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Construction Safety Risk Distribution in a Phase 7B Haul Road Project Using the IBPR Method in South Kalimantan, Indonesia

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ABSTRACT: Haul road construction in mining environments involves heavy equipment operations, material transportation, earthworks, and variable ground conditions, all of which may expose workers to occupational safety hazards. This study aimed to assess the distribution of occupational safety risk levels during the Phase 7B haul road construction project at PT Karya Halim Sampoerna, South Kalimantan, Indonesia, using the Identifikasi Bahaya dan Pengendalian Risiko (IBPR; Hazard Identification and Risk Control) method. A descriptive risk assessment approach was employed, integrating qualitative hazard identification with quantitative risk classification. Eight construction activities were evaluated: subgrade compaction, Dynamic Cone Penetrometer (DCP) testing, base course material supply, base course compaction, sub-base layer material supply, sub-base layer compaction, drainage excavation, and safety berm construction. A total of 81 potential risks were identified and classified into three categories: medium (scores of 5–9), high (10–19), and critical (20–25). No risks were classified as low. High-risk cases accounted for the largest proportion (40 cases; 49.4%), followed by critical-risk cases (30; 37.0%) and medium-risk cases (11; 13.6%). Sub-base layer material supply exhibited the highest proportion of critical risks (10 of 14 cases; 71.4%), followed by base course material supply (6 of 9 cases; 66.7%). These findings highlight the need to prioritize safety assessments and risk control measures related to material transportation, equipment manoeuvring, unloading operations, equipment–worker interactions, excavation conditions, and safety berm design. However, the absence of the original individual hazard register, complete risk-scoring matrix, observation schedule, and post-control risk scores limits the independent reproducibility of the assessment. Consequently, the findings should be interpreted as aggregated risk classifications rather than independently verified risk scores. This study provides an activity-specific framework for prioritizing occupational safety interventions and identifies essential documentation requirements for improving the transparency, reproducibility, and validation of future risk assessments.

KEYWORDS: Occupational hazard assessment; heavy equipment; mining infrastructure; material transportation; risk matrix

1. Introduction

Haul roads are essential components of mining infrastructure, facilitating the transportation of materials, equipment, and personnel between operational areas. The construction and maintenance of haul roads involve various activities, including earthworks, subgrade preparation, pavement-layer placement, compaction, drainage excavation, and safety berm construction. These activities frequently occur under dynamic working conditions characterized by heavy equipment movements, changing terrain, and simultaneous construction operations. Consequently, workers may be exposed to occupational hazards such as vehicle collisions, equipment–worker interactions, unstable ground conditions, material displacement, dust exposure, excessive noise, and excavation-related accidents. Inadequate identification and management of these hazards may increase the likelihood of workplace incidents, operational disruptions, and potentially severe injuries. Therefore, systematic hazard identification and risk assessment are essential for identifying hazardous activities, evaluating potential consequences, and prioritizing preventive measures in mining infrastructure projects [1–5].

Powered haulage represents a significant occupational safety concern in mining operations because large vehicles frequently interact with ground personnel, construction machinery, and variable road conditions. Previous research has emphasized the importance of coordinated safety procedures, operator training, equipment management, and technological interventions in reducing powered-haulage risks [1]. Furthermore, the structural performance of safety berms is influenced by several engineering parameters, including berm geometry, material volume, vehicle mass, operating speed, and vehicle approach conditions [2]. These findings demonstrate that haul-road safety depends not only on vehicle operations but also on infrastructure design and construction practices. During haul-road construction, the simultaneous occurrence of material transportation, earthmoving, compaction, and excavation activities may introduce additional hazards that require systematic assessment.

Various occupational safety assessment methods have been developed and implemented in construction and mining environments, including risk ranking, Hazard Identification, Risk Assessment, and Risk Control (HIRARC), and Hazard Identification, Risk Assessment, and Determining Control (HIRADC) [3–5]. These approaches provide structured procedures for identifying potential hazards, estimating risk levels, and establishing appropriate control priorities. Previous studies have also demonstrated that construction safety performance is influenced by organizational factors, worker competence, supervision, equipment interactions, and changing site conditions [6–12]. In addition, reviews of occupational risk assessment methods and emerging safety technologies emphasize the importance of selecting assessment approaches that are consistent with available data, operational characteristics, and research objectives [10, 11]. Nevertheless, the practical application of these methods requires consideration of the specific activities and working conditions encountered at individual construction sites.

Several studies have investigated occupational safety risks associated with road and bridge construction, mining transportation systems, haul-road geometry, and infrastructure development [6–8, 13–21]. These investigations have contributed to understanding construction hazards, transportation-related risks, and the importance of systematic safety management. However, existing findings from routine mining haulage operations or conventional building construction may not fully represent the occupational hazards

encountered during active haul-road construction. Unlike routine haulage operations, haul-road construction involves continuously changing work fronts, temporary traffic arrangements, simultaneous equipment operations, and direct interactions between construction workers and heavy machinery. These operational differences may influence the distribution and severity of occupational safety risks across individual construction activities.

Despite the availability of established hazard identification and risk assessment methods, limited activity-specific evidence is presented in the literature considered here regarding how risk categories are distributed across different stages of haul-road construction. In particular, comparisons based solely on the number of identified hazards may provide an incomplete understanding of safety priorities because construction activities can differ in the total number of recorded risks. An activity with numerous identified risks does not necessarily have the highest proportion of critical risks. Therefore, evaluating both the frequency of recorded risks and the proportion assigned to each risk category is important for developing a more balanced interpretation of occupational safety priorities. This distinction represents a practical analytical gap that can be addressed using aggregated risk assessment data, even when detailed individual hazard records are unavailable.

To address this gap, the present study applies the *Identifikasi Bahaya dan Pengendalian Risiko* (IBPR; Hazard Identification and Risk Control) approach to examine occupational safety risk classifications during the Phase 7B haul-road construction project at PT Karya Halim Sampoerna, Tanah Bumbu Regency, South Kalimantan, Indonesia. The novelty of this study lies in its activity-level comparison of recorded risk frequencies and within-activity risk-category proportions across eight haul-road construction activities. Rather than relying exclusively on overall risk counts, the analysis distinguishes between the total number of recorded risks and the relative concentration of critical risks within each activity, providing an additional basis for identifying activities requiring priority safety review.

The objectives of this study are to: (i) determine the overall distribution of 81 recorded occupational safety risks across medium, high, and critical categories; (ii) compare risk-category frequencies and within-activity proportions across eight haul-road construction activities; and (iii) identify construction activities requiring priority consideration in subsequent safety assessments and risk control planning. The study adopts a descriptive risk assessment approach based on the available aggregated classifications. Because the original individual hazard register, complete scoring matrix, and post-control assessment records were unavailable, the analysis does not independently validate individual risk scores or evaluate the effectiveness of implemented control measures. Nevertheless, the findings provide an activity-specific evidence base for prioritizing occupational safety reviews and identifying documentation requirements for future risk assessment validation.

2. Materials and Methods

2.1. Study Area and Research Design.

This study was conducted in relation to the Phase 7B haul-road construction project at PT Karya Halim Sampoerna, Tanah Bumbu Regency, South Kalimantan, Indonesia. A descriptive risk assessment design was adopted, integrating qualitative hazard identification with quantitative risk classification. The approach involved identifying potential occupational hazards through reported field observations and discussions with relevant project personnel,

followed by descriptive analysis of risk-category frequencies and percentages. This methodological framework is consistent with established hazard identification and risk assessment practices in construction and mining environments [3–5, 10, 20].

The assessment covered eight construction activities: (1) subgrade compaction, (2) Dynamic Cone Penetrometer (DCP) testing, (3) base course material supply, (4) base course compaction, (5) sub-base layer material supply, (6) sub-base layer compaction, (7) drainage excavation, and (8) safety berm construction. These activities were selected based on their inclusion in the available project risk assessment dataset. However, the available documentation does not establish whether these activities encompass all operations undertaken during the entire construction project. Detailed technical information, including equipment specifications, haul-truck capacities, compactor types, excavation dimensions, traffic volumes, and geotechnical conditions, was unavailable and therefore was not incorporated into the analysis.

The geographical location of the project is presented in Figure 1. A verified site map should identify the project boundary or haul-road alignment, principal construction areas, geographical coordinates, a north arrow, and a scale bar. Site characteristics are particularly relevant to occupational safety because ground bearing capacity, road gradients, visibility, drainage conditions, and available manoeuvring space may influence exposure to equipment-related and excavation hazards [1, 2, 17–19].

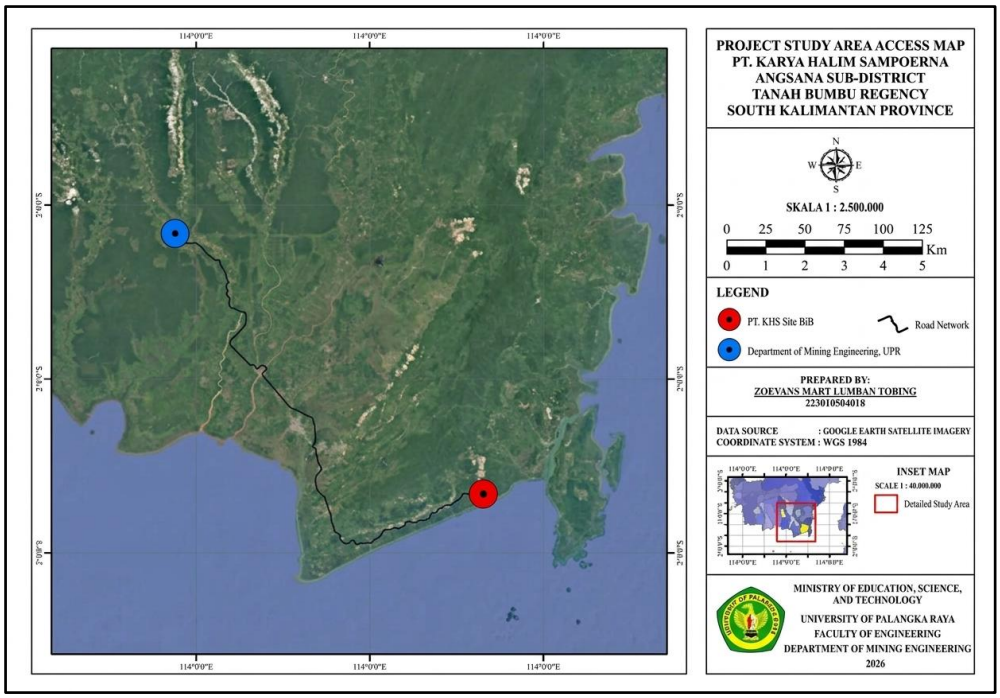


Figure 1. Location of the Phase 7B Haul Road Construction Project at PT Karya Halim Sampoerna, Tanah Bumbu Regency, South Kalimantan, Indonesia.

2.2. Data Collection.

Primary data were reportedly collected through field observations, discussions with project supervisors and quality control (QC) personnel, and a review of relevant project documentation. A purposive selection approach was used to involve supervisors and QC personnel familiar with construction activities, operational procedures, and prevailing site conditions. Field observations were intended to identify potential hazards associated with

equipment operations, material handling, worker movements, and environmental conditions, while discussions with project personnel provided additional contextual information regarding construction processes and potential safety concerns.

The documentation reviewed reportedly included company information and project-related records relevant to construction activities and occupational safety management. However, the available study materials did not specify the observation dates, total fieldwork duration, number of site visits, number of respondents, respondents' professional experience or qualifications, or the structured procedures used to identify and verify individual hazards. Consequently, these methodological details could not be independently confirmed.

For methodological transparency and reproducibility, the original field records should establish the fieldwork period, frequency and duration of site observations, number and professional characteristics of participants, types of documents and inspection checklists reviewed, and procedures used to verify identified hazards. Furthermore, the process through which likelihood and severity ratings were assigned should be clarified, including whether the ratings were determined through assessor consensus, independent evaluations, or verification by qualified occupational safety personnel. These considerations are important because risk classifications may be influenced by assessor judgement, differences in exposure assumptions, and variations in operational conditions [3,4,10,20]. No inter-rater reliability analysis or independent verification of the original hazard classifications was undertaken in the present analysis because the necessary supporting records were unavailable.

2.3. Hazard Identification and IBPR Risk Assessment.

The *Identifikasi Bahaya dan Pengendalian Risiko* (IBPR; Hazard Identification and Risk Control) method was employed in the original assessment to identify potential occupational hazards and classify their associated risks according to likelihood and severity. The available dataset comprised 81 recorded risk entries distributed across the eight construction activities. The assessment was organized at the activity level to facilitate comparisons of risk classifications and identify operations requiring greater attention in subsequent occupational safety evaluations.

In a comprehensive IBPR assessment, each construction activity should be systematically examined to identify the corresponding work steps, hazard sources, potential hazardous events, anticipated consequences, likelihood ratings, severity ratings, initial risk scores, existing control measures, additional recommended controls, and residual risk levels following control implementation. This activity-based approach is consistent with established occupational safety risk assessment practices in construction and mining operations [3–5,7,19,21].

The original assessment classified risks into four categories based on their numerical scores: low (1–4), medium (5–9), high (10–19), and critical (20–25). However, the complete 5 × 5 risk assessment matrix and the operational definitions associated with each likelihood and severity level were not available in the supplied documentation. Therefore, the mathematical procedure used to derive the original risk scores could not be independently verified. To avoid introducing unsupported assumptions, the present analysis retained the reported risk classifications without reconstructing individual likelihood ratings, severity ratings, or hazard-specific risk scores.

For greater transparency and reproducibility, the original risk assessment matrix should include clearly defined likelihood and severity criteria, corresponding scoring procedures, and

risk classification thresholds. Comprehensive documentation of all 81 identified risks, including their respective classifications and associated control measures, is essential for independently verifying the assessment results. The available aggregated risk classifications provide an overview of occupational safety risks across construction activities but do not allow independent verification of individual hazard scores.

The proposed risk control measures were developed based on the characteristics of the assessed construction activities and relevant occupational safety literature. These measures are intended as recommendations rather than controls confirmed to have been implemented or evaluated at the project site. The recommendations follow the hierarchy of controls, which prioritizes elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE), in descending order of preference [23,25].

2.4. Data Analysis.

Counts and within-activity percentages were used to summarize the distribution of risk categories. The percentage was calculated as $P = (n/N) \times 100\%$, where n is the number of risks in a specified category and N is the total number of recorded risks in the relevant activity or dataset. For the overall distribution, $N = 81$; for activity-level percentages, N is the total number of risks recorded for that activity. Percentages are descriptive and are not estimates of incident probability. Because the activities have different denominators (8–14 risks), comparisons of percentages are interpreted alongside the raw counts; small denominators can make proportions sensitive to a single classification [3–5, 10]. No inferential statistical test was performed.

3. Results and Discussion

3.1. Overall Distribution of Construction Safety Risks.

A total of 81 occupational safety risk entries were identified across the eight haul-road construction activities. As presented in Table 1, high-risk classifications accounted for the largest proportion, with 40 entries (49.4%), followed by critical-risk classifications with 30 entries (37.0%) and medium-risk classifications with 11 entries (13.6%). No risks were classified as low. Collectively, high and critical risks represented 70 entries (86.4%) of the total assessed risks, indicating a substantial concentration of recorded hazards in the upper risk categories.

The distribution presented in Table 1 suggests that several haul-road construction activities warrant particular attention in occupational safety planning and risk control prioritization. However, the relatively high proportion of risks classified as high or critical should not be interpreted as direct evidence of frequent workplace accidents or inadequate existing safety controls. Instead, these classifications represent the risk levels assigned during the original assessment, reflecting the estimated likelihood and severity of potential hazardous events. Similar construction and mining safety studies emphasize the importance of interpreting risk assessment results in relation to specific work activities, operating conditions, and the effectiveness of preventive measures [3–5, 7, 19].

Table 1. Distribution of assessed risks across Phase 7B haul road construction activities.

No.	Construction activity	Total	Low, n (%)	Medium, n (%)	High, n (%)	Critical, n (%)
1	Subgrade compaction	8	0 (0.0)	1 (12.5)	4 (50.0)	3 (37.5)
2	DCP testing	9	0 (0.0)	3 (33.3)	6 (66.7)	0 (0.0)
3	Base course supply	9	0 (0.0)	0 (0.0)	3 (33.3)	6 (66.7)
4	Base course compaction	10	0 (0.0)	4 (40.0)	6 (60.0)	0 (0.0)
5	Sub-base layer supply	14	0 (0.0)	1 (7.1)	3 (21.4)	10 (71.4)
6	Sub-base layer compaction	10	0 (0.0)	0 (0.0)	7 (70.0)	3 (30.0)
7	Drainage excavation	12	0 (0.0)	1 (8.3)	6 (50.0)	5 (41.7)
8	Safety berm construction	9	0 (0.0)	1 (11.1)	5 (55.6)	3 (33.3)
	Total	81	0 (0.0)	11 (13.6)	40 (49.4)	30 (37.0)

Note: Percentages are calculated using the total number of risks in each activity; overall percentages use 81 risks as the denominator.

3.2. Differences in Risk Distribution Across Activities.

Sub-base layer supply recorded both the largest number of entries (14) and the largest critical-risk proportion (10/14; 71.4%). Base course supply had six critical entries out of nine (66.7%). These two activities plausibly combine repeated heavy-vehicle movements, reversing, unloading, material displacement, and worker–vehicle interactions. Powered-haulage research identifies vehicle interaction and operational conditions as important safety concerns, while risk studies in mining emphasize traffic management and verification of critical controls [1 ,9, 19, 21]. However, the individual register is needed to determine which of these mechanisms were actually recorded and assigned the highest scores in this project.

The absolute count and percentage answer different questions. Sub-base supply has ten critical entries, the largest count, as well as the highest within-activity proportion. Base course supply has fewer total entries but a similarly high critical proportion. An activity with fewer identified risks can still require urgent attention if a large share is classified as critical or if a single credible event could cause fatal consequences. Conversely, percentages from activities with different denominators should not be interpreted as directly comparable measures of exposure or accident probability. The data represent counts of assessed risk entries, not normalized rates per worker-hour, vehicle movement, or task duration [3–5, 10].

Critical risks were also recorded in subgrade compaction, sub-base layer compaction, drainage excavation, and safety berm construction. DCP testing and base course compaction had no critical entries, but their high-risk proportions were 66.7% and 60.0%, respectively. Accordingly, the absence of a critical category does not justify treating these activities as low priority; work planning should consider the actual hazard mechanisms and controls as well as the matrix category [4, 5, 7].

3.3. Activity-Specific Interpretation and Control Priorities.

Eight risks were recorded: four high, three critical, and one medium. The relevant technical concern is interaction between compaction equipment and workers on a prepared but potentially variable ground surface. Uneven bearing conditions, restricted visibility, reversing, and overlapping work fronts can increase the likelihood of loss of control or struck-by events. Recommended priorities are pre-use inspections, designated equipment operating zones, separation of pedestrians and machinery, competent spotter use where visibility is restricted,

and dust/noise management. These are proposed measures, not controls verified as existing at the site [1, 3, 6, 22−25].

Six of nine entries were high and three medium. DCP testing typically places personnel near a test point while other construction activities may continue nearby. The risk depends on location selection, tool handling, visibility, and proximity to moving vehicles. Testing should be scheduled away from active traffic where practicable; otherwise, use a defined exclusion area, traffic control, warning signs, inspected equipment, and task-appropriate PPE. The available data do not support concluding that DCP testing is intrinsically safer than other activities; the reported category distribution is specific to this assessment [3–5, 13, 20].

Six of nine entries were critical, and the maximum reported score of 25 occurred in this activity. Delivery and unloading can expose workers to reversing vehicles, blind spots, unstable stopping positions, shifting loads, and uncontrolled access to the unloading area. Recommended controls include a traffic-management plan, designated one-way routes where feasible, engineered unloading areas, speed control, reliable operator–spotter communication, exclusion zones, and a stop-work rule for unsafe ground or visibility. Powered-haulage research supports prioritizing vehicle interaction and systematic operational controls [1, 9, 19, 21].

Four of ten entries were medium and six high, with no critical entries. The category distribution still indicates a need to manage compactor movement, vibration, visibility, surface conditions, and interactions with haul trucks or support equipment. Controls should include sequencing of equipment, separation distances, pre-start inspections, clear right-of-way rules, and communication between operators and ground personnel. Reassessment is necessary when the work front or ground condition changes [3–5, 10, 23, 25].

Ten of fourteen entries were critical, three high, and one medium; the maximum reported score of 25 occurred in this activity. This activity should receive the first detailed review of the original risk register because it combines the largest entry count with the highest critical proportion. Potential mechanisms include repeated delivery cycles, reversing, unloading, poor visibility, and interaction between vehicles and workers. The actual priority hazards must be confirmed from the original entries. Recommended controls are route separation, controlled unloading areas, surface inspection, spotters where needed, radio/visual communication, exclusion zones, and suspension of work when conditions are unsafe [1, 2, 9, 19, 21].

Seven of ten entries were high and three critical. The concentration of high and critical entries suggests that all recorded risks warrant review. Control priorities include maintaining a stable working platform, restricting access to operating equipment, sequencing compaction and delivery activities, checking equipment before use, and ensuring operators can see and communicate with ground personnel. The risk register should be revisited when compaction areas move or weather and surface conditions change [1, 3–5, 22].

Five of twelve entries were critical, six high, and one medium. Excavation creates potential exposure to ground instability, falling or rolling material, machine swing radius, vehicle approach, and changing water conditions. Recommended measures include pre-work assessment of soil and drainage conditions, locating underground services where relevant, barriers and safe access, keeping spoil and equipment away from edges as appropriate, competent-person inspections, and stopping work when cracking, sloughing, water accumulation, or other instability indicators appear. Excavation guidance emphasizes that

conditions can change and inspections should be repeated when hazards change [24]. These controls must be adapted to the actual depth, soil, geometry, and local legal requirements.

Three of nine entries were critical and five high. Berm work requires control of equipment movements and workers near the road edge, as well as verification of berm geometry and material stability. The presence of a berm alone does not demonstrate that it will restrain a vehicle. Full-scale and numerical studies show that performance depends on berm geometry, material volume and characteristics, vehicle mass, speed, and approach conditions [2,26]. The proposed control is to verify the design against applicable mine-road requirements, inspect berm continuity and material condition, keep personnel outside equipment operating zones, and document maintenance and acceptance checks.

3.4. Cross-Activity Comparison.

Figure 2 presents the counts of medium, high, and critical risks for all eight activities. The stacked bars show that sub-base layer supply is distinguished by a large critical segment, whereas base course supply has no medium entries and a two-thirds critical share. DCP testing and base course compaction are dominated by high entries rather than critical entries. This distinction helps avoid reading the figure as a simple ranking of total risk: the total bar height represents the number of entries, while each segment represents the count assigned to a category. The practical priority is to review sub-base supply first, followed by base course supply, while retaining targeted controls for drainage excavation and the other activities with critical classifications. The proposed priority order is a management interpretation of the aggregate counts and proportions, not a validated estimate of accident likelihood. Earlier construction risk-ranking research and recent mining HIRADC work similarly emphasize activity-level prioritization, but also highlight the value of detailed hazard records and critical-control verification [3–5, 19, 20, 21].

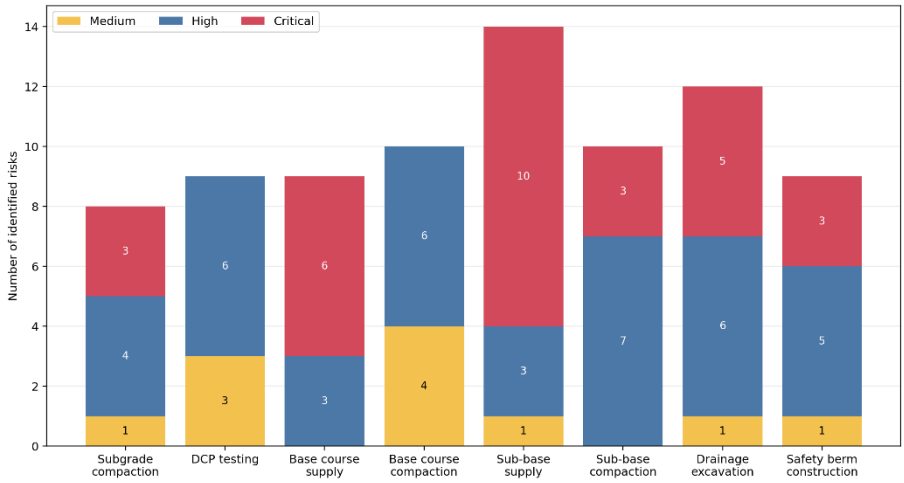


Figure 2. Distribution of Medium, High, and Critical Risks Across the Eight Haul Road Construction Activities.

3.5. Recommended Controls by Activity.

Table 2 summarizes proposed improvements using the hierarchy of controls. The supplied evidence does not document which controls were already in place; therefore, the table deliberately separates proposed controls from verified existing controls. Residual risk scores are not calculated because no evidence of implemented controls, revised likelihood/severity

scores, or post-control reassessment was supplied. The authors should populate the 'existing controls verified' and 'residual score' fields only after checking project records and reassessing the risks [23, 25].

Table 2. Proposed Improvements Using the Hierarchy of Controls.

Activity	Principal risk mechanisms to verify	Proposed controls (hierarchy-based)	Existing controls verified	Residual risk
Subgrade compaction	Equipment–worker collision; unstable surface; dust/noise	Engineering: physical separation/barriers where feasible. Administrative: equipment zones, pre-start checks, sequencing, spotter/communication. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
DCP testing	Exposure to traffic; tool handling; testing in active work zone	Eliminate exposure by scheduling outside traffic where possible. Engineering: barriers. Administrative: permit/traffic control, warning signs, inspected tool. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
Base course supply	Reversing vehicles; blind spots; unloading; unstable stopping area	Engineering: designated unloading pad and physical exclusion zone. Administrative: route plan, speed rules, spotter, radio/visual communication, stop-work trigger. PPE: high-visibility clothing and task-specific PPE.	Not documented in supplied records	Not calculated; reassess after implementation
Base course compaction	Compactor movement; interaction with trucks/workers; surface variability	Engineering: separate routes/work zones where feasible. Administrative: sequencing, pre-start inspection, access control, communication. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
Sub-base layer supply	Vehicle interaction; reversing; unloading; material movement	Engineering: safe unloading surface and separation. Administrative: traffic plan, designated routes, spotter, exclusion zone, communications, surface checks and stop-work rules. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
Sub-base layer compaction	Equipment–worker interaction; unstable work platform	Engineering: stable work platform and separation. Administrative: sequencing, equipment inspection, restricted access, communication and reassessment as work front moves. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
Drainage excavation	Ground collapse; falling material; machine swing; water accumulation	Eliminate entry where remote methods are feasible. Engineering: suitable slope/bench/shoring/protection based on conditions. Administrative: competent-person inspections, spoil setback, safe access, service locating, barriers, stop-work triggers. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation
Safety berm construction	Equipment near edge; inadequate berm geometry/material; worker exposure	Engineering: design/verify berm geometry and material for equipment and operating conditions. Administrative: inspection, maintenance, exclusion zone, speed/approach rules. PPE: task-specific.	Not documented in supplied records	Not calculated; reassess after implementation

The proposed controls should be treated as a planning checklist rather than proof of implementation. In line with the hierarchy of controls, elimination and engineering measures should be considered before relying on administrative procedures and PPE alone [23, 25]. For excavation, protective measures must reflect soil conditions, depth, geometry, water, adjacent loads, and applicable Indonesian requirements; generic recommendations cannot replace a competent site-specific assessment [24].

3.6. Limitations, Practical Implications, and Contribution.

This study provides an activity-level comparison of 81 aggregate risk entries in one haul-road construction project. Its practical contribution is to show why the total number of entries should be read together with the within-activity proportion classified as critical. Sub-base layer supply is notable on both measures; base course supply has a smaller denominator but a similarly high critical proportion. This can guide the order in which site managers review activity-specific risk registers, traffic arrangements, unloading zones, excavation controls, and berm design [1–5, 19, 21]. The findings have important limitations. The full 81-entry hazard register, individual hazard descriptions, likelihood and severity scores, matrix definitions, fieldwork dates, number of site visits, respondent details, and evidence of independent validation were not available in the materials supplied for revision. The geographical map and coordinates also require verification. Existing controls and post-control residual scores were not documented, and no accident or near-miss dataset was available for comparison. Consequently, this paper cannot establish inter-rater reliability, infer incident probability, calculate control effectiveness, or claim that the proposed controls reduced risk. The comparison is also affected by unequal activity denominators (8–14 entries). A higher percentage may reflect the way hazards were itemized as well as the severity of the activity; percentages are not exposure-normalized rates. Future studies should publish the full IBPR register, document the scoring matrix and assessor-validation process, record exposure measures such as task duration or vehicle movements where feasible, and reassess residual risk after verified control implementation. Repeated observations and critical-control audits would help determine whether risk profiles change as the construction front advances [10, 19–23].

4. Conclusions

The available IBPR dataset contains 81 potential risk entries across eight activities in the Phase 7B haul-road construction project. High risks accounted for 49.4%, critical risks for 37.0%, and medium risks for 13.6%; no low risks were reported. Sub-base layer supply had the highest critical-risk proportion (71.4%; 10/14), followed by base course supply (66.7%; 6/9). These activities warrant priority review, while drainage excavation and other activities with critical classifications also require targeted assessment.The main contribution is an activity-level comparison that distinguishes the total number of identified risks from the proportion classified as critical. The results should be used to prioritize review of the underlying risk register and site-specific controls, not as evidence of actual accident frequency or control effectiveness. Full reproducibility and stronger conclusions require the original likelihood–severity matrix, individual hazard records, fieldwork and respondent details, a verified location map, and residual-risk reassessment after controls are implemented.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Zoevans Mart L. Tobing: Conceptualization, methodology, investigation, data collection, formal analysis, and writing – original draft. Neny Sukmawatie: Supervision, methodology, validation, and writing – review and editing. Yusias Andrie: Investigation, data analysis, and visualization. Ferra Murati: Validation, interpretation of results, and writing – review and editing. Yossa Yonathan Hutajulu: Data curation, investigation, and writing – review and editing. All authors reviewed and approved the final version of the manuscript.

Competing Interest

No conflict of interest was reported by all authors.

Declaration of AI-Assisted Technologies

The authors used AI-assisted tools to improve the language, grammar, and readability of the manuscript. All AI-assisted content was critically reviewed and verified by the authors, who take full responsibility for the accuracy, originality, and integrity of the published work.

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