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PRIORITIZING OCCUPATIONAL SAFETY IMPROVEMENTS IN CONSTRUCTION PROJECTS USING INTERNAL AUDIT AND FMEA

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Abstract

The implementation of an Occupational Safety and Health Management System (SMK3) is essential for controlling occupational risks and improving safety performance in construction projects. However, internal safety audits generally identify non-conformities without objectively determining their priority for corrective action. This study aims to evaluate SMK3 implementation in the KoeniKoeni Hotel Semarang construction project managed by PT Total Bangun Persada and to establish corrective-action priorities by integrating internal safety audit findings with Failure Mode and Effects Analysis (FMEA). A case study approach was employed using internal safety audits, field observations, interviews, and document reviews. Audit findings were analyzed using FMEA based on Severity (S), Occurrence (O), and Detection (D), and the Risk Priority Number (RPN) was calculated to rank corrective-action priorities. The internal audit showed that 22 of 24 SMK3 elements met the established requirements, resulting in a compliance rate of 91.67%. Nevertheless, 20 non-conformities were identified from field audit findings. FMEA results indicated that failure to wear safety helmets had the highest RPN of 504, followed by damaged safety nets and uninspected scaffolding, each with an RPN of 360. Other high-priority findings included failure to wear safety shoes (RPN 336), failure to wear safety vests (RPN 288), and expired fire extinguishers (RPN 270). The findings indicate that the major risks were associated with unsafe worker behavior, inadequate supervision, and deficiencies in safety facilities. The integration of internal safety audits and FMEA provides a systematic and risk-based framework for identifying critical SMK3 deficiencies and prioritizing corrective actions. The approach can support construction project management in allocating improvement resources more effectively and strengthening the continuous implementation of SMK3.

Keywords: SMK3, Internal Safety Audit, FMEA, Risk Priority Number, Occupational Safety, Construction Project.

INTRODUCTION

The construction industry is one of the sectors with the highest occupational accident rates due to the complex, dynamic, and hazardous nature of its operations (Hayashi et al., 2023; Kineber et al., 2023). Construction activities frequently involve high-risk tasks, including working at heights, operating heavy machinery, performing electrical work, and handling or lifting construction materials (Andriyadi et al., 2021; Atasever et al., 2024). The complexity of these activities increases the likelihood of occupational accidents, which not only threaten workers' safety and health but also lead to project delays, cost overruns, reduced productivity, and substantial financial and reputational losses for construction companies (Alkaissy et al., 2022). Therefore, the implementation of an Occupational Safety and Health Management System (SMK3) represents a critical strategy for controlling occupational risks while enhancing safety performance in construction projects (Kementerian Pekerjaan Umum dan Perumahan Rakyat (PUPR), 2021; Kineber et al., 2023). An effective SMK3 implementation extends beyond mere regulatory compliance by fostering a proactive safety culture that supports project sustainability and continuously improves organizational performance(Hayashi et al., 2023; J. EL- Matury et al., 2025a; Puspita et al., 2025).

The successful implementation of an Occupational Safety and Health Management System (SMK3) depends not only on the availability of safety policies and procedures but also on the effectiveness of their implementation, monitoring, and continuous evaluation. One of the most widely adopted evaluation mechanisms is the internal audit, which assesses the conformity of SMK3 implementation with organizational standards and applicable regulations while

identifying non-conformities that require corrective action. Previous studies have examined SMK3 implementation in construction projects using compliance audits, perception surveys, and statistical analyses to identify the factors influencing successful implementation (Atasever et al., 2024; Hayashi et al., 2023). However, most of these studies have primarily focused on measuring the level of SMK3 implementation or identifying contributing factors, providing limited support for objectively prioritizing corrective actions for audit findings. Furthermore, the integration of internal audit outcomes with risk analysis methods capable of systematically prioritizing corrective actions remains limited (Cho & Chae, 2022; Soltanzadeh et al., 2022). This limitation highlights a significant research gap, as audit results should not only provide information on the level of compliance but also support systematic and risk-informed decision-making in determining improvement priorities. Accordingly, existing studies have not integrated internal audit findings with Failure Mode and Effects Analysis (FMEA) as a risk-based framework for establishing priorities for corrective actions.

Based on this research gap, the present study integrates internal auditing with Failure Mode and Effects Analysis (FMEA) to evaluate the implementation of the Occupational Safety and Health Management System (SMK3) while establishing priorities for corrective actions based on the risk level of each audit finding (ILO, 2022). While recent studies have applied FMEA to occupational-risk assessment and construction-risk prioritization, limited attention has been given to integrating internal SMK3 audit findings with FMEA-based RPN analysis to prioritize corrective actions. The novelty of this study lies in the development of a comprehensive evaluation framework that not only identifies weaknesses in SMK3 implementation but also provides a risk-based decision-making tool to assist project management in determining the most critical improvement priorities (Juan et al., 2023a). Accordingly, this study is expected to contribute both methodologically and practically by advancing risk-based approaches for evaluating SMK3 implementation and by providing construction companies with a structured framework for continuously improving the effectiveness of their occupational safety and health management systems.

LITERATURE REVIEW

Occupational Safety and Health Management System (SMK3)

The Occupational Safety and Health Management System (SMK3) is a management framework designed to systematically control occupational safety and health risks through the processes of planning, implementation, monitoring, evaluation, and continuous improvement. In Indonesia, the implementation of SMK3 is regulated under Government Regulation No. 50 of 2012, which stipulates that the system aims to establish a safe, healthy, efficient, and productive workplace by integrating occupational risk management into the organization's overall management system. In accordance with this regulation, SMK3 implementation comprises five principal elements: the establishment of occupational safety and health (OSH) policies, OSH planning, implementation of OSH programs, monitoring and evaluation of OSH performance, and management review and improvement of OSH performance. Collectively, these elements establish a systematic and continual-improvement-oriented management cycle for enhancing the effectiveness of occupational safety and health practices. Recent Indonesian studies continue to apply these five elements as the framework for evaluating SMK3 implementation in organizations and projects (Damario Primayudha & Kusumawati, 2024; Ketut Kembarejaya et al., 2026).

In construction projects, the implementation of the Occupational Safety and Health Management System (SMK3) plays a critical role due to the dynamic nature of construction activities, which involve a large workforce, the operation of heavy equipment, work at heights, electrical installations, and other high-risk tasks (Jaafar et al., 2018; Safira & Ramdhan, 2020). SMK3 implementation extends beyond compliance with regulatory requirements, aiming to systematically identify workplace hazards, control occupational risks, improve workers' adherence to safety procedures, and foster a strong safety culture within the organization (Gunduz & Laitinen, 2017; Liu et al., 2023). Consequently, the effectiveness of SMK3 implementation cannot be assessed solely by the existence of safety policies, documentation, or procedures; rather, it must be evaluated through their practical application in the workplace, including hazard identification, worker participation, safety training, inspections, audits, performance monitoring, and corrective-action follow-up (Golabchi et al., 2024; Xu et al., 2021). Therefore, evaluating SMK3 implementation is an essential component of continuous safety performance improvement, providing organizations with a sound basis for identifying deficiencies and implementing appropriate corrective actions to address non-conformities (J. EL- Matury et al., 2025b).

Internal Safety Audit

An Internal Safety Audit is a systematic evaluation process conducted to assess the conformity of an

Occupational Safety and Health Management System (SMK3) with organizational policies, applicable standards, and statutory regulatory requirements (ISO 45002:2023, 2023). Internal safety audits serve to identify non-conformities, evaluate the effectiveness of SMK3 implementation, and verify that safety management practices are consistently implemented throughout the organization. Beyond assessing compliance, internal safety audits support continual improvement by communicating audit findings to relevant management, providing recommendations, and ensuring that corrective actions are implemented to address identified non-conformities and enhance occupational safety and health performance (ISO 45002:2023, 2023; Ministry of Manpower of the Republic of Indonesia, 2014; Rohmat Fais Sahhal Hafidhuddin et al., 2025). Thus, internal safety audits contribute to strengthening the overall effectiveness, reliability, and continual improvement of the SMK3.

Although internal safety audits are effective in identifying non-conformities, their findings generally do not provide a risk-based prioritization of corrective actions. Consequently, a systematic approach is required to assess the criticality of each audit finding, enabling corrective resources to be allocated more efficiently and effectively. In this study, the findings of the internal safety audit are integrated with Failure Mode and Effects Analysis (FMEA) to evaluate each non-conformity using the parameters of Severity (S), Occurrence (O), and Detection (D). These parameters are used to calculate the Risk Priority Number (RPN), which serves as the basis for prioritizing corrective actions. This integrated approach enables the evaluation of SMK3 implementation to extend beyond the identification of implementation deficiencies by providing objective, risk-based recommendations for continuous improvement and more effective decision-making (Karamoozian & Wu, 2020a; Rezaei et al., 2018a).

Failure Mode and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a systematic risk assessment method used to identify potential failure modes, analyze their associated consequences, and prioritize corrective actions based on the level of risk (Karamoozian & Wu, 2020b; Rezaei et al., 2018b). In the FMEA process, each potential failure mode is evaluated using three key parameters: Severity (S), which measures the seriousness of the potential consequences; Occurrence (O), which estimates the likelihood of the failure occurring; and Detection (D), which assesses the ability of the existing control system to detect the failure before it results in adverse consequences. These three parameters are multiplied to calculate the Risk Priority Number (RPN), which serves as the basis for ranking failure modes and determining the priority of corrective actions (Rezaei et al., 2018c).

In this study, Failure Mode and Effects Analysis (FMEA) is applied to analyze each non-conformity identified through the internal SMK3 audit(Basuki, 2021). The resulting Risk Priority Number (RPN) enables each audit finding to be prioritized according to its level of risk, allowing the organization to allocate its resources more effectively by focusing on the most critical issues (Juan et al., 2023b). Consequently, the integration of internal safety audits with FMEA extends beyond merely identifying non-conformities in SMK3 implementation; it provides a systematic, objective, and risk-based framework for prioritizing corrective actions and supporting more effective safety management decision-making (Ardeshir et al., 2016; Saputra & Widodo, 2023).

METHOD

This study employs a case study approach to evaluate the implementation of the Occupational Safety and Health Management System (SMK3) in the construction project of the KoeniKoeni Hotel Semarang, managed by PT Total Bangun Persada. The case study approach was selected to provide a comprehensive understanding of the effectiveness of SMK3 implementation under actual project operating conditions. Data were collected through internal safety audits, field observations, interviews, and document reviews. The internal safety audit was conducted using a structured audit checklist developed in accordance with the company's SMK3 standards to identify non-conformities across the evaluated system elements. Subsequently, the audit findings were verified through field observations and interviews to ensure consistency between documented procedures and actual practices at the project site.

Each audit finding was subsequently analyzed using Failure Mode and Effects Analysis (FMEA) to establish the priority of corrective actions based on the associated level of risk. The analysis was performed by evaluating each finding using three key parameters: Severity (S), Occurrence (O), and Detection (D). These parameters were multiplied to calculate the Risk Priority Number (RPN), which served as the basis for prioritizing corrective actions. A higher RPN indicates a greater level of risk and, consequently, a higher priority for corrective action. The integration of internal safety audits with FMEA enables this study not only to identify non-conformities in SMK3 implementation but also to provide objective, systematic, and risk-based recommendations for prioritizing improvement initiatives. The overall research framework adopted in this study is illustrated in Figure 1.

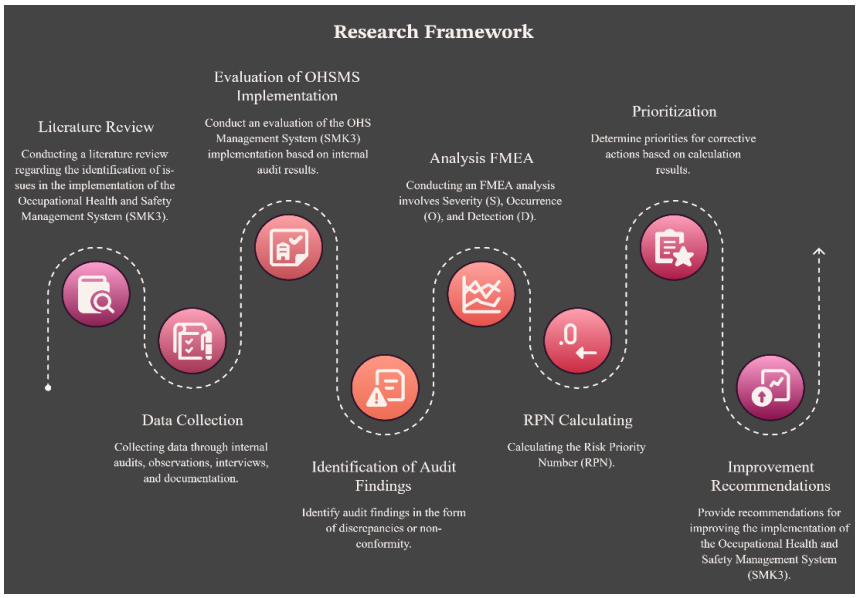


Figure 1. Research Framework

RESULTS AND DISCUSSION

Analysis of the Implementation Level of SMK3

Environmental Assessment Analysis

Table 1. Results of Occupational Safety Assessment

Yes	Assessment Aspects	Value	Weight	Weight Score
1	Waste Handling	3,5	9%	0,315
2	Location of Temporary Generator	3,5	7%	0,245
3	Material Placement B3	4,0	12%	0,480
4	Symbols, Labels and MSDS B3	4,0	9%	0,360
5	B3 Waste Placement	3,0	6%	0,180
6	Resource Usage	4,0	11%	0,440
7	Wastewater Management	4,0	12%	0,480
8	Pollution Control	4,0	14%	0,560
9	Environmental Management and Monitoring	4,0	13%	0,520
10	Environmental Signs and Promotion	4,0	7%	0,280
	Total		100%	3,860

The results of the environmental audit on the construction project of the KoeniKoeni Hotel Semarang obtained an environmental performance value of 3,860 from a maximum scale of 4.00 with the category "Very Good". These results show that the implementation of SMK3 in the aspect of environmental management has been effective through waste management, B3 materials, pollution control, wastewater, and environmental monitoring. However, there are still some drawbacks in B3 waste management, such as lack of identification, protection of storage areas, and waste mixing. Therefore, it is necessary to increase supervision, supporting facilities, routine inspections, and worker awareness to optimize the implementation of SMK3 and sustainable environmental management.

2K Assessment Analysis (Neatness and Cleanliness)

Table 2. 2K Assessment Recap

Assessment Area	Dominant Values	Remarks
Temporary Buildings	4	Excellent
Material Placement	4	Excellent
Tool Placement	3	Good
Toilets and Sanitation Facilities	4	Excellent
Temporary Roads	4	Excellent
Field Garbage Tub	3	Good

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Assessment Area	Dominant Values	Remarks
Temporary Fence	3	Good
Job Security	3	Good
Scaffolding Work	2–4	Enough – Very Good
MEP Fabrication and Materials	2–4	Good

The results of *the 2K* (Neatness and Cleanliness) assessment of the KoeniKoeni Hotel Semarang construction project show that most of the project areas are in the good to very good category. Areas such as *temporary buildings*, material placement, toilets and sanitation facilities, and temporary roads received high scores that showed the implementation of *housekeeping* had been effective. This condition reflects the project management's commitment to creating a safe, clean work environment, and supporting the implementation of SMK3.

However, there are still several aspects that need to be improved, such as the arrangement of work tools, work safety, temporary fences, *scaffolding*, as well as the fabrication area and MEP materials. Irregularities in some areas are caused by high work activity and limited workspace. Therefore, it is necessary to increase supervision, worker discipline, work area *zoning* arrangements, and routine evaluations so that the implementation of *housekeeping* can run consistently. Overall, the audit results showed that the project's cleanliness and cleanliness culture had been well implemented, but still needed continuous improvement to reduce the potential risk of work accidents.

SMK3 Internal Audit Results

The internal safety audit was conducted in accordance with the requirements of PP No. 50 of 2012, ISO 45001:2018, and the PUPR No. 10 of 2021 concerning the Construction Safety Management System (CSMS). The audit was performed using a checklist comprising 24 audit items covering key aspects of occupational safety and health management, including OSH policy, personal protective equipment (PPE) usage, safety training, safety inspections, risk control, emergency preparedness, and SMK3 documentation.

The results of the internal safety audit indicate that most SMK3 elements have been implemented effectively. However, several non-conformities were identified in relation to housekeeping practices, hazardous waste (B3) management, the use of personal protective equipment (PPE), and work area control. These findings suggest that the implementation of the SMK3 has not yet fully complied with the organization's established standards, indicating the need for corrective actions to address several critical areas requiring improvement.

Table 3. SMK3 Internal Audit Results

Yes	Audit Elements	Standard	Yes	No	Value
1	K3 policy available	PP 50/2012	✓		100
2	K3 targets set	ISO 45001	✓		100
3	Hazard Identification (HIRADC)	ISO 45001	✓		100
4	Risk Assessment is carried out	ISO 45001	✓		100
5	Use of PPE according to SOP			✓	0
6	Daily Meeting Toolbox		✓		100
7	K3 training workers		✓		100
8	Safety Induction of new workers		✓		100
9	Fire extinguisher inspection		✓		100
10	Scaffolding Inspection		✓		100
11	Tower Crane Inspection		✓		100
12	Safety Net according to standards			✓	0
13	Full Body Harness Usage		✓		100
14	Work Permit available		✓		100
15	LOTO applied		✓		100
16	Emergency Response Plan		✓		100
17	Emergency simulation		✓		100
18	Complete P3K box		✓		100
19	Complete K3 signs		✓		100

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Yes	Audit Elements	Standard	Yes	No	Value
20	Evacuation Routes		✓		100
21	K3 Documentation		✓		100
22	Keeping an Eye on K3		✓		100
23	Monthly Evaluation		✓		100
24	Periodic Internal Audit		✓		100
Total Values					**2200**
Maximum Amount					**2400**

Based on the results of the internal audit checklist, of the 24 elements of SMK3 that were evaluated, there were 22 elements that met the requirements and 2 elements that did not meet the requirements, namely the use of PPE according to SOPs and *safety net conditions*. The calculation results show a compliance rate of 91.67%, so that the implementation of SMK3 at PT Total Bangun Persada Tbk – Koeni Hotel Semarang Project is included in the Very Good category. However, there is still a need to improve field supervision, routine inspections, and worker development, especially in the aspects of compliance with the use of PPE and the maintenance of safety facilities.

Table 4. Recap of Audit Findings

Yes	Audit Findings	Frequency
1	Workers are not wearing helmets	18
2	Safety net broken	14
3	Scaffolding has not been inspected	12
4	Expired Fire	10
5	Toolbox Meeting is late	9
6	Housekeeping is not good	9
7	Not wearing a vest	8
8	Not wearing safety shoes	8
9	Stacked material	7
10	Slippery work area	7
11	Less K3 signs	6
12	HIRADC documents have not been updated	6
13	Late Work Permit	5
14	Safety Induction Not Yet	5
15	Incomplete P3K box	4
16	Closed evacuation lanes	4
17	Open power cord	4
18	Project waste	3
19	Late crane inspection	3
20	Less inspection documentation	2

Based on the results of an internal audit at PT Total Bangun Persada Tbk – Koeni Hotel Project Semarang, 20 types of non-conformities were found related to the implementation of SMK3 which were then grouped based on the frequency of incidents to determine the priority of repairs. The findings with the highest frequency were workers not wearing safety helmets in 18 incidents, followed by *damaged safety nets* in 14 incidents and *scaffolding* that had not been inspected in 12 incidents. The three findings show that the aspect of compliance with the use of PPE and occupational safety control at height is still the main problem that has the potential to increase the risk of work accidents.

In addition, several other inconsistencies were found such as *expired* fire extinguishers, *late toolbox meetings*, suboptimal *housekeeping*, and non-compliance with the use of safety vests and shoes. Although some findings have a lower frequency, such as HIRADC documents that have not been updated, work permit delays, incomplete P3K, blocked evacuation routes, and exposed power lines, control measures are still needed to prevent increased risks. In general, the audit results show that the main problems come from *unsafe action* and *unsafe conditions*, so it is necessary to increase worker discipline, periodic inspections, improve safety facilities, and strengthen supervision to increase the effectiveness of the implementation of SMK3.

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The audit findings indicate that the identified non-conformities are not limited to administrative compliance issues but are also directly associated with on-site conditions that may increase the risk of occupational accidents. Therefore, each finding requires further analysis to determine its level of risk and establish the appropriate priority for corrective action.The results of this audit then become the basis for risk identification using the Failure Mode and Effect Analysis (FMEA) method to determine the priority of corrective actions.

Risk Analysis Using Failure Mode and Effect Analysis (FMEA)

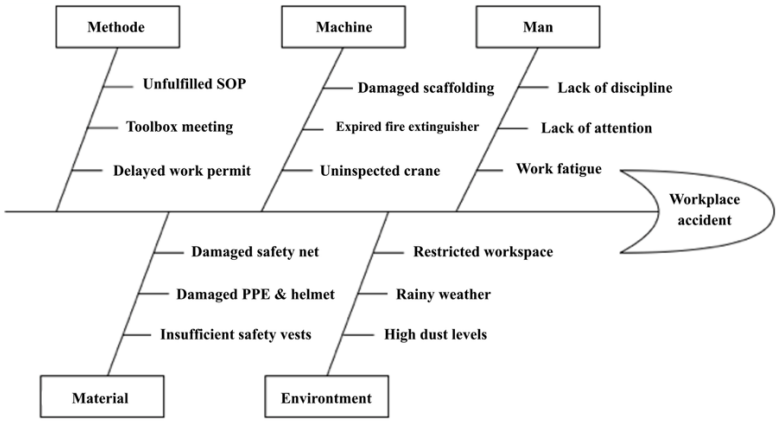


Figure 2. Fishbone Diagram

The results of *the fishbone analysis* show that the main cause of the inconsistency in the implementation of SMK3 in the Koeni Semarang Hotel Project comes from five factors, namely *Man*, *Machine*, *Method*, *Material*, and *Environment*. The *Man* factor is related to low discipline in the use of PPE, understanding safety procedures, and worker fatigue. Machine factors include sub-optimal inspections of equipment such as *scaffolding*, fire extinguishers, and heavy equipment. *The Method factor* is related to inconsistencies in the implementation of safe work procedures, such as *toolbox meetings* and *work permits*. Material factors include damage or incompleteness of safety facilities, while *Environment factors* are related to the condition of dense, slippery, dusty work areas, and weather influences. These five factors are the basis for the preparation of corrective actions to increase the effectiveness of the implementation of SMK3.

Table 5. Failure Mode and Effect Analysis (FMEA)

Yes	Failure Mode	Effect	Cause	Existing Control	S	O	D
1	Not wearing a helmet	Head injuries	Lack of discipline	Safety Patrol	9	8	7
2	Safety net broken	Workers fall	Damaged material	Weekly inspection	10	6	6
3	Scaffolding not inspected	Scaffold collapsed	Late inspection	Inspection checklist	10	6	6
4	Not wearing safety shoes	Leg injuries	Lack of supervision	Field surveillance	8	7	6
5	Not wearing a vest	Hit by heavy equipment	Employee negligence	Safety briefing	8	6	6
6	Expired Fire	Unhandled fires	Less inspection	Fire extinguisher checklist	9	5	6
7	Slippery work area	Slipped	Poor housekeeping	Area cleaning	8	5	6
8	Stacked material	Tripping	Poor arrangement	5R	7	6	5
9	Toolbox Meeting is late	Lack of hazard information	Low discipline	Toolbox schedule	6	6	5
10	Poor housekeeping	Unsafe environment	Lack of supervision	Cleaning Schedule	6	5	5
11	HIRADC has not been updated	Unidentified risks	Administration	Document review	8	4	4
12	Late Work Permit	Unlicensed work	Poor coordination	Approval SPK	7	4	4

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Yes	Failure Mode	Effect	Cause	Existing Control	S	O	D
13	Safety Induction has not been done yet	Workers don't understand the risks	New hires	Initial training	8	3	4
14	Incomplete P3K box	Late handling	Slow procurement	P3K Inspection	6	3	4
15	Closed evacuation lanes	Evacuation hampered	Project materials	Safety Patrol	8	2	4
16	Open power cord	Electrocution	Less maintenance	Electrical inspection	9	2	3
17	Project waste	Dirty environment	Housekeeping	Cleaning	5	3	3
18	Late crane inspection	Tool failure	Less schedule	Preventive Maintenance	9	2	2
19	Less inspection documentation	Incomplete data	Administration	Document review	4	3	2
20	Less K3 signs	Unclear hazard information	Procurement	Signage installation	5	2	2

Based on the results of SMK3's internal audit at PT Total Bangun Persada Tbk – Koeni Hotel Semarang Project, a risk analysis was carried out using *the Failure Mode and Effect Analysis* (FMEA) method to identify potential failures, impacts, causes, and effectiveness of the controls that have been implemented. The risk assessment is carried out based on three parameters, namely *Severity* (S), *Occurrence* (O), and *Detection* (D), which are used in the calculation of *the Risk Priority Number* (RPN) as the basis for determining improvement priorities.

The results of the analysis showed that there were 20 *failure modes* which included aspects of the use of PPE, safety facility conditions, work procedures, and K3 administration. The highest severity risk was found in *failure mode* not wearing a safety helmet, with values *of Severity* 9, *Occurrence* 8, and *Detection* 7, indicating the potential for serious injury due to low compliance with PPE use and limited supervision. In addition, *the safety net* is damaged and *the scaffolding* is not inspected with *Severity* 10, *Occurrence* 6, and *Detection* 6 values, making it a critical risk to work at height.

Some other risks such as not wearing safety shoes, not wearing safety vests, expired *fire extinguishers*, and slippery work areas also indicate the level of risk that needs to be controlled. In general, the identification results show that most of the *failure modes* come from *unsafe actions* and *unsafe conditions*, so the improvement of the implementation of SMK3 needs to be focused on strengthening *safety culture*, field supervision, worker training, and improving safety facilities. The results of the FMEA analysis are then used as the basis for calculating the RPN to determine the priority of corrective actions to increase the effectiveness of the implementation of SMK3 and create a safer working environment in the Koeni Hotel Semarang Project.

Table 6. Ranking Risk Priority Number (RPN)

Ranking	Failure Mode	RPN
1	Not wearing a helmet	504
2	Safety net broken	360
3	Scaffolding not inspected	360
4	Not wearing safety shoes	336
5	Not wearing a vest	288
6	Expired Fire	270
7	Slippery work area	240
8	Stacked material	210
9	Toolbox Meeting is late	180
10	Poor housekeeping	150
11	HIRADC has not been updated	128
12	Late Work Permit	112
13	Safety Induction has not been done yet	96
14	Incomplete P3K box	72
15	Closed evacuation lanes	64
16	Open power cord	54
17	Project waste	45

Ranking	Failure Mode	RPN
18	Late crane inspection	36
19	Less inspection documentation	24
20	Less K3 signs	20

The results of the *Risk Priority Number* (RPN) analysis using *the Failure Mode and Effect Analysis* (FMEA) method show that the highest risk in the Koeni Semarang Hotel Project is non-compliance with the use of safety helmets with an RPN value of 504. The next risk is that the *safety net* is damaged and *the scaffolding* is not checked with an RPN value of 360 each, which has the potential to cause accidents at work at height. Other risks to consider include not wearing safety shoes (336), not wearing safety vests (288), expired *fire extinguishers* (270), and slippery work areas (240). In general, the dominant risk comes from *unsafe action* and *unsafe conditions*, so it is necessary to improve *safety culture*, field supervision, periodic inspections, and worker compliance with K3 procedures. The results of the RPN rating are used as the basis for the preparation of *an action plan* to increase the effectiveness of the implementation of SMK3 and reduce the potential for work accidents.

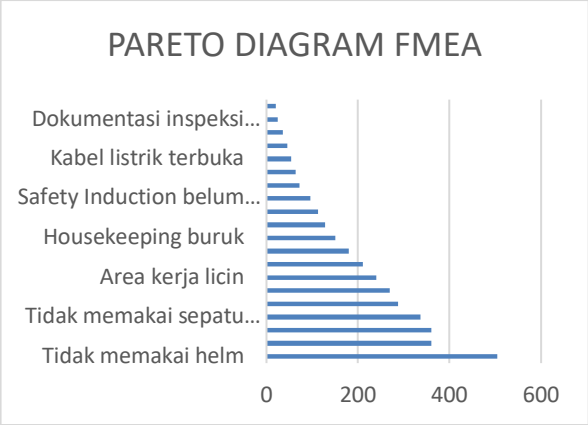


Figure 3. Pareto Diagram FMEA

Analysis of Improvement Recommendations

Table 7. SMK3 Repair Recommendations

Problems	Causes	Recommendations
Mixed B3 waste	Lack of supervision	Addition of daily inspections
B3 bin is less	Inadequate facilities	Addition of B3 facilities
Housekeeping has not been consistent	Low employee discipline	Reward and punishment programs
Non-standard job security	Less supervision	Regular evaluation of supervisors
Improper placement of tools	Limited work area	Material zoning arrangements

Based on the results of SMK3's internal audit on the construction project of the KoeniKoeni Hotel Semarang, the improvement recommendations are focused on B3 waste management, the provision of safety facilities, the implementation of *housekeeping*, supervision of safety facilities, and the regulation of work areas. Improvements were made through increased inspections by supervisors and HSE teams, the addition of facilities such as B3 waste sites, *spill kits*, and *secondary containment*, as well as the implementation *of a reward* and *punishment* system to improve worker discipline. In addition, regular evaluations of *safety signage*, safety fences, *safety* nets, *scaffolding*, and work area *zoning arrangements* are required to support project safety and efficiency. The implementation of these recommendations requires management commitment through continuous monitoring and evaluation so that the implementation of SMK3 can become a consistent work culture.

DISCUSSION

The internal audit results indicate that the implementation of the Occupational Safety and Health Management System (SMK3) at the Hotel KoeniKoeni Semarang construction project was generally well established, with a compliance level of 91.67%. However, the presence of non-conformities despite the high compliance level indicates a gap between the formal implementation of safety requirements and their practical application at the worksite. This finding suggests that a high level of management-system compliance does not necessarily guarantee

consistent safety performance in daily construction activities. Similar findings have been reported by Ahamed and Mariappan (2023), who identified human-related errors associated with PPE use, safety training, and safety supervision at different organizational levels in construction projects. Their findings demonstrate that safety problems may arise from the interaction of errors committed by management, safety supervisors, and workers rather than from a single source. In the present study, this condition is reflected in the remaining non-conformities related to PPE compliance, safety facilities, and worksite conditions. Therefore, the high audit score should be interpreted as evidence that the basic SMK3 system has been established, while further improvement is still required to ensure consistent implementation at the operational level (Nazeer Ahamed & Mariappan, 2023).

The identified non-conformities further indicate that safety performance was influenced by both unsafe actions and unsafe conditions. Unsafe actions were particularly associated with PPE non-compliance, whereas unsafe conditions included damaged safety facilities and inadequate inspection of work equipment. The Fishbone analysis showed that these problems were associated with Man, Machine, Method, Material, and Environment factors, indicating that safety performance was influenced by the interaction of behavioral, technical, procedural, and environmental factors. This interpretation is consistent with Ahamed and Mariappan (2023), who found that inadequate PPE use and poor safety supervision were associated with multiple contributing errors across management, supervisors, and workers. The finding also emphasizes that corrective actions should not focus solely on workers' behavior, but should address the organizational and supervisory conditions that influence such behavior. In this context, strengthening safety monitoring, worker coaching, enforcement of PPE requirements, and the condition of safety facilities is necessary to reduce the recurrence of non-conformities.

The FMEA results provide a further basis for distinguishing which non-conformities require the greatest attention. The failure mode of not wearing a safety helmet obtained the highest RPN of 504, followed by damaged safety nets and uninspected scaffolding, each with an RPN of 360. The high RPN of helmet non-compliance reflects the combined influence of severity, occurrence, and detection, rather than the frequency of the finding alone. This result is particularly important because the audit recorded repeated helmet non-compliance, while existing safety monitoring was not fully effective in detecting every violation. The importance of prioritizing work-at-height risks is also supported by Uchoa et al. (2019), who applied FMEA to construction activities at height and identified 65 failure modes, with 49.2% classified as moderate risk and 35.4% as high risk. These findings are consistent with the present study, where damaged safety nets and uninspected scaffolding were among the highest-priority failure modes. However, the present study extends this approach by applying FMEA specifically to non-conformities identified through an internal SMK3 audit, thereby linking actual audit findings with risk-based prioritization (Uchoa et al., 2019).

The integration of internal audit and FMEA therefore provides a structured basis for improving SMK3 implementation. Internal audit identifies whether safety requirements are being fulfilled and reveals the types of non-conformities occurring in the workplace, while FMEA evaluates the relative priority of those findings based on severity, occurrence, and detection. Previous research has demonstrated the usefulness of FMEA for prioritizing construction safety risks, particularly for work-at-height activities. The contribution of the present study lies in connecting the two approaches so that audit findings are not treated as equally important corrective actions. Instead, the findings are further analyzed according to their risk characteristics and translated into targeted improvement priorities. The results indicate that corrective actions should simultaneously address worker behavior, supervision, equipment inspection, and safety-facility maintenance. Thus, the integration of internal audit and FMEA provides a practical risk-based mechanism for directing corrective resources toward the most critical SMK3 deficiencies and supporting continuous improvement of safety performance at the construction-project level.

CONCLUSION

This study demonstrates that the implementation of SMK3 in the KoeniKoeni Hotel Semarang construction project managed by PT Total Bangun Persada was generally well implemented, with 22 of 24 audited SMK3 elements meeting the established requirements and an overall compliance rate of 91.67%. The environmental assessment also showed good performance, with a score of 3.860 out of 4.00. However, the audit identified 20 field non-conformities involving PPE compliance, safety facilities, housekeeping, work procedures, and safety administration. These findings indicate that a high level of overall compliance does not necessarily eliminate operational safety deficiencies at the workplace.

The integration of internal safety audit findings with FMEA provided a systematic basis for prioritizing corrective actions according to risk. The highest-priority failure mode was workers not wearing safety helmets, with

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an RPN of 504, followed by damaged safety nets and uninspected scaffolding, each with an RPN of 360. Other important priorities included failure to wear safety shoes (RPN 336), failure to wear safety vests (RPN 288), expired fire extinguishers (RPN 270), and slippery work areas (RPN 240). These results demonstrate that the most critical deficiencies were predominantly associated with unsafe actions and unsafe conditions rather than solely with administrative non-compliance.

The main factors contributing to SMK3 non-conformities were identified as worker-related factors, inadequate supervision, and limitations in safety facilities and infrastructure. Therefore, corrective actions should focus on strengthening PPE compliance, increasing field supervision and periodic inspections, improving safety facilities, enhancing worker training and safety induction, maintaining housekeeping, and ensuring continuous monitoring of safety performance. The integration of internal safety audits and FMEA contributes a risk-based decision-making framework that enables construction project management to move beyond identifying non-conformities toward objectively prioritizing corrective actions and allocating improvement resources to the most critical safety issues.

Future studies may apply the proposed approach to multiple construction projects and incorporate a broader range of safety performance indicators or alternative risk-prioritization methods to improve the robustness and generalizability of the proposed framework.

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