0 | 4 | 13 | 7 |
| **Implementation of Work Accident Control** | | | | | | |
| 1 | Routine inspection of Personal Protective Equipment (PPE) usage among workers | 0 | 0 | 2 | 12 | 10 |
| 2 | Installation of safety signage and safety lines | 0 | 0 | .0 | 10 | 14 |
| 3 | Inspection and routine maintenance of equipment | 0 | 0 | 1 | 15 | 8 |
| 4 | Availability of work methods and work programs | 0 | 0 | 0 | 14 | 10 |
| 5 | Provision of fire extinguishers | 0 | 0 | 6 | 14 | 4 |
| 6 | Availability of emergency evacuation routes | 0 | 0 | 0 | 9 | 15 |
| 7 | Occupational safety and health training/socialization | 0 | 0 | 2 | 17 | 5 |
| 8 | Health monitoring/check-ups for workers | 0 | 0 | 0 | 14 | 10 |
| **Supervision of Work Accident Control** | | | | | | |
| 1 | Storage, use, and maintenance of work equipment | 0 | 0 | 2 | 16 | 6 |
| 2 | Personal protective equipment used by workers | 0 | 0 | 0 | 10 | 14 |
| 3 | Workers' health condition | 0 | 0 | 0 | 10 | 14 |
| 4 | Supervision of occupational accident risks | 0 | 0 | 0 | 14 | 10 |
| 5 | Safety and health signage in hazardous areas | 0 | 0 | 2 | 11 | 11 |
| 6 | Routine inspection of the workplace and occupational safety and health (OSH) equipment completeness | 0 | 0 | 0 | 14 | 10 |
| 7 | Measurement of the achievement of OSH program implementation | 0 | 0 | 1 | 18 | 5 |
| 8 | Evaluation of OSH program targets | 0 | 0 | 2 | 16 | 6 |

Field observations and interviews revealed that the risk of being struck by falling materials was most concentrated in specific work zones, particularly around the tower crane operational areas and along the scaffolding perimeters where material hoisting and vertical transportation activities were most intense. These zones exhibited higher frequencies of material transfer and temporary storage at height, thereby increasing the probability of accidental drops, especially during peak construction periods when multiple trades were working simultaneously in proximity.

Based on the average Likert scale scores for each major variable group—namely, Work Accident Risks, Potential Accident Causes, Accident Control Implementation, and Accident Control Supervision—the questionnaire data were transformed into a graphical representation, as further illustrated in Figure 2.

As presented in Figure 2, the results indicate that all variables fall within a relatively high average score range (above 4.0), suggesting that respondents generally perceive occupational safety conditions and their management positively.

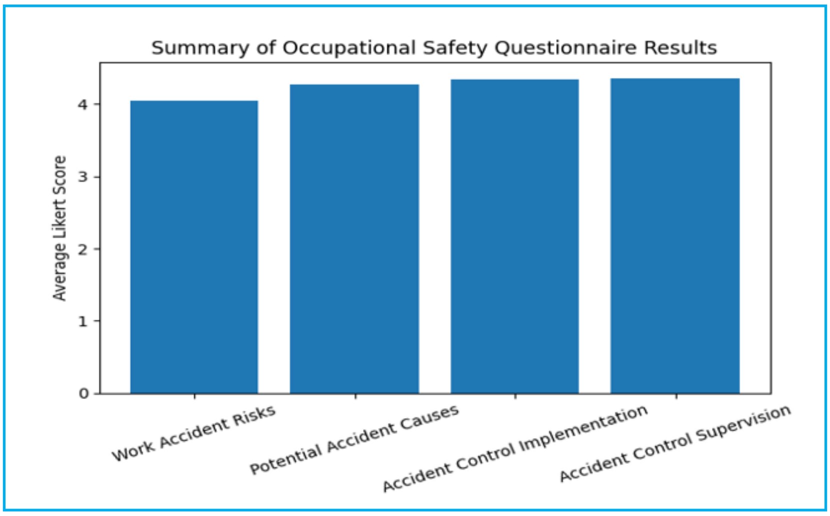


**Figure 2.** Results of Respondents' Questionnaire Assessment

Specifically:

- Work Accident Risks show slightly lower average scores compared to other variables, indicating that risks are still present and require attention.
- Potential Accident Causes demonstrate relatively high scores, reflecting strong awareness among workers regarding factors contributing to accidents.
- Accident Control Implementation and Supervision exhibit the highest scores, suggesting that safety management practices and monitoring systems are well implemented on the project site.

In terms of potential causes of accidents, workers' behavior is identified as the primary factor, particularly related to non-compliance with regulations and the failure to use personal protective equipment. This indicates that the safety culture aspect still needs to be improved through more intensive education and supervision.

In terms of control measures, safety facilities such as evacuation routes and safety signage have been properly implemented. This indicates that project management has paid attention to safety aspects. However, improvements in training and safety socialization are still required to enhance workers' awareness.

### *Results of Field Observations and Evaluations*

Based upon the findings derived from interviews and observations, the occupational accidents occurring at the project site were determined to be relatively minor and non-fatal in nature. From these findings, it is inferred that the control system which has been implemented is operating at a level of adequate effectiveness. The non-occurrence of severe accident incidents serves as evidence that the relevant safety procedures have been duly enforced. The utilization of personal protective equipment, the emplacement of safety signage, and the performance of routine supervisory activities are recognized as the principal factors in the prevention of workplace accidents.

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In addition, activities such as safety briefings and routine inspections have also been implemented as part of efforts to improve workers' awareness. Therefore, it can be inferred that the Occupational Safety and Health Management System has been implemented in this project in accordance with the fundamental principles of safety management as can be seen in Table 7 and Table 8.

**Table 7.** Occupational Accident Control Measures

| No | Questionnaire Items | $\bar{x}$ | IKR | Rank | Description |
|---|---|---|---|---|---|
| 1 | Routine inspection of workers' use of personal protective equipment (PPE) | 4.33 | 0.87 | 5 | Implemented |
| 2 | Installation of safety signage and safety lines | 4.58 | 0.92 | 2 | Implemented regularly |
| 3 | Routine inspection and maintenance of equipment | 4.29 | 0.86 | 6 | Implemented |
| 4 | Availability of work methods and work programs | 4.42 | 0.88 | 3 | Implemented |
| 5 | Provision of fire extinguishers | 3.92 | 0.78 | 8 | Implemented |
| 6 | Availability of emergency evacuation routes | 4.63 | 0.93 | 1 | Implemented regularly |
| 7 | Occupational safety and health training/socialization | 4.13 | 0.83 | 7 | Implemented |
| 8 | Health monitoring of workers | 4.42 | 0.88 | 4 | Implemented |

**Table 8.** Occupational Accident Control Measures Based on Ranking

| No | Questionnaire Items | $\bar{x}$ | IKR | Rank | Description |
|---|---|---|---|---|---|
| 1 | Availability of emergency evacuation routes | 4.63 | 0.93 | 1 | Implemented regularly |
| 2 | Installation of safety signage and safety lines | 4.58 | 0.92 | 2 | Implemented regularly |
| 3 | Availability of work methods and work programs | 4.42 | 0.88 | 3 | Implemented |
| 4 | Health monitoring of workers | 4.42 | 0.88 | 4 | Implemented |
| 5 | Routine inspection of workers' use of personal protective equipment (PPE) | 4.33 | 0.87 | 5 | Implemented |
| 6 | Inspection and routine maintenance of equipment | 4.29 | 0.86 | 6 | Implemented |
| 7 | Occupational safety and health training/socialization | 4.13 | 0.83 | 7 | Implemented |
| 8 | Provision of fire extinguishers | 3.92 | 0.78 | 8 | Implemented |

The accident control data were transformed into a horizontal bar chart using the mean ($\bar{x}$) Likert scale values to provide a clearer comparative visualization of each safety measure as can be seen in Figure 3.

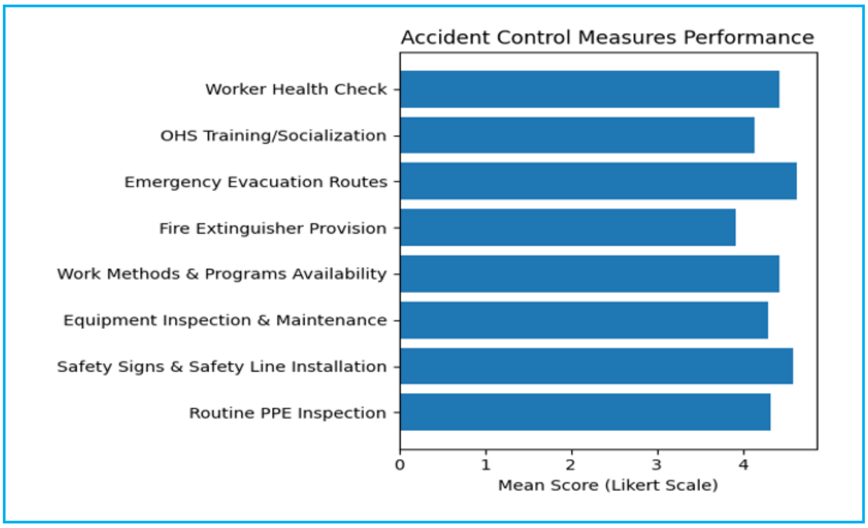


**Figure 3.** Results of Occupational Accident Control

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As presented in Figure 3, the analysis indicates that all accident control indicators fall within a high-performance category (mean > 3.9), suggesting that safety control practices are generally well implemented.

- The highest score is observed in Emergency Evacuation Routes ($\bar{x}$ = 4.63; IKR = 0.93), indicating that emergency preparedness measures are consistently and effectively implemented.
- Safety Signs and Safety Line Installation ($\bar{x}$ = 4.58; IKR = 0.92) also demonstrates a very strong performance, reflecting a high level of compliance in visual safety communication.
- Work Methods and Program Availability and Worker Health Checks show similarly high values, suggesting that procedural and health monitoring aspects are well managed.
- Meanwhile, Fire Extinguisher Provision ($\bar{x}$ = 3.92; IKR = 0.78) records the lowest score among all variables, although it still falls within the “implemented” category, indicating a need for improvement in emergency equipment readiness.

## Discussion

Overall, it is demonstrated by the research findings that the occupational accident risk level is significantly reduced through the implementation of an occupational safety and health management system. The human factor is identified as the most dominant aspect; therefore, a more focused approach is required to promote behavioral change and enhance awareness. Previous studies have reported that companies adopting occupational safety and health management systems have a lower accident risk (approximately 14%) compared to those that do not [27].

Furthermore, an important role in supporting the successful implementation of occupational safety systems is attributed to both technical and managerial factors. The integration of these three aspects is recognized as the key to the formation of a safe and productive working environment. This finding is consistent with those reported in previous studies, in which organizational (managerial) factors have been stated to constitute the most dominant set of variables [28]. Thus, it can be concluded that the successful implementation of an occupational safety and health management system does not depend solely on the availability of facilities, but also on the commitment of all parties to consistently and continuously adhere to safety procedures.

## Conclusion

Based on the results and discussion concerning the implementation of the Occupational Safety and Health Management System in the Landmark BSI building project, several key findings are obtained as follows:

1. The Occupational Safety and Health Management System has been implemented properly and systematically in the Landmark BSI Aceh

Building Construction Project, being supported by adequate work procedures, safety facilities, and supervision systems.

2. Effective occupational risk identification has been performed, through which the main potential hazards in construction activities, especially those related to high-altitude work, have been properly recognized and managed.
3. Consistent implementation of accident control measures has been achieved by means of the provision of personal protective equipment, the installation of safety signage, and the application of work methods conforming to safety standards.
4. Optimal results have been shown by monitoring activities concerning the implementation of the Occupational Safety and Health Management System, particularly with respect to ensuring workers' compliance with the use of personal protective equipment and maintaining workers' health conditions in the project environment. Despite these positive outcomes, field observations revealed that the most frequently violated safety rule was the improper or inconsistent use of personal protective equipment, particularly safety helmets and harnesses, among workers in high-altitude areas during non-routine tasks or when supervisors were not present. This indicates that while monitoring systems are in place, their effectiveness is contingent upon continuous and rigorous enforcement, especially during periods of reduced supervision.
5. It has been proven overall that the implementation of the Occupational Safety and Health Management System in this project has led to the creation of a safe and conducive working environment, in addition to supporting the efficient and effective execution of construction activities.

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## Conflicts of Interest

No conflicts of interest with respect to the research, writing, or publication of this article are declared by the authors.

## Author Contributions

**Hendra Hendra:** conceptualization, data curation, formal analysis, investigation, methodology, writing-original draft. **Heru Pramanda:** validation, resources, supervision, writing-review & editing. **Dedek Ariansyah:** conceptualization, data curation, visualization, writing-review & editing.

**Bunyamin Bunyamin:** conceptualization, formal analysis, funding acquisition, project administration, supervision, validation, writing-review & editing. **M Reza Hani:** conceptualization, formal analysis.

## Data Availability Statement

The data used to support the findings of this study are included within the article.

## Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

Not Applicable.

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