

Hazard Identification and Occupational Risk Mapping in Asphalt Paving Work on the Main Access Road to the Rongi Micro Hydro Power Plant, Sampolawa District

La Sianto¹, Sonya Zahir²

^{1,2}Civil Engineering Study Program, Faculty of Engineering, Universitas Muhammadiyah Buton, Baubau, Indonesia

Corresponding Author: La Sianto, E-Mail: siantho.civil07@gmail.com

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ABSTRACT

The study purpose was to identify occupational hazards, assess risk levels, and formulate appropriate risk control measures in asphalt paving activities on the main access road to the Rongi Micro Hydro Power Plant (PLTMH), Sampolawa District. Asphalt paving work involves high-risk construction activities due to the use of heavy equipment, exposure to hot asphalt materials, interaction with traffic, and environmental conditions such as sloped terrain and high rainfall. These conditions require systematic Occupational Health and Safety (OHS) management to prevent work accidents and improve safety performance. **Materials and methods:** This study employed a qualitative descriptive approach using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. Data were collected through field observations, interviews with workers and supervisors, documentation, and literature review. Risk levels were determined using a semi-quantitative risk matrix by assigning numerical values to likelihood and severity, and calculating the risk score to classify hazards into risk categories. **Results:** The study identified 50 potential hazards across eight stages of asphalt paving activities, consisting of 16 high-risk hazards and 34 medium-risk hazards. High-risk hazards were mainly associated with heavy equipment operation, hot asphalt exposure, chemical substances, traffic interaction, and worker fatigue. Environmental factors also contributed significantly to the occurrence of occupational hazards. These findings indicate that asphalt paving activities require strict safety management and priority control measures. **Conclusions:** Asphalt paving work on the PLTMH Rongi access road presents significant occupational safety risks that must be managed through systematic hazard identification, risk assessment, and risk control. The implementation of engineering controls, administrative measures, and proper use of personal protective equipment is essential to reduce accident potential and improve construction safety performance.

Keywords: Occupational Health and Safety, Hazard Identification, Risk Assessment, Asphalt Paving, HIRARC

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INTRODUCTION

Road infrastructure development plays a vital role in supporting regional connectivity, economic activities, and the sustainability of strategic infrastructure facilities (B et al., 2024; Efendi & Budiman, 2022). One form of such development is road asphalt paving, which aims to improve road quality, safety, and accessibility. Nevertheless, asphalt paving is classified as a high-risk construction activity due to the involvement of heavy equipment, high-temperature materials such as hot asphalt, and intensive interaction between workers, equipment, and the surrounding environment. These conditions require serious attention to Occupational Health and Safety (OHS) implementation to prevent work accidents and occupational diseases. The asphalt paving of the main access road to the Rongi Micro-Hydro Power Plant (PLTMH) in Sampolawa District has strategic importance, as the road serves as the primary transportation route for local communities as well as for PLTMH operational activities. The project is carried out under challenging geographical conditions, including hilly terrain, sloping road alignment, limited working space, and a tropical climate with high rainfall intensity. Such characteristics significantly increase safety risks during construction activities and demand a systematic and preventive approach to OHS management.

In asphalt paving works, various potential hazards may arise, including workers being struck or crushed by heavy equipment, burns caused by contact with hot asphalt, respiratory disorders due to dust and asphalt fumes, fatigue-related incidents, and traffic accidents involving construction vehicles and public road users. If these hazards are not properly identified and controlled, they can lead to occupational injuries, health problems, project delays, financial losses, and safety risks for surrounding communities. In practice, the absence of structured hazard identification and risk mapping often causes OHS control measures to be reactive rather than preventive, thereby increasing the likelihood of work accidents. Considering these conditions, this research is urgently needed to provide a comprehensive understanding of occupational safety and health risks in asphalt paving activities, particularly in projects located in geographically constrained and high-risk environments. The importance of the PLTMH Rongi access road further emphasizes the need for effective OHS implementation, as safety failures during construction may disrupt project completion and reduce the long-term benefits of the infrastructure. A scientific and systematic assessment of risks is therefore essential to support safer and more sustainable project execution.

The primary objective of this study is to identify potential occupational hazards and analyze OHS risks at each stage of the asphalt paving work on the main access road to PLTMH Rongi in Sampolawa District. In addition, this study aims to develop OHS risk mapping based on the likelihood and severity of potential hazards, which can serve as a basis for formulating appropriate and effective risk control measures. Through this approach, the study seeks to minimize occupational accidents, reduce health risks, and enhance overall worker safety during the paving process. The novelty of this research lies in its specific focus on OHS risk identification and mapping for asphalt paving works supporting renewable energy infrastructure, particularly micro-hydropower facilities, in areas with challenging geographical and environmental conditions. This study integrates field-specific characteristics such as limited working space, continuous exposure to hot materials, and intensive interaction between workers and heavy equipment into a structured analysis using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach combined with a risk matrix. By presenting a systematic and stage-based OHS risk mapping, this research is expected to contribute both practically and scientifically as a reference for improving OHS implementation in similar high risk road construction projects that support sustainable infrastructure development.

The risk assessment stage in this study was conducted using a risk analysis matrix that combines the likelihood of hazard occurrence and the severity of its consequences. The matrix illustrates the relationship between probability and impact in determining risk levels, ranging from minor to severe risks. This framework serves as the basis for evaluating occupational safety and health risks in asphalt paving activities on the main access road to PLTMH Rongi. The resulting risk levels were then used to prioritize risk control measures in accordance with the HIRARC approach.

		Consequences				
		Insignificant Any injury or disease that needs first-aid treatment only. 1	Minor Any injury or disease requiring medical treatment and/or that is likely to result in a person being incapacitated from normal activity for a continuous period of up to 7 days. 2	Moderate Any injury or disease that is likely to result in a person being incapacitated from normal activity for a continuous period of 7 or more days. 3	Major A fatality or total and permanent disability. 4	Catastrophic Multiple fatalities. 5
Likelihood	Almost Certain The event is expected to occur in most circumstances.	1				
	Likely The event will probably occur in most circumstances.	2				
	Moderate Given time, likely to occur.	3				
	Unlikely More likely not to occur under normal conditions.	4				
	Rare The event may occur only in exceptional circumstances.	5				

Once you have determined above the likely Consequences Ratings for the identified risks refer to the Risk Analysis Matrix to determine the overall Risk Rating for the identified Risk. The higher the Risk Rating the more immediate and higher level attention is required.

Severe Risk	Discontinue operation and / or immediate corrective action required.
Significant Risk	Corrective action needed. Action in short term as appropriate.
Moderate Risk	Attention indicated.
Minor Risk	Implement practicable short-medium term control measures.

Figure 1. Risk Assessment Matrix Based on Likelihood and Severity

METHOD

This study employed a qualitative descriptive approach with a case study design to analyze Occupational Health and Safety (OHS) risks in asphalt paving work. The research was conducted on the main access road asphalt paving project to the Rongi Micro Hydro Power Plant (PLTMH), located in Rongi Village, Sampolawa District. The research population consisted of all work activities involved in the asphalt paving process on the PLTMH Rongi access road. The research sample was determined using purposive sampling, focusing on workers directly involved in asphalt paving activities, including heavy equipment operators, field workers, foremen, and OHS supervisors. This sampling technique was chosen to ensure that data were obtained from respondents with direct exposure to occupational hazards at the project site. Data collection was conducted using multiple techniques to ensure data validity and completeness. Field observations were carried out to directly identify work activities, equipment usage, and potential hazards at each stage of asphalt paving. Semi-structured interviews were conducted with workers, foremen, and OHS personnel to obtain information regarding accident experiences, safety constraints, and OHS implementation practices. Documentation was collected in the form of photographs, OHS reports, and records of work-related incidents when available. In addition, a literature review was conducted using journals, books, and regulations related to occupational health and safety in road construction projects.

The main variables analyzed in this study included hazard identification, risk assessment, and risk mapping. Hazard identification covered all potential hazards present during asphalt paving activities. Risk assessment was based on the likelihood of occurrence and severity of impact, while risk mapping categorized risks into medium and high levels to determine priority control areas. Data analysis was performed using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. The analysis stages included hazard identification at each work phase land preparation, material transportation, asphalt spraying, hot mix paving, compaction, and traffic management followed by risk assessment using a risk matrix to calculate risk levels. The results were then visualized through risk mapping to identify high-risk work areas requiring immediate control measures.

FINDING AND DISCUSSION

Overview of the Study Area

The research was conducted at the asphalt paving project of the main access road to the Rongi Micro-Hydro Power Plant (PLTMH), located in Rongi Village, Sampolawa District, South Buton Regency, Southeast Sulawesi Province. This road serves as a vital transportation link for surrounding villages and supports operational activities of the PLTMH facility. The study area is characterized by hilly topography with winding road alignments, which increases construction complexity and occupational safety risks.

The tropical climate with relatively high rainfall intensity further influences construction activities, particularly during asphalt paving operations. Prior to the project, the road consisted of unpaved and rocky surfaces, making it difficult to access during the rainy season. The asphalt paving work involved several construction stages, including land clearing, subgrade leveling, base course installation, hot mix asphalt paving, compaction, and final cleaning. These conditions highlight the importance of implementing comprehensive Occupational Health and Safety (OHS) measures throughout the project.

Hazard Identification in Asphalt Paving Activities

Hazard identification was carried out through direct field observation and interviews with workers involved in each stage of asphalt paving activities. The results indicate that potential hazards were present at all stages of work, originating from heavy equipment operations, unstable ground conditions, exposure to hot asphalt materials, chemical substances, traffic interaction, and environmental factors such as dust, noise, and extreme weather.

Hazards identified ranged from minor injuries, such as cuts and slips, to severe risks including heavy equipment collisions, burns due to hot asphalt, and fire or explosion hazards. The

distribution of hazards across all work stages indicates that asphalt paving activities present continuous safety challenges that require systematic risk management.

Table 1. Hazard Identification in Asphalt Paving Activities

No	Work Stage	Hazard Source	Identified Hazard
1	Land clearing and preparation	Vegetation, debris, dust, weather	Cuts, slips, respiratory irritation
2	Subgrade leveling and compaction	Unstable soil, traffic, heavy equipment	Collision, slipping, equipment accidents
3	Base course installation	Aggregate materials, noise	Falling objects, hearing disorders
4	Upper base layer spreading (LPA)	Heavy equipment, hot materials	Crushing injuries, burns
5	Prime coat & tack coat spraying	Asphalt fumes, chemicals	Respiratory irritation, fire hazards
6	Hot mix asphalt paving	Hot asphalt, heavy equipment	Burns, heat stress, collisions
7	Asphalt compaction	Vibrations, fatigue, rollers	Musculoskeletal injuries, fatal accidents
8	Final cleaning and finishing	Residual materials, tools	Slips, cuts, chemical exposure

To provide a clearer overview of the dominant sources of hazards identified during asphalt paving activities, the distribution of occupational hazard sources is presented in Figure 3.

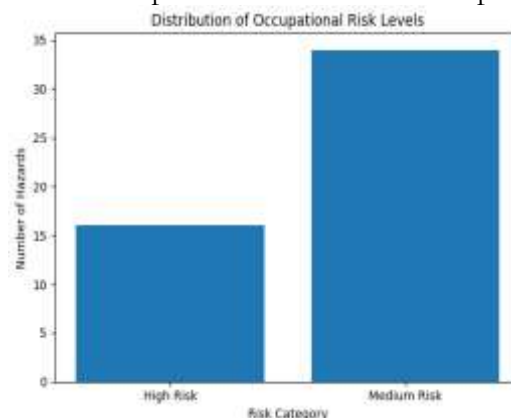


Figure 2. Dominant Sources of Occupational Hazards

Risk Assessment Results

After hazard identification, a risk assessment was conducted using a semi-quantitative method by assigning numerical values to likelihood (L) and severity (S). The risk level was calculated using the formula $R = L \times S$ and classified into medium and high-risk categories.

The assessment results show that asphalt paving activities contain a significant number of high-risk hazards, particularly in work stages involving heavy equipment operation, hot asphalt handling, and interaction with external traffic and weather conditions. These high-risk hazards have the potential to cause severe injuries or fatal accidents if not properly controlled.

Table 2. Risk Assessment Results Using Risk Matrix

No	Work Stage	Identified Hazard	L	S	Risk Score	Category
1	Land clearing	Heavy equipment collision	2	5	10	High
2	Subgrade compaction	Traffic accident	2	5	10	High
3	Base course installation	Noise exposure	3	3	9	High
4	LPA spreading	Hot asphalt contact	3	3	9	High

No	Work Stage	Identified Hazard	L	S	Risk Score	Category
5	Prime coat spraying	Fire and explosion	2	5	10	High
6	Hot mix paving	Asphalt burns	3	3	9	High
7	Asphalt compaction	Worker fatigue	3	3	9	High
8	Final cleaning	Chemical exposure	3	3	9	High

The risk assessment findings in Table 2 indicate the presence of significant high-risk hazards across multiple work stages. To highlight the distribution of these risk levels, Figure 4 presents a graphical representation of occupational risk categories identified in the study.

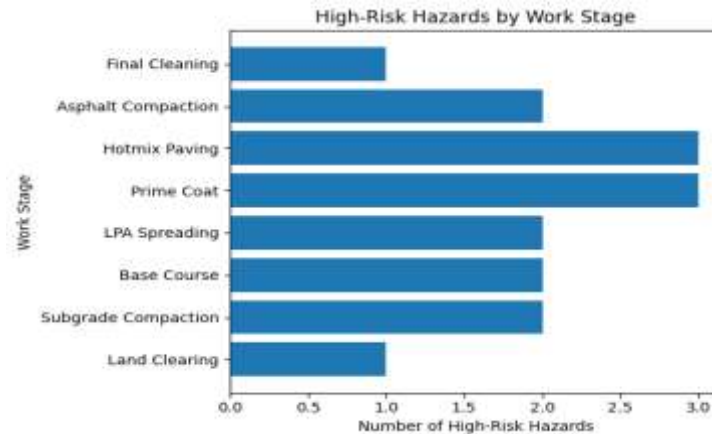


Figure 3. Distribution of Occupational Risk Levels

Risk Control Measures and Discussion

Based on the risk assessment results, risk control measures were formulated using the hierarchy of controls, including engineering controls, administrative controls, and the use of personal protective equipment (PPE). High-risk hazards were prioritized for immediate control due to their potential for severe or fatal consequences.

Engineering controls included the establishment of safety zones around heavy equipment operations, installation of warning signs and physical barriers, and proper traffic management systems. Administrative controls focused on regulating working hours, implementing standard operating procedures, conducting safety briefings, and ensuring operator certification. PPE usage, such as helmets, safety shoes, reflective vests, heat-resistant gloves, respirators, and protective clothing, was mandatory across all work stages.

Table 3. Risk Control Measures Based on Hazard Type

Work Stage	High-Risk Hazard	Risk Control Measures
Land clearing	Heavy equipment collision	Certified operators, safety zoning
Subgrade compaction	Traffic accident	Traffic controllers, warning signs
Base course installation	Noise exposure	Hearing protection, work rotation
LPA spreading	Equipment collision	Restricted zones, clear communication
Prime coat spraying	Fire and explosion	Fire extinguishers, SOP for chemicals
Hot mix paving	Burns and heat stress	Thermal PPE, work-rest scheduling
Asphalt compaction	Fatigue and vibration	Shift rotation, ergonomic controls
Final cleaning	Chemical exposure	PPE usage, site housekeeping

Considering that risk control efforts must prioritize the most hazardous activities, Figure 5 presents the distribution of high-risk hazards across asphalt paving work stages as a basis for determining targeted control strategies.

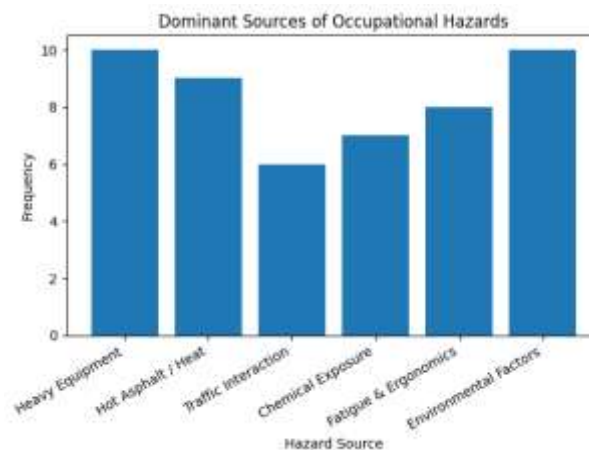


Figure 4. High-Risk Hazards by Work Stage

Discussion

The results of this study indicate that asphalt paving activities on the main access road to the Micro Hydro Power Plant (PLTMH) Rongi involve a complex range of occupational hazards and present a relatively high level of occupational safety risk. This condition is influenced by the use of heavy equipment, exposure to high temperatures from hot asphalt, road conditions that tend to be sloped and slippery, and environmental factors such as weather and surrounding terrain. These characteristics make occupational health and safety (OHS) management a critical aspect in ensuring safe construction activities (Olsen, 2021; Noroozi, 2023; Hao, 2024). Hazard identification results show that potential hazards exist at every stage of the asphalt paving process, starting from land clearing, subgrade compaction, base course installation, asphalt spreading, compaction, and final cleaning. The hazards identified include being struck by materials, slipping due to uneven surfaces, exposure to dust and noise, contact with hot asphalt, chemical exposure, and the risk of accidents involving heavy equipment. These hazards may lead to minor injuries, serious injuries, and even fatal accidents, as well as reduced worker productivity if not properly controlled (Dewantari, 2022; Kabul, 2022; Leonardo, 2022).

The risk assessment results further demonstrate that a significant proportion of hazards fall into moderate and high-risk categories. High-risk hazards are generally concentrated in activities involving heavy equipment operation, prime coat spraying, hot mix asphalt paving, and interaction with external traffic. These activities involve not only physical hazards but also chemical and ergonomic risks, which have the potential to cause severe injuries or fatal accidents (Burhanudin, 2024; Adrian, 2025; Permana, 2025). The graphical visualization of risk distribution reinforces that these risks are systemic and inherent in the construction process rather than isolated incidents. Environmental conditions, such as tropical climate, high rainfall intensity, and sloped terrain, also contribute significantly to the occurrence of occupational hazards. These factors increase the likelihood of slipping, equipment instability, and work delays that may affect overall safety performance. Therefore, safety management strategies must consider both operational and environmental aspects simultaneously to ensure effective risk mitigation (Anggraeni, 2023; Manurung, 2025). Although medium-risk hazards were more frequent, their cumulative impact should not be underestimated. Minor incidents such as slips, cuts, respiratory irritation, and fatigue-related injuries can significantly affect worker productivity and may escalate into more severe accidents if safety practices are neglected.

This finding highlights the importance of preventive safety measures, including consistent housekeeping practices, proper use of personal protective equipment (PPE), and continuous safety supervision (Magda, 2023; Putra, 2019). The distribution of high-risk hazards across work stages

provides important insight into priority areas for risk control. The concentration of risks in heavy equipment operations, hot asphalt handling, and traffic interaction indicates that engineering and administrative controls must be strengthened in these stages. This supports the application of the hierarchy of controls, where engineering controls and administrative measures should be prioritized before relying solely on PPE (Ahmad, 2016; Mahendra, 2025). Risk control measures implemented in this project include the use of PPE, installation of warning signs, safety zoning, traffic management, operator certification, and work scheduling. Engineering controls are aimed at reducing direct exposure to hazards, while administrative controls focus on improving work behavior and safety awareness among workers. PPE serves as the final layer of protection to minimize injury severity when hazards cannot be fully eliminated (Angriani, 2025; Chong, 2024).

Overall, this study confirms that hazard identification, risk assessment, and risk control are interrelated processes that must be implemented systematically in construction projects. The absence of one component may increase the probability of accidents and reduce safety performance. Therefore, the implementation of an integrated OHS management system is essential to support safe asphalt paving operations, protect workers, and ensure the sustainability of infrastructure development activities, particularly in areas with complex environmental and operational conditions (Zuhriyah, 2025).

CONCLUSIONS

This study concludes that asphalt paving activities on the main access road to the Rongi Micro Hydro Power Plant (PLTMH) involve significant Occupational Health and Safety (OHS) risks at every stage of the construction process. Hazard identification results indicate that potential risks originate from heavy equipment operation, exposure to hot asphalt materials, chemical substances, traffic interaction, and environmental factors such as sloped terrain and high rainfall.

The risk assessment identified a total of 50 potential hazards, consisting of 16 high-risk hazards and 34 medium-risk hazards. High-risk hazards were primarily associated with heavy equipment activities, hot mix asphalt paving, prime coat spraying, and worker fatigue. These hazards have the potential to cause serious injuries or fatal accidents if not properly managed.

The implementation of risk control measures based on the hierarchy of controls engineering controls, administrative controls, and personal protective equipment proved essential in minimizing hazard exposure and improving workplace safety. Priority control actions should focus on high-risk work stages, particularly those involving heavy equipment and hot asphalt operations.

Overall, the integration of hazard identification, risk assessment, and risk control using the HIRARC approach provides an effective framework for improving OHS performance in asphalt paving projects. The findings of this study can serve as a reference for similar infrastructure projects, especially in areas with complex environmental and operational conditions, to reduce accident potential and ensure safer construction practices.

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