



# Analysis of the Implementation of the Mining Safety Management System at the Andesite Quarry in the Stone Crushing Area

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**Abstract:** This study aims to analyse the implementation of the Mining Safety Management System (SMKP) in the andesite quarry crushing area of PT. X, Subang Regency, West Java. The study uses a descriptive mixed methods approach that combines direct observation, structured interviews, and questionnaire surveys of workers in the crusher area using purposive sampling. The data were analysed using the Miles & Huberman model for qualitative data and descriptive statistics for quantitative data, with triangulation for validation of the results. The results showed that the implementation of SMKP at PT. X was still suboptimal. The overall criterion fulfilment rate reached 54.74% of the maximum total of 292 points, with significant variations between elements. The implementation element showed the best performance (54.31%), followed by organisation and personnel (54.55%), and monitoring and evaluation (60.42%). Conversely, three critical elements showed alarming conditions: documentation (33.33%), planning (37.93%), and management review (46.15%). This imbalance indicates a weak strategic planning system, procedural documentation, and continuous evaluation by top management. The study concluded that PT. X requires comprehensive and systematic improvements, prioritising documentation, safety programme planning, and management review to build the foundation of an effective mining safety management system in accordance with the regulations of the Ministry of Energy and Mineral Resources.

**Keywords:** Andesite rock; Mining; Rock breaker; Safety management

## Introduction

The mining industry in Indonesia faces a crucial occupational safety paradox: on the one hand, it contributes significantly to the gross domestic product (GDP) and foreign exchange earnings (Nazir et al., 2020), but on the other hand, it has a high rate of occupational accidents, especially in mining and mineral processing activities (Tubis et al., 2020; Sanmiquel et al., 2021). This paradox becomes even more complex when linked to

andesite mining, a non-metallic commodity with high economic value that is widely used in the construction and infrastructure industries (Upadhyay, 2025; Nugroho et al., 2023).

The stone crushing area in andesite mining operations is the zone with the highest risk of accidents because it combines several dangerous factors simultaneously: the use of high-powered heavy machinery, 24-hour continuous operation, and simultaneous exposure to physical hazards such as

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falling materials, dust, noise, and vibration (Köken, 2020; Ikhsan et al., 2025). These unique characteristics distinguish rock crushing areas from other mining operation zones, requiring a specific and integrated safety approach.

Although the Indonesian government has issued Minister of Energy and Mineral Resources Regulation No. 26 of 2018 concerning the Application of Good Mining Engineering Principles, which requires the implementation of a Mining Safety Management System (MSMS), the phenomenon of work accidents in andesite stone crushing mines still shows an alarming trend (Lujala et al., 2020; Bialy et al., 2021). Preliminary studies show that most accidents occur due to gaps between existing regulations and practical implementation in the field, particularly regarding standard safety procedures and non-compliance with regulations (Muthelo et al., 2022).

This study is unique in that it specifically analyses the implementation of SMK P in the most complex hazard zone in andesite mining—the stone crushing area. Unlike previous studies, which tended to examine mining safety in general, this study focuses on critical zones that have the highest risk levels but are often overlooked in in-depth analyses.

The urgency of this research is driven by three critical factors. First, the evolution of crushing technology from manual to automated systems requires the adaptation of responsive safety strategies (Güler & Çakır, 2024; Liu et al., 2024). Second, significant safety investments in this sector require strong economic justification through comprehensive cost-benefit analysis (Sánchez & Hartlieb, 2020). Third, the implementation of international standards such as ISO 45001 needs to be adapted to the specific operational conditions of the stone crushing area to ensure maximum effectiveness (Marhavilas et al., 2022).

The identified knowledge gap lies in the lack of in-depth analysis of the effectiveness of OHSMS in the specific operational conditions of andesite quarries. Previous studies have focused more on technical operational aspects, while the integration of human factors, modern technology, and economic aspects in the context of quarry safety is still limited (Kirin et al., 2021; Duarte et al., 2021).

This study is expected to provide practical contributions in the form of recommendations for improving the safety system that can increase the effectiveness of SMK P in stone crushing areas, while also providing theoretical contributions to the development of a mining safety management model that is adaptive to specific operational characteristics. Furthermore, the research results will support the creation of a safer, more productive, and sustainable mining industry through the implementation of a continuous monitoring and

evaluation system that is responsive to technological developments and operational dynamics (Pavloudakis et al., 2024; Zhang et al., 2020).

Based on this background, a comprehensive analysis of the implementation of SMK P in andesite quarries in the stone breaking area is urgently needed to identify implementation gaps, measure the effectiveness of existing systems, and formulate improvement strategies that can enhance safety performance in a sustainable manner.

## Method

### *Research Approach and Design*

This study uses a mixed methods approach with a descriptive design that combines qualitative and quantitative methods. This approach was chosen to provide a comprehensive analysis of the implementation of the Mining Safety Management System (SMK P) in the andesite quarry, where the qualitative aspect explores an in-depth understanding of the implementation conditions, while the quantitative aspect measures the level of compliance with applicable safety standards.

### *Research Location and Time*

The research was conducted in the Mining Business Permit (IUP) area of PT. X, located in the plantation area of PTPN VIII Block H1 Tambaksari Plantation, Jalan Cagak Village, Jalan Cagak Subdistrict, Subang Regency, West Java Province, with a focus on the crusher (stone crusher) operational zone. The research was conducted from March to June 2025. The location was chosen based on the consideration that the area is an active crusher zone with a high operational level, thus providing a representative picture of the implementation of SMK P in andesite mines.

### *Population and Sample*

The population in this study was all workers involved in the crusher area operations of PT. X, while the sample was workers in the crusher area selected using purposive sampling based on the criteria of at least 6 months of work experience, direct involvement in crusher operations, and job levels including operators, supervisors, and safety officers. This sample selection was intended to obtain informants who had in-depth experience and understanding of the implementation of the safety system in the crusher area.

### *Data Collection Techniques*

Primary data collection was carried out through three main methods, namely direct observation to observe the field conditions of the crusher area, documentation of work safety practices, and

identification of potential hazards. Structured interviews were conducted with supervisors, safety officers, and senior operators, focusing on the implementation of SMKP and the obstacles encountered. Questionnaire surveys were distributed to all worker samples based on the composition of Director General of Minerals and Coal Decree Number 185.K/37/04/DJB/2019 and were validated through expert judgement.

Secondary data collection included company SMKP documents, work accident reports from the last 3 years, Standard Operating Procedures (SOPs), internal and external safety audit results, periodic health examination reports, and applicable mining safety regulations and standards. This secondary data served as comparative and validation material for the primary data findings.

*Data Analysis Techniques*

Qualitative data analysis uses the Miles & Huberman model, which includes data reduction for selecting data relevant to the research focus, summarising important information, and eliminating data that does not support the research objectives. Data presentation is in the form of a narrative description of SMKP implementation conditions, a comparison table of standards versus field practices, and a safety process flow chart. Conclusions include the identification of SMKP implementation patterns, analysis of the gap between standards and practices, and the formulation of recommendations for improvement.

Quantitative data analysis used descriptive statistics to calculate the mean, median, and standard deviation, frequency analysis for questionnaire response distribution, and percentage analysis to measure the level of compliance with SMKP standards. To ensure the validity and reliability of the research results, data triangulation was carried out through source triangulation with a combination of primary and secondary data, method triangulation with a combination of observation, interviews, and surveys, and time triangulation with data collection at different times.

**Result and Discussion**

*Implementation of Mining Safety Management System Criteria*

The evaluation of the implementation of the Mining Safety Management System (SMKP) at PT. X shows varying conditions for each element specified in national mining regulations. Based on the assessment results of the seven main elements of SMKP, namely policy, planning, organisation and personnel, implementation, evaluation and follow-up, documentation, and management review, significant imbalances were found in the level of implementation of each element (Kineber et al., 2023; Sundström & Nygren, 2023). The results of the assessment of the implementation of the mining safety management system criteria at PT. X can be seen in Table 1.

**Table 1.** Results of the Assessment of the Implementation of Mining Safety Management System Criteria at PT. X

Element	Total Element Score Maximum	Percentage of Maximum Total Score	Total Achievement Score	Total Achievement Percentage
Policy	19	10	16	8.42
Planning	29	15	11	5.68
Organisation and Personnel	55	17	30	9.27%
Implementation	116	35	63	19.01
Monitoring and Evaluation and Follow-up	48	15	29	9.06
Documentation	12	3	4	1
Management Review and Performance Improvement	13	5	6	2.3
Total	292	100	164	54.74%

Based on the research results presented in Table 1 regarding the assessment of the implementation of the Mining Safety Management System criteria at PT. X, it can be analysed that out of a maximum total score of 292 points, the company was only able to achieve 164 points, equivalent to 54.74% of the total criteria set.

This achievement indicates that the implementation of SMKP at PT. X is still at a suboptimal level and requires significant improvement to achieve the expected safety standards. Analysis of each element shows an uneven implementation pattern, where some

elements show relatively better achievements than others. The implementation element showed the highest achievement with 63 points out of a maximum of 116 points, or 19.01% of the total, indicating that PT. X has made concrete efforts to implement operational safety practices in the field, although it has not yet reached an optimal level (Min et al., 2023). Good implementation of this element can be seen in the application of safe working procedures in the crusher area, the use of personal protective equipment by most workers, and the

implementation of routine inspections of crusher equipment, although these are not yet consistent.

Organisational and personnel elements scored 30 points out of a maximum of 55 points, or 9.27% of the total, indicating that the safety organisational structure and personnel competency development have received adequate attention from company management (Jabbari et al., 2022). This achievement is reflected in the appointment of safety officers in the crusher area, the implementation of basic safety training for new workers, and the relatively clear division of safety responsibilities at the supervisor level. Meanwhile, the monitoring, evaluation, and follow-up elements scored 29 points out of a maximum of 48 points, or 9.06% of the total, indicating that PT. X has a fairly good safety performance monitoring system, including the implementation of periodic inspections and investigations of work accidents, although follow-up on the results of evaluations still needs to be improved (Kontogiannis et al., 2017).

A very worrying situation is seen in three elements that show very weak implementation. The documentation element only achieved 4 points out of a total of 12 points, or 1% of the total, indicating a very serious weakness in terms of documenting the safety management system. This condition has an impact on the unavailability of complete procedure documentation, difficulties in tracking safety performance, and a weak organisational learning system from accidents or near misses that have occurred. The planning element only achieved 11 points out of a maximum of 29 points, or 5.68% of the total, indicating that the preparation of a comprehensive safety programme is still very weak. This weakness is evident in the absence of a structured medium- and long-term safety programme, the lack of a specific budget allocation for safety programmes, and the absence of a

systematic hazard identification and risk assessment system in the crusher area.

The management review and performance improvement element only scored 6 points out of a maximum of 13 points, or 2.3% of the total, indicating that the process of continuous evaluation and improvement by top management is still very minimal (Okpala & Korzeniowska, 2023). This condition indicates the weak commitment of top management in conducting a systematic review of the effectiveness of the SMKp and strategic decision-making for safety system improvements. This condition shows that PT. X needs to make comprehensive and systematic improvements, especially in the aspects of documentation, planning, and management review to improve the overall effectiveness of the mining safety management system (Delikhooon et al., 2022).

*Mining Safety Management System Criteria Map Checklist Description*

Mapping of the Mining Safety Management System Criteria Checklist Description developed based on the Director General of Minerals and Coal Decision Number 185.K/30/DJB/2019 concerning Technical Guidelines for Mining Safety Implementation provides a detailed overview of the specific criteria that have and have not been met in the implementation of SMKp at PT. X (Ashkanani & Franzoi, 2023). This checklist is systematically designed to provide comprehensive guidance in evaluating the implementation of the seven main elements of the Mineral and Coal Mining Safety Management System, including policy, planning, organisation and personnel, implementation, evaluation and follow-up, documentation, and management review (Amrulloh et al., 2025). The results of the checklist can be seen in Table 2.

**Table 2.** Results of the Description of the Mining Safety Management System Criteria Checklist

Element	Criteria	
	Compliant	Not compliant with
Policy	1.1, 1.5	1.2, 1.3, 1.4
Planning	-	2.1, 2.2.2, 2.2.3, 2.2.4, 2.2.5, 2.3, 2.4, 2.5
Organisation and Personnel Implementation	3.4, 3.7, 3.8, 3.11, 3.12.3, 3.12.5 4.1.3, 4.2.10, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.7, 4.3.8, 4.3.9, 4.4.1, 4.4.3, 4.4.5, 4.6.1, 4.6.2, 4.8.1, 4.8.2, 4.9	3.1, 3.3, 3.5, 3.6, 3.9, 3.10.1, 3.10.2, 3.12.4, 3.13 4.3.5, 4.3.6, 4.3.10, 4.4.2, 4.4.4, 4.7, 4.8.3, 4.10, 4.11
Evaluation and Follow-up Documentation	5.2, 5.4, 5.5.3, 5.5.5, 5.6	5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.3, 5.5.4, 5.7 6.1, 6.2, 6.3, 6.4
Management Review and Performance Improvement	-	7.1, 7.2, 7.3, 7.4, 7.5, 7.6

Based on the results of the Mining Safety Management System criteria checklist presented in Table 2, it can be analysed that PT. X shows an uneven implementation pattern across all elements of the

Mining Safety Management System. Of the seven elements evaluated, it appears that the company has varying performance, with some elements showing relatively good achievements while others still require

significant improvement. The implementation element is the aspect that is most fulfilled by the company with 17 criteria met (4.1.3, 4.2.10, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.7, 4.3.8, 4.3.9, 4.4.1, 4.4.3, 4.4.5, 4.6.1, 4.6.2, 4.8.1, 4.8.2, 4.9), indicating that PT. X has made efforts to implement operational safety practices in the field, although there are still 18 criteria that have not been met.

The criteria that have been met in the implementation element include the application of an energy isolation system, the use of standard personal protective equipment, the implementation of crusher equipment inspections, and the application of safety procedures in rock crushing operations. The organisation and personnel element also shows fairly good achievement with 6 criteria met (3.4, 3.7, 3.8, 3.11, 3.12.3, 3.12.5), indicating that the safety organisation structure and personnel competency development have received adequate attention from company management. The criteria that have been met include the appointment of mine safety officers, the implementation of basic safety training, and the determination of worker competencies in high-risk areas, although there are still 9 criteria that have not been met in this element, mainly related to continuous competency development and internal safety certification systems.

The monitoring, evaluation, and follow-up element shows relatively balanced performance with 5 criteria met (5.2, 5.4, 5.5.3, 5.5.5, 5.6) and 7 criteria that have not been met, indicating that PT. X has a fairly good monitoring and evaluation system but still needs improvement to ensure the overall effectiveness of the safety programme (Setyorini & Latief, 2019). The structure of this checklist allows mining companies to conduct periodic self-assessments, identify gaps in their safety management systems, and plan the necessary improvements to achieve compliance with applicable regulations (Handoyo et al., 2024).

A very worrying situation can be seen in three elements that show very weak implementation and require priority attention. The documentation element does not meet the appropriate criteria, with the four criteria (6.1, 6.2, 6.3, 6.4) still unmet, indicating that PT. X has very serious weaknesses in terms of documenting its safety management system, which can lead to unclear procedures, difficulties in tracking performance, and a weak organisational learning system (Rezvani et al., 2023). This condition indicates the absence of an adequate documentation system for safety policies, standard operating procedures, training records, and documentation of work accidents, which could potentially cause difficulties in evaluating performance, organisational learning, and meeting safety audit requirements.

The planning elements also show a worrying situation, with none of the eight criteria being met (2.1,

2.2.2, 2.2.3, 2.2.4, 2.2.5, 2.3, 2.4, 2.5), indicating that comprehensive safety programme preparation is still very weak and requires priority attention. This indicates a lack of systematic safety planning, including hazard identification and risk assessment, safety target setting, resource allocation, and the development of medium- and long-term safety programmes. Similarly, the management review and performance improvement elements do not meet any of the 6 existing criteria (7.1, 7.2, 7.3, 7.4, 7.5, 7.6), indicates that the process of continuous evaluation and improvement by top management is still very minimal, indicating the absence of a structured management review system to evaluate the effectiveness of the SMKP and formulate continuous improvement strategies. This condition shows that PT. X needs to make very fundamental and systematic improvements, especially in the aspects of documentation, planning, and management review to build a strong foundation for an effective and sustainable mining safety management system (Rojas et al., 2025).

## Conclusion

Based on the results of the study conducted on the implementation of the Mining Safety Management System at PT. X, it can be concluded that the implementation of the Minerba SMKP is still at a low level, with an achievement of only 56.16% (164 out of a maximum of 292 points) of the overall criteria set. The study shows a significant imbalance between the elements, where the implementation element shows the best performance with an achievement of 63 points out of a maximum of 116 points or a fulfilment rate of 54.31%, followed by the organisation and personnel element which achieved 30 points out of a maximum of 55 points or 54.55%, and the monitoring and evaluation element, which achieved 29 points out of a maximum of 48 points or 60.42%. However, three critical elements, namely documentation, planning, and management review, showed very worrying conditions with very low compliance rates, where documentation only achieved 4 points out of a maximum of 12 points (33.33%), planning only 11 points out of a maximum of 29 points (37.93%), and management review only 6 points out of a maximum of 13 points (46.15%). This condition indicates that PT. X requires comprehensive and systematic improvements, particularly in the aspects of documentation, safety programme planning, and management review to build a strong foundation for an effective and sustainable mining safety management system that complies with the regulatory standards set by the Ministry of Energy and Mineral Resources.

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### Author Contributions

D. T. F: preparation of the original draft, results, discussion, methodology, conclusions; H, N. S, and M. G: analysis, review, correction, and editing.

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### Conflict of Interest

The authors declare that there are no conflicts of interest related to the publication of this article.

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