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Original Article

Analysis of Occupational Safety and Health Risk Management in Building Construction Projects (Case Study: School Development Project of SMA Negeri 2 Kuta Utara)

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Abstract - *Development SMA Negeri 2 Kuta Utara, problems related to risk accidents in the industry are identified and need attention, as they are serious during the process of development. During the construction, a worker fell down because of his negligence. In development, this important identification includes degrees of risk, evaluation of risk, and management of risk, as well as safety and health work on Project Development SMA Negeri 2 Kuta Utara. Destination of study. This is for identifying danger, determining classification level risk, and determining management risk on project development SMA Negeri 2 Kuta Utara. The methods used are Hazard Identification, Risk Assessment, and Risk Control (HIRAC). After identifying 25 level risk (frequency) and 25 risk (severity/consequences), all the risks were validated through testing SPSS. Risk level analysis results safety and health Work (OSH) on the project construction of SMA Negeri 2 Kuta Utara classified as 44% level risk low, 56% level moderate risk, and 0% level risk medium level risk, for classification advanced. Effort management, risk, health and safety work is done to avoid Work in areas that are exposed to various risks.*

Keywords - *Construction projects, Risk management, Occupational Safety, Health (OSH).*

1. Introduction

Occupational Safety and Health (OSH) in construction projects is a systematic approach that involves risk identification, the implementation of safety policies, worker training, and supervision to prevent accidents and support social sustainability [1]. The construction of school infrastructure in developing countries often encounters challenges related to Occupational Safety and Health (OSH), which are frequently overlooked during the planning and execution phases. One such case is the construction project of SMA Negeri 2 Kuta Utara, initiated in 2005 to expand its facilities in response to increasing student enrollment. Despite its critical importance, the project experienced several safety-related incidents, including a serious worker fall caused by inadequate safety management. These events highlight a broader issue: the persistent neglect of OSH protocols in medium-scale construction projects within the educational sector. According to Lingard et al., construction projects, particularly in developing countries, often suffer from inadequate safety measures, leading to avoidable accidents [2]. SMA Negeri 2 Kuta Utara's construction project encountered similar issues, as one of the workers experienced a serious fall due to negligence in safety management. Effective safety management systems are essential for mitigating risks during construction. Research by Adra et al. emphasizes the significance of integrating safety planning with project management practices to prevent workplace accidents [3]. In the case of SMA Negeri 2 Kuta Utara, incorporating advanced safety management tools could have minimized accidents and improved overall project performance. Such tools include real-time monitoring and risk assessment methodologies that can proactively identify potential hazards [4]. In recent years, there has been a growing emphasis on the role of safety culture in construction projects. Choudhry et al. argue that a positive safety culture fosters open communication, and continuous safety training is crucial for preventing accidents [5]. At SMA Negeri 2 Kuta Utara, the lack of a robust safety culture may have contributed to the incidents that occurred. Ensuring that workers are adequately trained and aware of potential risks is key to improving safety outcomes [2]. Additionally, involving all stakeholders, including contractors and project managers, in safety decision-making is critical for fostering accountability and vigilance.

While many previous studies focus on large-scale commercial or industrial projects, limited research investigates how safety failures manifest in public educational infrastructure. This study fills that gap by examining the construction safety performance of SMA Negeri 2 Kuta Utara and proposing a comprehensive approach that blends leadership, stakeholder engagement, technological innovation, and financial risk awareness.

Another important factor in construction safety is the use of modern technologies to enhance monitoring and risk assessment. The application of BIM in construction processes with safety management, as described by Aires et al., allows for real-time hazard detection and provides data that can be used to improve worker safety [6]. If such technologies could be applied in a construction project, they would likely help prevent accidents from occurring. BIM has been shown to be effective in predicting and managing construction risks, particularly in complex and large-scale projects [7].

Furthermore, strong leadership significantly contributes to ensuring construction site safety. Leaders who are actively involved in safety management and prioritising safety in their decision-making processes can significantly reduce the likelihood of accidents. Research by Guo et al. shows that effective safety leadership correlates with lower accident rates in construction [8]. At SMA Negeri 2 Kuta Utara, leadership could have improved safety outcomes by fostering a stronger safety culture and ensuring that all safety protocols were strictly adhered to throughout construction [9].

The financial impact of inadequate safety management cannot be ignored. Bernal et al. highlight the economic consequences of workplace accidents, which can lead to delays, legal liabilities, and increased project costs [10]. Avoiding accidents safeguards workers' well-being and also helps maintain project timelines and cost efficiency. This reinforces the need for integrating OSH protocols into every phase of the construction process, from planning to execution [11].

In conclusion, the construction of SMA Negeri 2 Kuta Utara underscores the importance of OSH management in school infrastructure projects. The incidents that occurred during the project's execution could have been avoided with better safety planning, stronger leadership, and the use of modern safety technologies. As future construction projects continue to expand, especially in educational sectors, it is crucial to adopt a proactive approach to safety management to protect both workers and the overall success of the project [12].

2. Literature Review

Occupational Safety and Health (OSH) is a critical component of construction project management, particularly due to the persistently high rates of workplace accidents in the sector. Bourahla et. al (2024) [1] conducted a systematic literature review, which revealed that major contributing factors to construction accidents include inadequate safety training, lack of access to proper personal protective equipment (PPE), and poor integration of OSH practices into project management systems. They emphasise that the implementation of comprehensive OSH strategies such as regular training programs, safety inspections, and a strong safety culture can significantly reduce accident rates and simultaneously enhance overall project performance.

In parallel, Obasi and Benson (2025) [13] explore how the advent of Industry 4.0 technologies, including Artificial Intelligence (AI), the Internet of Things (IoT), and Cyber Physical Systems (CPS), introduces both opportunities and challenges for OSH management. These technologies support proactive safety measures such as real-time hazard monitoring and predictive maintenance. However, the authors also caution about emerging risks such as technostress, data privacy concerns, and regulatory gaps that may hinder safe implementation. While much of the current literature focuses on OSH in large-scale industrial or commercial environments, both studies highlight the lack of focused research on OSH practices in public infrastructure projects, particularly educational facilities. Addressing this gap is essential for ensuring the safety of school construction projects, which have direct implications for community well-being and long-term social sustainability.

3. Materials and Methods

Occupational Health and Safety (OSH) is a field that plays a crucial role in every workplace, aiming to protect workers and employees from potential hazards and risks that may occur during work activities [14]. This study will be conducted on the SMA Negeri 2 Kuta Utara construction project, located at Gunung Sari Street No. 100, Kerobokan Kaja, Kuta Utara District, Badung Regency, Bali, carried out by PT. Tuna Jaya Nusantara. The survey will take place from October to November 2023. During this study, both primary and secondary data will be collected through interviews, questionnaires, and project data [15].

All participants involved in interviews and questionnaires were informed about the purpose of the research and gave their informed consent voluntarily. Participation was entirely optional, and respondents had the right to withdraw at any time without any consequences. We also ensured confidentiality by anonymizing responses and securely storing all data. No physical or psychological harm was posed to any participant during data collection, and the research adhered to general ethical standards for human subject research.

The methodology used for risk identification, assessment, and control is the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method, which is essential for ensuring a safe working environment [16]. The primary objective of Occupational Health and Safety (OSH) is to ensure the health, safety, and welfare of workers and employees while reducing the risks of injury and illness in the workplace [17]. This case study focuses on the SMA Negeri 2 Kuta Utara construction project. While several studies have utilized risk analysis methods such as HAZOP, HIRARC, and survey methods (questionnaires), there has been no specific study applying the AS/NZS 4360:2004 framework in the context of OSH risk management in construction projects like this one [18]. The AS/NZS 4360:2004 framework offers a systematic approach to identifying, assessing, and controlling OSH risks in a structured manner [19].

The goals of this research are to:

1. Identify Occupational Health and Safety (OSH) risks in the construction project [20].
2. Assess the risk level related to Occupational Safety and Health (OSH) throughout the project [21].
3. Establish control measures for managing OSH hazards in the construction project [22].

4. Results and Discussion

In preparing this final assignment, both primary and secondary data were utilized. Secondary data were obtained through personal observations, while primary data were collected directly from the project. This involved analyzing general project data and gathering responses from 50 workers regarding the severity and frequency of job risks. These responses were essential to understanding the potential hazards faced by the workforce [23].

After collecting the questionnaire and project data, validity and reliability tests were conducted to determine the r table and r count values, allowing us to ascertain whether the job risk assessment was valid and reliable [24]. A robust validity test was performed using the Pearson Bivariate correlation method, facilitated by statistical analysis software such as SPSS. This approach enhances the accuracy of insights gained regarding the relationship between risk factors and incidents within the construction field, thus providing a foundation for better risk management strategies [25].

The validity test was executed based on calculations from the SPSS 24 program, applying Pearson's Bivariate correlation stages with a significance level of 5% (statistical confidence/accuracy level) [26]. The calculated r-value for each risk hazard variable exceeded the r-table value of 0.279, based on the responses of 50 participants.

This result indicates that the data collected in the survey are valid and can be reliably used for further analysis. Additionally, the reliability test in this study was conducted using SPSS 24. This test compared the Cronbach's Alpha value against the significance level/degree value to ensure consistency in the measurement instruments used in the risk assessment [27].

If the Cronbach's Alpha value is greater than the significance level, the instrument is deemed reliable. Conversely, if the Cronbach's Alpha value is less than the significance level, the instrument is considered unreliable [28]. The criteria for reliability testing are as follows: a Cronbach's Alpha value of 0.7 or higher indicates high reliability, whereas values below this threshold suggest that the instrument may need refinement [29]. Ensuring reliability and validity in risk assessments is crucial for providing accurate recommendations in the field of construction safety [30].

Table 1. Results of the questionnaire validity test: frequency level

Item	(r-count)	Significance level 5%	Information
Item 1	0.452	0.279	Correct
Item 2	0.466	0.279	Correct
Item 3	0.438	0.279	Correct
Item 4	0.404	0.279	Correct
Item 5	0.437	0.279	Correct
Item 6	0.38	0.279	Correct
Item 7	0.411	0.279	Correct
Item 8	0.413	0.279	Correct
Item 9	0.44	0.279	Correct
Item 10	0.44	0.279	Correct
Item 11	0.443	0.279	Correct
Item 12	0.417	0.279	Correct
Item 13	0.413	0.279	Correct
Item 14	0.471	0.279	Correct
Item 15	0.384	0.279	Correct
Item 16	0.392	0.279	Correct
Item 17	0.439	0.279	Correct
Item 18	0.408	0.279	Correct
Item 19	0.484	0.279	Correct
Item 20	0.424	0.279	Correct
Item 21	0.383	0.279	Correct
Item 22	0.499	0.279	Correct
Item 23	0.485	0.279	Correct
Item 24	0.495	0.279	Correct
Item 25	0.437	0.279	Correct

Source: Analysis results

Table 2. Results of the validity test of the severity/consequence questionnaire

Item	(r-count)	Significance level 5%	Information
Item 1	0.597	0.279	Correct
Item 2	0.636	0.279	Correct
Item 3	0.649	0.279	Correct
Item 4	0.533	0.279	Correct
Item 5	0.786	0.279	Correct
Item 6	0.716	0.279	Correct
Item 7	0.741	0.279	Correct
Item 8	0.741	0.279	Correct
Item 9	0.675	0.279	Correct

Item 10	0.533	0.279	Correct
Item 11	0.612	0.279	Correct
Item 12	0.676	0.279	Correct
Item 13	0.744	0.279	Correct
Item 14	0.569	0.279	Correct
Item 15	0.635	0.279	Correct
Item 16	0.561	0.279	Correct
Item 17	0.443	0.279	Correct
Item 18	0.413	0.279	Correct
Item 19	0.416	0.279	Correct
Item 20	0.428	0.279	Correct
Item 21	0.415	0.279	Correct
Item 22	0.415	0.279	Correct
Item 23	0.42	0.279	Correct
Item 24	0.415	0.279	Correct
Item 25	0.407	0.279	Correct

Source: Analysis results

Table 3. Reliability test: statistical reliability

Cronbach's Alpha	No items
0.810	25
Cronbach's Alpha	**No items**
0.911	25

Source: Analysis Results

Table 4. Risk assessment

No	Hazard Identification	Risk Assessment Level		
		Mode Value of Frequency Level (K)	Mode Value of Consequence/Severity Level (A)	***Risk Level***
A.	**Earthworks**			
X1	Landslide/side wall collapse	2	3	6
X2	Workers hit by work tools/materials	1	2	2
X3	Worker falls into the excavation	2	3	6
X4	Workers inhale dust/dirt	1	2	2
X5	Hit/struck by heavy equipment	1	3	3
B.	**Couple and Wall Work**			
X6	Hit by work tools/materials	1	2	2
X7	Respiratory disorders due to sand/cement dust	2	3	6
X8	Worker hit by rock/wall	1	4	4
X9	Stuck on a *scaffolding*	1	2	2
X10	Skin irritation due to frequent direct contact with cement	2	2	4
C.	**Steel Works**			
X11	Accidents due to lifting equipment/ *cranes*	1	5	5
X12	Accident due to the collapse of the scaffolding	2	4	8
X13	Steel material falls from heavy equipment during moving or lifting	1	3	3
X14	Exposed to heat while welding	3	2	6
X15	Sparks hit the skin	2	3	6
X16	Worker's eyes hurt when welding	2	3	6
X17	Grinding wheel is loose or broken	2	4	8
X18	Worker falls while installing formwork	2	4	8
X19	Formwork collapse	1	4	4
X20	Electric shock due to exposed vibrator cable or surrounding electrical	2	4	8
X21	Leg pierced by reinforcement/iron	2	3	6
X22	Hit by a concrete mixer	2	4	8
X23	Irritation due to material spillage	2	2	4
X24	Impaled by a nail	2	3	6
X25	Injuries caused by vibrator use	2	2	4

Source: Analysis Results

Table 5. Risk level

No	Hazard Identification	Risk Level
A	**Earthworks**	
1	Landslide/side wall collapse	Medium Risk Level Classification
2	Workers hit by work tools/materials	Low Risk Level Classification
3	Worker falls into the excavation	Medium Risk Level Classification
4	Workers inhale dust/dirt	Low Risk Level Classification
5	Hit/struck by heavy equipment	Low Risk Level Classification
B.	**Couple and Wall Work**	
6	Hit by work tools/materials	Low Risk Level Classification
7	Respiratory disorders due to sand/cement dust	Medium Risk Level Classification
8	Worker hit by rock/wall	Low Risk Level Classification
9	Stuck on a *scaffolding*	Low Risk Level Classification
10	Skin irritation due to frequent direct contact with cement	Medium Risk Level Classification
C.	**Steel Works**	
11	Accidents due to lifting equipment/ cranes	Medium Risk Level Classification
12	Accident due to the collapse of the scaffolding	Medium Risk Level Classification
13	Steel material falls from heavy equipment during moving or lifting	Low Risk Level Classification
14	Exposed to heat while welding	Medium Risk Level Classification
15	Sparks hit the skin	Medium Risk Level Classification
16	Worker's eyes hurt when welding	Medium Risk Level Classification
17	Grinding wheel is loose or broken	Medium Risk Level Classification
D.	**Concrete Work**	
18	Worker falls while installing formwork	Medium Risk Level Classification
19	Formwork collapse	Low Risk Level Classification
20	Electric shock due to exposed vibrator cable or surrounding electrical	Medium Risk Level Classification
21	Leg pierced by reinforcement/iron	Medium Risk Level Classification
22	Hit by a concrete mixer	Medium Risk Level Classification
23	Irritation due to material spillage	Low Risk Level Classification
24	Impaled by a nail	Medium Risk Level Classification
25	Injuries caused by vibrator use	Low Risk Level Classification

Source: Analysis results

Tables 4 and 5 present the outcomes of a comprehensive risk evaluation for various hazards identified in different types of construction work, including earthworks, concrete and wall work, steel works, and concrete work. The risk assessment process involves evaluating each hazard based on two key parameters: the frequency level (K) and the consequence/severity level (A). By calculating the mode values for each, the overall risk level is derived. For example, in earthworks, hazards such as "landslide/side wall collapse" (X1) and "worker falls into excavation" (X3) are categorized with a medium risk level, given their frequency and severity values of 2 and 3, leading to a risk score of 6. In contrast, risks such as "workers hit by tools/materials" (X2) or "inhaling dust" (X4) are classified as low risk with lower values of frequency and severity.

In the couple and wall work section, hazards like "respiratory disorders due to sand/cement dust" (X7) are considered medium risk, while other hazards like "being hit by tools" (X6) fall into the low-risk category. Similarly, steel works demonstrate some higher risk activities, such as "collapse of scaffolding" (X12) and "grinding wheel loose or broken" (X17), both classified as medium risk. Finally, in concrete work, hazards such as "worker falls while installing formwork" (X18) and "electric shock from exposed vibrator cables" (X20) are also medium risks, reflecting the relatively higher danger inherent in those tasks.

The classification system in Table 5 shows that medium-risk activities often involve tasks where the consequences of an incident could be severe, even if the likelihood of occurrence is not extremely high. Conversely, low-risk tasks generally involve less severe outcomes or happen with less frequency, thereby requiring less immediate mitigation [31].

The comprehensive assessment allows for a structured approach to managing risks on construction sites, focusing resources on mitigating the most significant hazards to ensure worker safety [32].

In earthworks, hazards like landslides or wall collapses pose medium risks due to the possible catastrophic consequences of such incidents, even if their frequency is moderate [33]. These risks can be reduced by proper site inspections and adherence to safety guidelines. Similarly, respiratory issues caused by exposure to dust and cement particles during wall work represent a medium risk [34]. This can be mitigated by using dust suppression systems and ensuring workers wear adequate respiratory protection [35].

Moreover, the risk assessment emphasizes the need for continuous monitoring of potential hazards to prevent accidents [36] proactively. Studies have shown that integrating real-time data collection and risk prediction technologies can enhance construction safety [37]. This proactive approach, combined with worker training programs, is vital in maintaining safety and reducing incident rates on construction sites.

This research adds to the current body of literature on Occupational Safety and Health (OSH) risk management by offering a structured and task-specific approach that combines the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method with the AS/NZS 4360:2004 risk management framework. While many previous studies have applied general risk analysis techniques in construction, few have focused specifically on educational infrastructure projects, particularly in developing countries. By applying this integrated method to the construction project of SMA Negeri 2 Kuta Utara, the study provides more granular insights into hazard types, risk levels, and appropriate control measures tailored to each construction activity.

This enhances the practical relevance of risk assessments and addresses a gap in the literature where school-based construction safety has been underexplored. The findings are expected to inform policymakers, contractors, and safety practitioners in developing more effective and context-specific safety strategies for similar infrastructure projects.

This study significantly advances previous construction risk assessment research by providing a more detailed and actionable framework, identifying 25 specific hazards across four key work types (earthworks, masonry, steelwork, and concrete) using mode-based risk scoring (Frequency × Severity), which reveals that 56% of activities are categorized as medium risk compared to earlier studies that often relied on generic classifications. Unlike traditional qualitative approaches, the empirical methodology employed quantifies risks with precision, highlighting critical high-consequence hazards such as scaffolding collapse (Risk = 8) and electric shock (Risk = 8), while also detecting frequently overlooked medium risks such as cement dust exposure (Risk = 6). Importantly, the study bridges a key gap by linking each identified hazard to specific control measures, such as slope stabilization for landslide prevention and the application of PPE in ensuring safety for dust mitigation.

5. Conclusion

Based on the research results, 25 hazard identifications were found from 4 types of work: earthworks, masonry and wall work, steel work, and concrete work. In earthworks, 5 hazards were identified: landslides/collapse of side walls, workers being hit by tools/materials, workers falling into excavations, workers inhaling dust/dirt, and being struck by heavy equipment. In masonry and wall work, 5 hazards were identified: being hit by tools/materials, respiratory issues due to sand/cement dust, workers being struck by rocks/walls, being trapped by scaffolding, and skin irritation from frequent direct contact with cement. In steel work, 7 hazards were identified: accidents involving lifting equipment/cranes, accidents from collapsed scaffolding, steel materials falling from heavy equipment during lifting or moving, exposure to heat during welding, skin being exposed to sparks, eye irritation during welding, and grinding wheels detaching or breaking. In concrete work, 8 hazards were identified: workers falling while installing formwork, formwork collapsing, electric shocks, feet being pierced by reinforcement/iron, being struck by concrete mixers, irritation from spilt material, being pierced by nails, and injuries from using vibrators.

The risk level assessment in the field of Occupational Health and Safety (OSH) for the SMA N 2 Kuta Utara construction project found that 44% of the activities were classified as low risk, 56% were classified as medium risk, and 0% were classified as high risk. If a machine learning based risk prediction method were applied, the risk levels could be predicted more accurately, making OSH management more effective. This aligns with the findings of Zhang et al. [4], which demonstrate that using risk prediction technology can reduce incidents by up to 30%. These findings are expected to serve as a reference for improving OSH practices in similar construction projects. In the SMA N 2 Kuta Utara School construction project, efforts were made to control OSH risks by avoiding work in areas that are prone to various risks. This can be done by avoiding work in landslide-prone areas, choosing safe construction locations, implementing alternative construction techniques to reduce the risk of landslides, selecting more stable and safe construction materials or techniques, installing appropriate barriers or support systems, taking preventive measures to manage risks, and ensuring that workers are equipped with personal protective equipment suited to the risks faced. For masonry and wall work, safety measures comprised the application of PPE and engineering controls. For steel work, control measures included administrative controls, PPE, and engineering controls. For concrete work, control measures included administrative controls, PPE, and engineering controls.

Future research can explore several promising directions. First, developing AI-based risk prediction models capable of processing real-time IoT sensor data for early warnings. Second, investigating the integration of BIM with wearable technologies like smart helmets to monitor worker conditions. Third, examining behavioral factors in OHS, including evaluating the effectiveness of VR-based training programs. Fourth, conducting comparative studies across various construction project types to generalize the findings more broadly. This study provides practical contributions through risk management guidelines and paves the way for digital transformation in construction OHS through advanced technologies. Additionally, it offers a framework for developing more adaptive, data-driven safety protocols. These findings are expected to serve as a foundation for creating safer and more efficient construction environments in the future.

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