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Implementasi Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) pada Proyek Konstruksi: Studi Komparatif di Empat Lokasi di Sumatera

Implementation of Occupational Safety and Health Management Systems (OSHMS) in Construction: A Comparative Study of Four Sumatra Sites

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ABSTRACT

The Occupational Safety and Health Management System (OSH-MS) is a critical framework for promoting safe working environments, particularly within infrastructure construction projects characterized by high risk and extensive labor involvement. Despite its regulatory importance, OSH-MS implementation remains inconsistent across projects, influenced by managerial capacity, technical complexity, and contextual factors. This descriptive quantitative study evaluated the implementation of OSH-MS in four infrastructure projects: the LS Dam Project, the KAPB Toll Bridge Project, the Old Town (Kesawan) Project, and the Waste Drainage Project. The assessment was based on five OSH-MS principles policy establishment, planning, implementation, monitoring and evaluation, and performance review supported by twelve operational elements. Data were collected using structured checklists and compliance scoring, analyzed descriptively, and presented through tables and charts. The Old Town Project (93%) and KAPB Toll Bridge Project (87%) demonstrated strong OSH-MS implementation, classified as "good," while the LS Dam (71%) and Waste Drainage (73%) projects exhibited moderate compliance, categorized as "fair." Weaknesses were primarily found in document control, inspection procedures, and performance monitoring, particularly in larger, multi-contractor projects. The findings reveal uneven OSH-MS maturity across projects, emphasizing the need for stronger national and local policy enforcement, routine audits, and continuous workforce training. Consistent implementation of OSH-MS not only enhances safety and project efficiency but also supports worker health and contributes to Sustainable Development Goal 8 on decent work and economic growth.

Keywords : *construction, safety, health, waste drainage, bridge, dam.*

ABSTRAK

Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) merupakan kerangka penting dalam menciptakan lingkungan kerja yang aman, khususnya pada proyek konstruksi infrastruktur yang memiliki tingkat risiko tinggi dan melibatkan tenaga kerja dalam jumlah besar. Meskipun penerapan SMK3 telah diatur secara nasional, implementasinya masih bervariasi antar proyek, dipengaruhi oleh kapasitas manajemen, kompleksitas teknis, serta faktor kontekstual di lapangan. Penelitian ini merupakan studi deskriptif kuantitatif yang bertujuan mengevaluasi tingkat penerapan SMK3 pada empat proyek infrastruktur, yaitu Proyek Bendungan LS, Proyek Jembatan Tol KAPB, Proyek Kota Lama Kesawan, dan Proyek Drainase Limbah. Penilaian dilakukan berdasarkan lima prinsip utama SMK3 perumusan kebijakan, perencanaan, pelaksanaan, pemantauan dan evaluasi, serta tinjauan kinerja yang diperkuat dengan dua belas elemen operasional. Data dikumpulkan menggunakan daftar periksa terstruktur dan sistem penilaian kepatuhan, kemudian dianalisis secara deskriptif serta disajikan dalam bentuk tabel dan grafik. Proyek Kota Lama Kesawan (93%) dan Proyek Jembatan Tol KAPB (87%) menunjukkan tingkat penerapan SMK3 yang tinggi dan dikategorikan "baik", sedangkan Proyek Bendungan LS (71%) dan Proyek Drainase Limbah (73%) menunjukkan tingkat kepatuhan yang "cukup". Kelemahan utama ditemukan pada aspek pengendalian dokumen, pelaksanaan inspeksi, dan pemantauan kinerja, terutama pada proyek besar dengan banyak subkontraktor. Hasil penelitian mengindikasikan adanya ketimpangan tingkat kematangan penerapan SMK3 antar proyek. Diperlukan penguatan kebijakan nasional dan lokal terkait penegakan SMK3, pelaksanaan audit keselamatan berkala, serta peningkatan pelatihan tenaga kerja. Implementasi SMK3 yang konsisten tidak hanya meningkatkan keselamatan dan efisiensi proyek, tetapi juga berdampak positif terhadap kesehatan pekerja dan mendukung pencapaian Tujuan Pembangunan Berkelanjutan (SDGs) ke-8 tentang pekerjaan layak dan pertumbuhan ekonomi.

Kata Kunci : konstruksi, keselamatan, kesehatan, saluran limbah, jembatan, bendungan.

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BACKGROUND

The construction sector plays a vital role in national infrastructure development and significantly contributes to Indonesia's economic growth. Nevertheless, it remains one of the most hazardous industries, with high rates of occupational accidents in both frequency and severity. These risks are largely attributed to the dynamic and complex nature of construction sites, the involvement of multiple stakeholders, and time and cost pressures that often result in the neglect of occupational safety practices. Globally, the construction industry is recognized for its elevated risk profile. According to the International Labour Organization (ILO), it accounts for a substantial proportion of occupational injuries and fatalities worldwide. Common contributing factors include working at heights, the use of heavy machinery, unstable structures, and tight project deadlines (1). In the Indonesian context, similar patterns are observed national data consistently place construction among the top sectors for workplace accidents (2). Importantly, the impact of construction accidents extends beyond the workers themselves. Fatal and disabling injuries can lead to profound socioeconomic consequences for workers' families, including the loss of primary income earners and long-term financial instability. At the community level, construction-related accidents can also pose risks to public safety, such as structural failures, debris hazards, and pollution incidents that affect nearby residents. These broader repercussions underscore that construction safety is not solely an occupational issue but also a matter of public health and community welfare. Therefore, strengthening the implementation of Occupational Safety and Health Management Systems (OSH-MS) within construction projects is essential not only for worker protection but also for sustaining community resilience and social stability.

To address these concerns, the Indonesian government introduced a mandatory Occupational Safety and Health Management System (OSH-MS) through Government Regulation No. 50 of 2012 (3). This regulation mandates OSH-MS implementation in companies with over 100 employees or high-risk operations, aligning with international standards such as OHSAS 18001 and ISO 45001:2018. The framework emphasizes proactive hazard prevention and includes key elements such as safety policy development, hazard identification, risk assessment, control measures, monitoring, evaluation, and continuous improvement. Despite this regulatory framework, the implementation of OSH-MS across construction projects in Indonesia remains inconsistent. Challenges include variations in commitment among stakeholders, gaps in worker competence, insufficient documentation systems, and limited external oversight. While prior studies have explored individual factors influencing OSH performance, empirical research offering comparative evaluations across multiple infrastructure project types and geographical locations remains limited. However, non-compliance persists, as some workers neglect PPE usage and rely on experience over protocol, indicating a gap between awareness and practice (4).

Although progress has been made in Occupational Safety and Health (OSH) interventions, gaps remain in fully understanding their effectiveness and in providing actionable implementation guidance. The literature highlights future research directions, including the promotion of human-centered technological development and the establishment of more integrated stakeholder networks characterized by enhanced coordination, knowledge sharing, and open communication. Advancing these areas is expected to support continuous OSH improvement by enabling more effective, evidence-based interventions and encouraging proactive organizational engagement in daily OSH practices (5). Most existing literature focuses on single case studies or specific project types, with few comparative assessments of how OSH-MS components are applied across diverse

project settings (6–10). Moreover, there is a lack of structured evaluations that categorize implementation levels such as fully implemented, partially implemented, or deficient for each OSH-MS element. This gap is particularly critical in Indonesia, where regulatory mandates exist, but enforcement and performance monitoring are not uniformly practiced. Given these issues, the present study aims to assess the implementation level of OSH-MS across four infrastructure projects in Indonesia: the LS Dam Project, the Kesawan Old Town Revitalization Project, the KAPB Toll Bridge Project, and the Wastewater Drainage Project. By conducting a comparative analysis, this study seeks to identify key implementation gaps, contextual challenges, and potential best practices for enhancing safety performance in the construction sector.

METHOD

This study is quantitative research using a descriptive approach. This research was conducted in The Musi Toll Bridge Kayu Agung - Palembang - Betung (KAPB) Project in South Sumatra of PT.KAW and the Lau Simeme (LS) Dam Project in Deli Serdang, North Sumatra of PT.KIW. The research was conducted from November 2023 to January 2025. The informants interviewed were 5 people in the Dam project and 5 people in the Tool bridge project, namely the OHS Manager, OHS Coordinator, Safety Officer and OHS administrator. The three project contractors are an Indonesian state-owned enterprise (LS Dam Project, Kesawan Old Town Project, KAPB Toll Bridge Project), and one project contractor is a private company (Waste Drainage Project).

Data was acquired using a questionnaire survey method by interviews, observation, and document review using form checklist of The Indonesian Regulation of Occupational Safety and Health Management System (OSHMS) Number 50, 2012. The survey consisted of establishment of OSH Policy, OSH planning, implementation of OSH Plan, OSH performance monitoring and evaluation, OSH performance review and improvement. Collecting data was performed in four construction sites in North Sumatra Province, South Sumatra Province, and Jambi Province in Sumatra Island. Five staff members of each construction site who became the informants for this study are staff who oversaw OSH, OHS Manager, OHS Coordinator, Safety Officer and OHS administrator.

The Indonesian Regulation of Occupational Safety and Health Management System (OSHMS) Number 50, 2012 checklist was used as the instrument for the data collection technique, which involved interviewing and observation to capture both primary and secondary data. While secondary data is gathered from papers that already exist in the firm, primary data is the outcome of observation and in-depth interviews. The instructions for the execution of the OSH-MS Peraturan Pemerintah (Government Regulation) No. 50/2012 based on 12 elements with 166 assessment criteria were the subject of this study variable such as commitment development and maintenance, making and documenting of OSH Plans, contract control, design, and review, document control, Product purchasing and control, work safety based on OSH-MS, Management of materials and the movements, monitoring standards, data collection and utilization, inspection of OSH-MS, reporting and correction of disadvantages, skill and ability development.

In this study, implementation assessment was conducted using a two-step structured evaluation system. The first step, shown in Table 1, involves applying a binary scoring method where each item on the checklist is scored as 0 or 1. A score of 0 indicates that the item does not conform to the established requirements, which can manifest as a critical, major, or minor nonconformity depending on the severity of the deviation. Conversely, a score of 1 indicates that the item is in conformity, meaning the requirements fully comply with the established standards. This scoring approach was chosen to ensure objectivity by clearly distinguishing between acceptable and unacceptable conditions.

Table 1. The scoring

Score	Description
0	Incompatible (critical, major, minor)
1	Suitable

The results of the observation checklist and interviews were processed using the following formula:

$$achievement\ level = \frac{\Sigma\ suitability\ score}{n\ criteria}\ x\ 100\%$$

Description:

Σ suitability score: the number of application values that are fulfilled.

n criteria : the number of criteria sub-element

The second step involves converting the accumulated scores into percentage values by dividing the total score obtained by the maximum possible score and multiplying the result by 100. The percentage values are then used to classify the overall implementation level into three categories as shown in Table 2. Percentages ranging from 0–59% are classified as Category C (Poor), indicating a low level of implementation where many requirements are not met and substantial improvements are needed. Percentages of 60–84% are classified as Category B (Good), reflecting a generally good level of implementation, although some aspects still require further improvement. Meanwhile, percentages of 85–100% are classified as Category A (Satisfactory), indicating that most requirements have been successfully met and the implementation can be considered effective and satisfactory.

Table 2. The scoring system

Percentage (%)		Description
0 – 59%	C	Implementation assessment level Less (Less)
60 – 84%	B	Good implementation assessment level (Good)
85 – 100%	A	Satisfactory implementation assessment level (Satisfactory)

Content validity in this study was established through an extensive literature review and alignment with the provisions of Government Regulation No. 50/2012 concerning the implementation of the Occupational Safety and Health Management System (SMK3). This methodological approach ensures that each item within the assessment checklist is theoretically and normatively grounded in the national regulatory framework. Given that the checklist items are derived from established legal and procedural standards, individual validity testing is not deemed necessary, as each indicator inherently reflects predetermined regulatory requirements. To enhance methodological rigor, it is advisable to incorporate expert judgment involving two to three Occupational Safety and Health (OSH) professionals to evaluate the checklist's relevance, coherence, and adequacy in measuring the implementation of OSH-MS within construction projects. This triangulation of regulatory compliance and expert assessment would further substantiate the instrument's validity and ensure its applicability in diverse occupational contexts.

RESULT

Lau Simeme Dam Project in Biru-biru District, Deliserdang Regency, which functions to reduce flooding in North Sumatra. Kesawan Old Town Project in the middle of Medan City is a construction work for the Development of Residential Infrastructure in the Old City Area of Kesawan, Medan City. The KAPB Musi Toll Bridge Project in Palembang is a 1.7 km long toll road bridge construction project built over the Musi River with a width of 450 m. The construction of the Sewerage Channel in Jambi City is part of the Centralized Domestic

Wastewater Management System (SPALD-T) project which is part of the Metropolitan Sanitation Management Investment Project (MSMIP) Program. The Jambi City SPALD-T has a capacity of 7,600 m3/day with a service potential of 10,300 House Connections (SR). The location of the construction project is on the island of Sumatra, which can be seen in Figure 1, a map of the island of Sumatra.

Figure 1. Map of Sumatra Island (11)

Table 3. Applications compliance level of OSH-MS

Elements	Criteria	LS Dam Project		KAPB Tol Bridge Project		Kesawan Old Town Project		Waste Drainage Project	
	N	Suitable n (%)	Remarks (Incompatible)	Suitable n (%)	Remarks (Incompatible)	Suitable n (%)	Remarks (Incompatible)	Suitable n (%)	Remarks (Incompatible)
E1	26	18 (69%)	1.1.5, 1.2.1, 1.2.7, 1.4.1, 1.4.7, 1.4.8, 1.4.9, 1.4.11	25 (96%)	1.3.3	25 (96%)	1.3.2	22 (85%)	1.1.4, 1.3.2, 1.4.10
E2	14	12 (86%)	2.3.1, 2.3.2	12 (86%)	2.2.3, 2.3.2	14 (100%)		10 (71%)	2.2.1, 2.3.2, 2.3.3
E3	8	5 (62%)	3.1.1, 3.1.4, 3.2.4	8 (100%)		6 (75%)	3.1.1, 3.2.1	5 (63%)	3.1.1, 3.1.2, 3.2.1
E4	7	1 (14%)	4.1.1, 4.1.2, 4.1.4, 4.2.1, 4.2.2, 4.2.3	6 (86%)	4.2.3	5 (71%)	4.1.1, 4.2.1	6 (86%)	4.2.3
E5	9	3 (33%)	5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.4.1, 5.4.2	8 (89%)	5.1.4, 5.1.5	6 (67%)	5.1.1., 5.1.4, 5.1.5	4 (44%)	5.1.1, 5.1.5
E6	41	32 (78%)	6.1.7, 6.2.4, 6.2.5, 6.4.4, 6.5.6, 6.7.1, 6.7.4, 6.7.5, 6.7.7	38 (93%)	6.5.1, 6.7.6, 6.8.1	34 (83%)	6.2.2, 6.2.4, 6.4.7, 6.5.3, 6.5.4, 6.6.1, 6.6.2	31 (76%)	6.1.2, 6.1.4, 6.1.8, 6.2.1, 6.2.2, 6.5.1, 6.5.9, 6.6.2
E7	12	11 (92%)	7.3.1	10 (83%)	7.3.1, 7.3.5	11 (92%)	7.1.3	8 (67%)	7.1.3, 7.1.7, 7.2.2, 7.3.1,

Elements	Criteria	LS Dam Project		KAPB Tol Bridge Project		Kesawan Old Town Project		Waste Drainage Project	
									7.3.2
E8	17	14 (82%)	8.1.5, 8.2.1, 8.4.3	17 (100%)		14 (82%)	8.2.3, 8.3.1, 8.4.5	10 (59%)	8.2.1
E9	6	3 (50%)	9.1.1, 9.2.1, 9.2.2	6 (100%)		4 (67%)	9.1.1, 9.1.3	4 (67%)	9.2.1, 9.3.1, 9.3.3
E10	3	1 (33%)	10.1.1, 10.1.2	2 (67%)	10.1.3	3 (100%)		2 (67%)	10.1.2, 10.1.3
E11	9	7 (78%)	11.2.1, 11.3.6	9 (100%)		9 (100%)		8 (89%)	11.1.1
E12	14	11 (79%)	12.1.6, 12.3.1, 12.3.2	14 (100%)		14 (100%)		11 (79%)	12.1.2, 12.1.3, 12.2.1
Total	**166**	**118 (71%) Good**		**154 (93%) Satisfactory**		**145 (87%) Satisfactory**		**121 (73%) Good**	

Note: E1= Commitment development and maintenance; E2= Making and Documenting of OSH Plans; E3= Contract control, design, and review; E4= Document control; E5= Product purchasing and control; E6= Work safety based on OSHMS; E7= Management of materials and the movements; E8= Monitoring standards; E9= Data collection and utilization; E10= Inspection of OSHMS; E11= Reporting and correction of disadvantages; E12= Skill and ability development.

Table 3 provides a comprehensive assessment of OSH-MS (Occupational Safety and Health Management System) elements across four infrastructure projects, using twelve evaluation elements (E1 to E12). The Kesawan Old Town Project stands out with the highest overall suitability, achieving 100% compliance in 5 out of 12 elements (E2, E8, E10, E11, E12), and no critical incompatibilities in major elements. Its average suitability across all criteria is approximately 93%, classifying its OSH-MS performance as "Good." Similarly, the KAPB Toll Bridge Project also displays strong adherence to OSH-MS, achieving 100% suitability in four elements (E8, E9, E11, E12) and maintaining high compliance (over 85%) in most others. Its performance is rated "Satisfactory" overall at 87%. The Waste Drainage Project shows moderate implementation, with full suitability in none of the elements, and the lowest score in E8 (Monitoring Standards at 59%) and E7 (Material Management at 67%). Its total suitability rate is 73%, placing it in the lower end of the "Satisfactory" category.

In contrast, the LS Dam Project demonstrates the weakest performance, with only three elements exceeding 85% suitability (E2, E7, E8). It suffers from severe incompatibility in E4 (Document Control, 14%) and E10 (OSHMS Inspection, 33%), with a total suitability of 71%, barely qualifying as "Good" under the minimum threshold. Across all projects, E4 (Document Control) and E10 (OSHMS Inspection) appear as common areas of concern, particularly for the LS Dam and Waste Drainage Projects. Conversely, E11 (Reporting and Correction) and E12 (Skills Development) consistently receive high scores, indicating these areas are well-managed across sites. The Kesawan Old Town and KAPB Toll Bridge Projects lead in OSH-MS implementation with robust systems in place, while the LS Dam Project requires significant improvements, especially in documentation and inspection procedures.

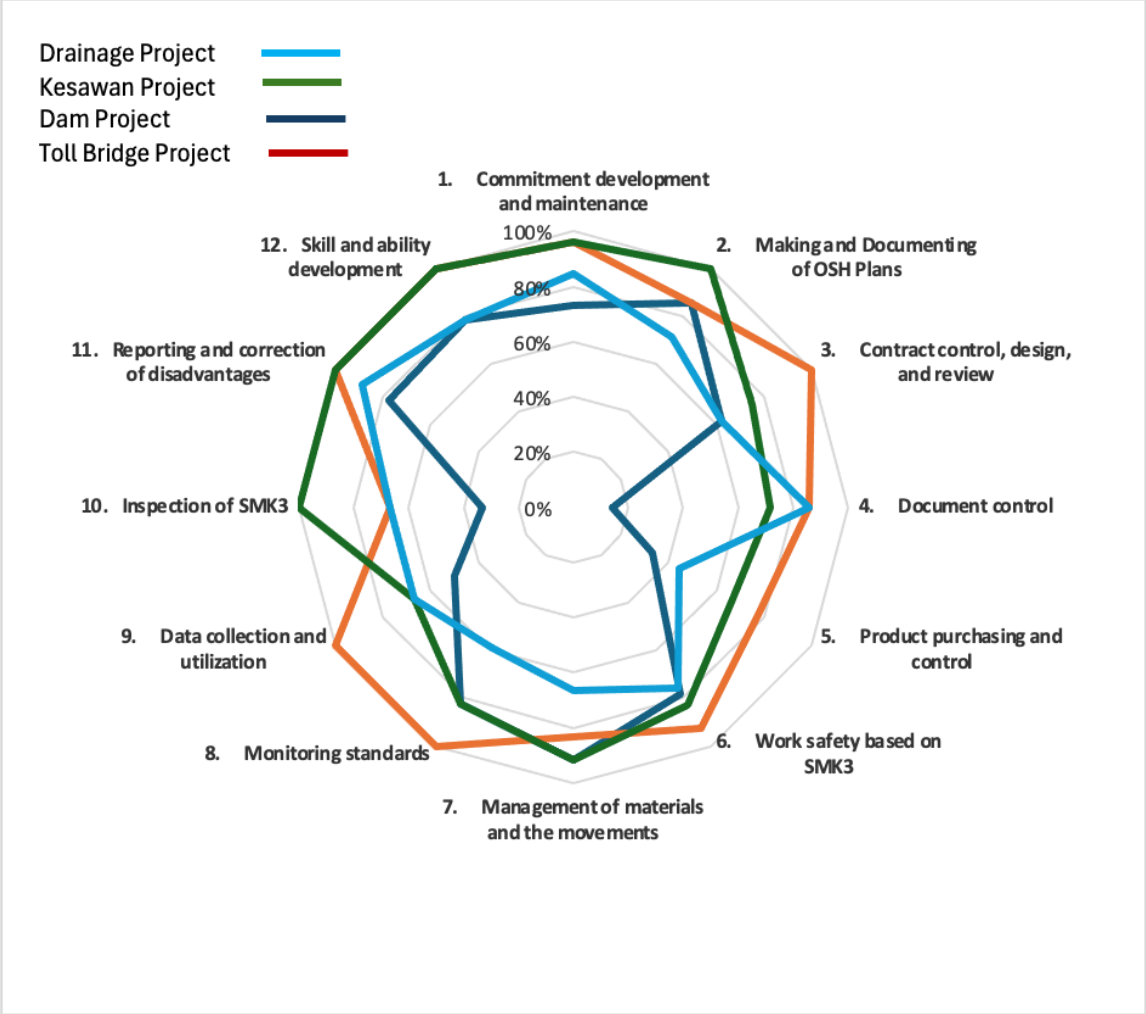

Figure 2. Compliance level of the 12 elements of OSH-MS

The radar chart of figure 2 presents a comparative assessment of the implementation of key Occupational Safety and Health (OSH) components based on SMK3 (Indonesian OSH Management System) across four infrastructure projects: the Drainage Project, Kesawan Project, Dam Project, and Toll Bridge Project. The Kesawan Project consistently scores the highest across nearly all twelve criteria, particularly excelling in commitment development and maintenance, skill development, inspection of SMK3, and reporting and correction of disadvantages. This indicates a robust and well-rounded approach to OSH implementation, reflecting strong organizational commitment and compliance with SMK3 standards. The Drainage Project demonstrates relatively strong performance in commitment development, OSH planning, and skill development, but shows notable weaknesses in document control, product purchasing, and data utilization, suggesting a need for better operational control and data management systems.

The Toll Bridge Project shows a highly balanced and moderate level of compliance across most criteria. While it does not lead in any specific area, it maintains consistently acceptable levels of implementation, particularly in contract review, document control, and monitoring standards. In contrast, the Dam Project displays significant performance gaps across several criteria, especially in contract control, document management, and data utilization, where it falls

well below 40%. Despite some strengths in areas like product control and SMK3-based work safety, its overall OSH implementation appears limited and inconsistent. Overall, the chart reveals considerable variation in OSH implementation effectiveness. The Kesawan Project leads with comprehensive and high-level compliance, followed by the Toll Bridge and Drainage Projects with more moderate but focused efforts. The Dam Project, however, requires substantial improvements to meet minimum OSH standards across most operational and administrative areas.

Table 4. Results Based on 5 Principles

	Principle	Criteria N	LS Dam Project	Kesawan Old Town Project	KAPB Tol Bridge Project	Waste Drainage Project
			n (%)	n (%)	n (%)	n (%)
1.	Establishment of OSH Policy	26	18 (69%)	25 (96%)	25 (96%)	22 (85%)
2.	OSH Planning	14	12 (86%)	14 (100%)	12 (86%)	10 (71%)
3.	Implementation of OSH Plan	77	52 (68%)	62 (81%)	69 (90%)	54 (70%)
4.	OSH Performance Monitoring and Evaluation	26	18 (69%)	21 (81%)	25 (96%)	16 (62%)
5.	OSH Performance Review and Improvement	23	11 (78%)	23 (100%)	23 (100%)	19 (83%)

The quantitative evaluation of Occupational Safety and Health (OSH) Management System implementation across four infrastructure projects, based on five core principles as shows in table 4, reveals a clear hierarchy in compliance levels. The Kesawan Old Town Project exhibits the most comprehensive implementation, achieving 100% compliance in both OSH Planning and Performance Review and over 95% in Policy Establishment and Monitoring & Evaluation, indicating a fully institutionalized and well-managed OSH framework. The KAPB Toll Bridge Project mirrors this strong performance, matching 100% compliance in Performance Review and achieving 96% in both Policy Establishment and Monitoring & Evaluation. These results reflect a solid integration of both strategic OSH planning and operational follow-through. The Waste Drainage Project demonstrates moderate compliance, particularly strong in Policy Establishment (85%) and Performance Review (83%), but significantly lower in Monitoring & Evaluation (62%) and Planning (71%).

These gaps point to challenges in oversight and systematic execution despite a sound policy foundation. Conversely, the LS Dam Project presents the lowest levels of OSH-MS implementation, with scores below 70% in four out of five areas, and a peak of 86% in OSH Planning. Its weak performance in Plan Implementation (68%) and Monitoring & Evaluation (69%) suggests deficiencies in operationalization and feedback mechanisms essential for continuous improvement. Overall, the data indicate significant disparities in OSH-MS maturity among the projects. The Kesawan Old Town and KAPB Toll Bridge Projects demonstrate exemplary safety practices aligned with best standards, while the LS Dam Project requires immediate corrective actions and capacity development to achieve acceptable levels of OSH compliance.

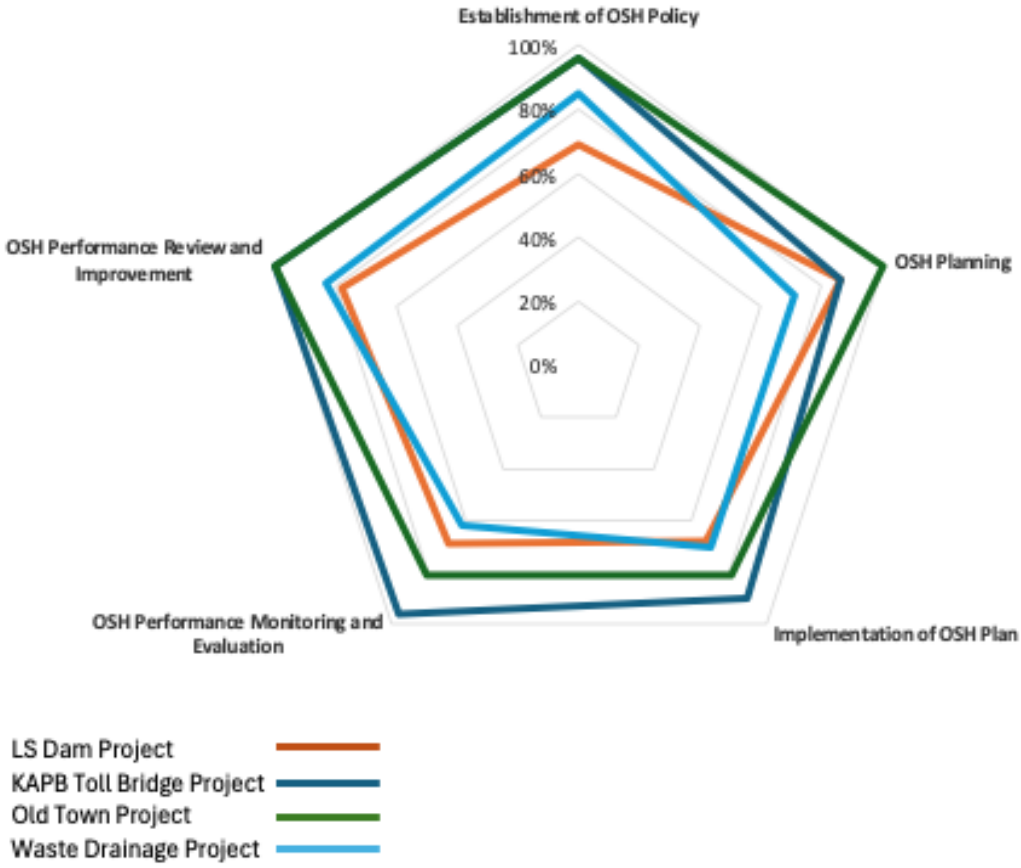

Figure 3. Compliance level of OSHMS

The radar chart of figure 3 provides a comparative overview of the implementation levels of key Occupational Safety and Health Management System (OSH-MS) components across four infrastructure projects: the LS Dam Project, KAPB Toll Bridge Project, Old Town Project, and Waste Drainage Project. Among them, the Old Town Project consistently demonstrates the highest performance across all OSH-MS dimensions, particularly excelling in OSH Policy establishment, planning, monitoring, and performance review, indicating a well-integrated safety management approach. The KAPB Toll Bridge Project follows closely, showing strong scores especially in monitoring and evaluation, suggesting a proactive approach to tracking OSH outcomes. The Waste Drainage Project shows moderate performance across most areas, with relatively stronger results in policy establishment and planning but room for improvement in implementation and monitoring. In contrast, the LS Dam Project exhibits the lowest performance in all five OSH-MS areas, highlighting significant gaps in both strategic planning and operational execution of safety measures. Overall, the chart underscores notable variability in OSH-MS implementation across projects, with the Old Town Project setting the benchmark for best practices.

DISCUSSION

The assessment reveals notable variation in the implementation of Occupational Safety and Health Management Systems (OSH-MS) across infrastructure projects, reflecting differences in institutional capacity, leadership commitment, and safety culture. The Kesawan Old Town Project demonstrates the most effective implementation, indicating the integration of a mature safety management culture supported by strong

leadership and adequate resources. The KAPB Toll Bridge Project also performs well, particularly in policy formulation and performance evaluation, suggesting that systematic monitoring and decision-making frameworks are well established. In contrast, the Waste Drainage Project and LS Dam Project exhibit partial or weak adherence to OSH-MS standards, implying that the existence of formal safety policies alone does not ensure effective implementation.

These findings are consistent with earlier studies on occupational safety and health in Indonesian construction projects. For instance, research on the Kediri Airport Project found that while OSH-MS (SMK3L) implementation achieved satisfactory outcomes, barriers such as low worker awareness, cognitive risk biases, and limited capital investment constrained its operational effectiveness (12). Similarly, the Way Ampu Dam Project achieved a 98% effectiveness level but identified gaps in training, equipment maintenance documentation, and maintenance request procedures, emphasizing the need for refresher training and technological integration to improve data accessibility (13,14). Comparable results were also found in the Jakarta–Cikampek II Elevated Toll Road Project, which demonstrated 98.04% compliance with SMK3 criteria, showing that leadership engagement and systematic monitoring are critical determinants of strong OSH performance (15,16).

From a policy standpoint, these results align with Indonesia's national effort to strengthen the Occupational Safety and Health Management System (SMK3), as mandated in Government Regulation No. 50/2012, which encourages integration of safety management into all levels of project planning and execution. The variation in implementation quality across projects reflects broader national challenges in regulatory enforcement, institutional capacity, and cross-sector collaboration issues highlighted in recent occupational health policy reviews (17). In the context of community health, effective OSH-MS implementation plays a key role in building healthy working communities by ensuring that worker safety, well-being, and empowerment are integrated into organizational culture. Projects with high compliance, such as Kesawan and KAPB, demonstrate that consistent leadership support, adequate resources, and employee engagement lead to safer and more resilient workplaces. This aligns with the broader public health perspective that emphasizes the workplace as a central setting for promoting health, social stability, and productivity (18).

Overall, this study contributes to the understanding of how OSH-MS implementation supports Indonesia's vision of creating healthy working communities. Strengthening leadership training, enhancing workforce competence, and adopting standardized monitoring mechanisms across projects will help bridge performance gaps and foster a nationwide culture of safety, aligning occupational health management with sustainable development goals.

Multiple Correspondence Analysis

As outlined in the data analysis section, Multiple Correspondence Analysis (MCA) was employed to further explore the data and identify relationships among categorical variables. The case study included four project sites: one located in Deli Serdang Regency, one located in Medan City, one located in Palembang, and one located in Jambi. Table 5 presents the model summary of the MCA analysis, and Figure 4 displays the joint plot of the category points. The model summary indicates that the two-dimensional solution captures 57.143% of the total variance, with both dimensions having eigenvalues greater than 1. Dimension 1 reflects the level of OSH-MS across the project sites, while Dimension 2 corresponds to the cities involved in the case study.

Table 5 MCA Test Result

Dimension	Cronbach's Alpha	Variance Accounted For		
		Total (Eigenvalue)	Inertia	% of Variance
1	0.938	5.106	0.729	72.936
2	0.764	2.894	0.413	41.349
Total		8.000	1.143	
Mean	0.875[a]	4.000	0.571	57.143

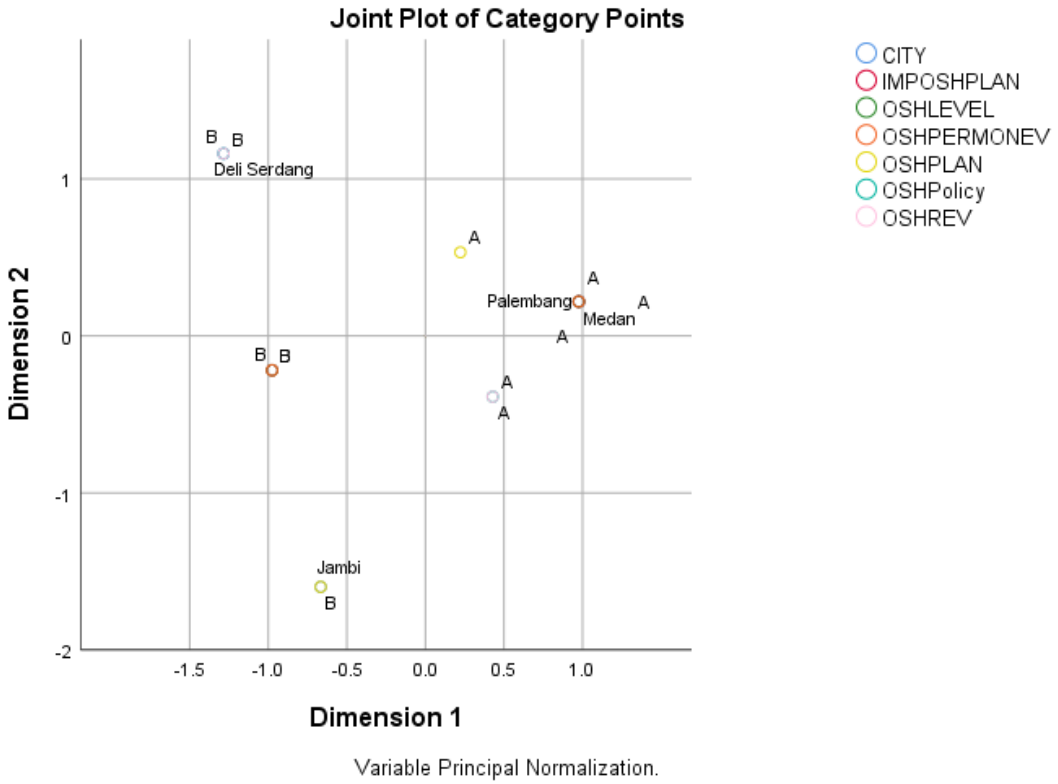

Figure 4 Multiple Correspondence Analysis

The joint plot of category points of figure 4, derived from Multiple Correspondence Analysis (MCA), reveals spatial differentiation in the implementation of Occupational Safety and Health Management Systems (OSH-MS) across four project sites. Medan and Palembang cluster around category A variables—such as OSH planning, policy establishment, monitoring and evaluation, and performance review—indicating a higher degree of OSH-MS compliance. This proximity suggests that these sites have effectively institutionalized key components of OSH management in line with recognized standards. Conversely, Deli Serdang and Jambi are positioned near category B variables, reflecting lower levels of implementation and reduced adherence to core OSH-MS practices. The clear spatial separation between these groups in the two-dimensional MCA solution underscores significant disparities in OSH-MS effectiveness among the sites. These findings support the conclusion that geographic or organizational factors may influence the extent of safety system adoption, with Medan and Palembang demonstrating superior alignment with occupational safety protocols relative to Deli Serdang and Jambi.

Improving the implementation of Occupational Safety and Health Management Systems (OSH-MS) across infrastructure projects requires a multifaceted and evidence-based approach. Strengthening leadership commitment is critical, as managerial support has been shown to directly influence the integration and effectiveness of safety practices (19,20). Standardization of OSH procedures across project sites can enhance consistency and reduce variability in implementation outcomes (21). Targeted training and capacity-building initiatives are essential to increase worker competency and ensure adherence to safety protocols. Furthermore, the development of a robust monitoring and evaluation framework, incorporating key performance indicators (KPIs) and regular audits, will facilitate data-driven decision-making and continuous improvement.

The implementation of Occupational Health and Safety Management Systems (OHSMS) in the construction sector has been proven to significantly reduce work-related accidents and enhance project efficiency. However, the effectiveness of these systems depends on several factors, including worker awareness, safety culture, and budgetary support. Although OHSMS adoption yields measurable safety and productivity benefits, its application at the operational level remains limited due to behavioral and financial constraints (22). Studies indicate that the implementation of Occupational Health and Safety Management Systems (OHSMSs) in the construction sector is often hindered by inadequate communication, improper use of personal protective equipment (PPE), unsafe work postures and practices, insufficient training, psychosocial factors such as stress and burnout, and a weak safety culture. Additionally, poor compliance with regulatory frameworks remains a critical safety concern. Despite the recognized importance of evaluating OHSMS implementation, management, and performance, such assessments are constrained by the limited availability of comprehensive field, organizational, and clinical data on incident occurrences within the industry (23).

Knowledge transfer from high-performing projects (e.g., Kesawan Old Town and KAPB Toll Bridge) to those with lower compliance can accelerate best-practice adoption. Finally, ensuring sufficient allocation of resources both human and financial is necessary to support sustained OSH-MS operations. Collectively, these measures are expected to enhance safety performance, reduce occupational risks, and support regulatory compliance across infrastructure development projects, conducting various outreach activities to workers regarding matters related to OSHE, providing OSH training to all workers and not minimizing capital for OSHE implementation (22).

However, this study has several limitations. The assessment relied primarily on document-based evaluation and checklist scoring, which may not fully capture the practical aspects of on-site implementation and behavioral compliance among workers. The sample size was also limited to four projects within a single province, restricting the generalizability of findings to broader national contexts. Future studies should incorporate a mixed-method approach, combining quantitative compliance assessments with qualitative interviews or field observations, to provide a more comprehensive understanding of OSH-MS effectiveness in various construction environments.

CONCLUSION

The comparative assessment of OSH Management System (OSH-MS) implementation across the four infrastructure projects revealed substantial variation in performance. The Kesawan Old Town Project achieved the highest level of compliance, reflecting mature and well-integrated safety management practices, followed by the KAPB Toll Bridge Project, which also demonstrated strong implementation, particularly in planning and performance evaluation. Conversely, the LS Dam Project recorded the lowest overall score, indicating notable

deficiencies in document control, inspection, and performance monitoring, while the Waste Drainage Project achieved a moderate level of compliance with weaknesses in planning consistency. Geographically, projects located in urban areas such as Medan showed higher OSH-MS maturity compared to those in Deli Serdang, suggesting that regional capacity and institutional oversight play a role in implementation quality.

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