Analysis of the Implementation of Job Safety Analysis in Quartz Sand Mining at PT X, Tuban

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Abstract

This study aims to comprehensively analyze the implementation of Job Safety Analysis (JSA) in the quartz sand mining system at PT X, Kerek District, Tuban Regency, East Java Province. Open-pit mining activities take place in a dynamic and fluctuating work environment, creating significant hazards throughout each production cycle. This study uses a qualitative descriptive method involving direct field observations, technical documentation, and in-depth interviews with the Safety Officer and heavy-equipment operators. Risk levels were analyzed and assessed using Likelihood and Severity parameters based on the AS/NZS 4360 risk management standard and ISO 45001. Hazard identification across four main observation areas—the mechanical condition of excavation, loading, and hauling equipment; workforce operating behavior; loading methods; and haul-road geometry—showed that all identified risks were categorized as High Risk, accounting for a cumulative 100%. The dominant risks included collisions between heavy equipment due to limited visibility, workers being struck in blind-spot areas, road subsidence or vehicle skidding on haul roads, and low compliance with the use of personal protective equipment (PPE). Based on these findings, corrective-action recommendations were developed using the hierarchy of risk controls (engineering controls, administrative controls, and PPE) to reduce operational risks to an acceptable level (As Low as Reasonably Practicable) and achieve safe and sustainable operational excellence.

Keywords: *Hierarchy of controls; Job Safety Analysis (JSA); Quartz sand mining; Risk assessment; Open-pit mining.*

1. Introduction

The mining industry is an economic pillar that is capital-intensive, technology-intensive, and inherently high-risk [1]. Globally and nationally, it is classified as an industry with a very high risk of occupational accidents [2]-[3]. Working conditions in open-pit mining are strongly influenced by uncertain geotechnical conditions, extreme weather changes, the use of large mechanical equipment, and intensive interactions between people and machines. Inadequate control of these factors can lead to serious workplace accidents, fatalities, and occupational diseases that adversely affect business continuity.

According to 2023 statistics from Minerba One Indonesia (MODI) of the Ministry of Energy and Mineral Resources (ESDM), Indonesia's mining areas recorded 105 minor accidents, 65 serious accidents, and 48 fatal incidents resulting in worker deaths [4]. This is a strong warning that occupational safety and health (OSH) must no longer be viewed merely as a means of legal compliance with government regulations, but must be embedded as a fundamental necessity and part of corporate risk-mitigation strategy [5].

To minimize incident rates, modern mining safety management emphasizes a proactive rather than reactive approach. One management tool that has proven effective in identifying hazards at the frontline is Job Safety Analysis (JSA). JSA is a structured method for identifying potential physical, chemical, and ergonomic hazards at each stage of a job, and then formulating the most effective control

measures before the work is performed. Consistent JSA implementation helps mitigate two major causes of accidents: unsafe acts by workers and unsafe environmental conditions [6].

PT X is a private company engaged in non-metallic mineral mining, focusing on quartz sand (silica) extraction in Kerek District, Tuban Regency, East Java. With a Mining Business License (IUP) area of 33.62 hectares, PT X operates an open-pit mining method involving intensive use of heavy equipment such as excavators and dump trucks. Given that quartz sand material tends to be unstable and dusty, and that a comprehensive evaluation of on-site occupational safety effectiveness has not yet been conducted, analyzing JSA implementation is essential. This study aims to identify gaps between written JSA documents and actual field implementation in order to formulate safer mining improvement recommendations in accordance with Good Mining Practice.

2. Method

2.1 Overview of the Study Area

PT X is committed to optimizing its high-quality non-metallic mineral resources, namely quartz sand, to supply the cement, glass, and construction industries in East Java. Administratively, the company's 33.62-hectare IUP area covers Hargoretno Village and Tengger Wetan Village, Kerek District, Tuban Regency, East Java Province.

The mining site can be reached by two main land routes:

From Surabaya (the provincial capital): approximately 106 km to the northwest along the North Coast Highway (Pantura), with a normal travel time of around 3 hours and 44 minutes by car.

From Tuban Regency town square: approximately 29.5 km to the west, with a travel time of around 47 minutes via regency roads, most of which are paved.

Based on detailed exploration using core drilling at eight locations, each with a hole depth of approximately 20 meters, PT X has substantial quartz-silica resources and reserves. The calculated reserve volume reaches 19,777,944 tonnes, equivalent to 7,463,375 m^3, supporting a long mine life.

2.2 Regional Geology and Physical Environmental Conditions

Physiographically, the study area lies within the Rembang Zone (Rembang anticlinorium), which is dominated by east–west-trending folded hills. The geological structures controlling the Kerek District area are relatively complex and include intensive joint patterns, the Meliwang anticline, and indications of a regional thrust fault.

The regional stratigraphic sequence, from the oldest to the youngest rock units, is as follows:

Tuban Formation: composed of alternating claystone and sandy limestone lithologies rich in shallow-marine fossils.

Paciran Formation: dominated by reef limestone, dolomitic limestone, and chalk that have undergone intensive karstification.

Terarosa Deposit Unit: a reddish-brown Holocene weathering-soil layer containing accumulated silica/quartz material derived from the leaching of the underlying parent rock.

The topographic elevation of PT X's mining area ranges from approximately 250 to 315 meters above sea level, with undulating karst hills. Seasonal rainfall in Tuban Regency affects the condition of the mine's surface soil, making it slippery and muddy during the rainy season and very dusty during the dry season.

2.3 Mining System Stages

PT X applies open-pit quarry mining using a benching system. The daily mining sequence includes:

[Land Clearing] ➔ [Overburden Stripping] ➔ [Digging & Loading] ➔ [Hauling]

Land Clearing: Removal of shrubs and local trees, as well as leveling of surface boulders, using a Komatsu D85E-12 bulldozer.

Overburden Stripping: Topsoil and overburden are removed using a Komatsu PC200-10M0 excavator, then loaded into a Hino Dutro 130 HD dump truck and transported to a designated dumping area.

Digging & Loading: Because some quartz sand deposits are relatively well cemented and hard, initial breaking is carried out using a Komatsu PC200-10M0 excavator breaker. Once the material has been broken into loose fragments, an excavator equipped with a bucket loads it directly into the haul-truck body.

Hauling: Loaded quartz sand is transported to a temporary stockpile or washing plant using three Hino Dutro 130 HD dump trucks.

2.4 Approach and Data Collection

This study uses a field-based qualitative descriptive method. The qualitative approach was selected to examine socio-technical occupational safety phenomena, human behavior, and structural barriers to safety implementation naturally and in depth, without manipulating variables at the mining site.

Data Collection Methods

Primary Data:

Field Observation: Direct shadowing of mine crew operating behavior, interactions between heavy-equipment operators and field checkers, the physical condition of equipment cabins, and haul-road geometry.

Structured Interviews and Focus Group Discussions (FGDs): Intensive direct interviews with the Safety Officer responsible for OSH, field supervisors (foremen), and mechanical-equipment operators to understand their knowledge of the JSA documents.

Documentation: Aerial and ground photographs documenting actual physical hazards at the mine site.

Secondary Data: Company regulatory documents, equipment specifications, internal standard operating procedures (SOPs), rainfall reports, and the PT X IUP boundary map.

2.5 Data Analysis and Risk Assessment Matrix

Risk assessment in this study was quantified using a Risk Matrix based on the international references AS/NZS 4360 and ISO 45001. The risk index is determined using the following equation:

Likelihood is rated on a scale from 1 (very rare) to 5 (almost certain). Severity is rated from 1 (insignificant/minor injury with no lost workdays) to 5 (catastrophic/fatality). The resulting scores are grouped into three risk-significance zones: Low Risk (scores 1–4), Moderate Risk (scores 5–12), and High Risk (scores 15–25).

3. Results and Discussion

3.1 Actual Implementation of JSA at PT X

Document investigation and comparison with field conditions indicate that PT X has formally prepared Job Safety Analysis (JSA) documents for several core activities. However, these documents tend to serve merely as supporting materials for internal audits and are rarely updated to reflect constantly changing field conditions. The evaluation focused on four critical operational components: heavy-equipment mechanical reliability, operator safety behavior, compliance with loading methods, and standardization of haul-road infrastructure.

The risk-matrix tabulation of fundamental field hazards produced a striking result: all identified major hazards were classified as High Risk (risk score ≥ 15), with the proportion of findings reaching 100%. This 100% High Risk result indicates a systemic failure to reduce residual risk after initial preventive measures, leaving the mine site vulnerable to occupational accidents.

3.2 Analysis of Major Potential Hazards

3.2.1 Physical Condition of Excavation, Loading, and Hauling Equipment

Field observations found that a Komatsu PC200-10M0 excavator had been operated for an extended period despite its front operator-cabin windshield being shattered and heavily cracked. Allowing this condition to persist creates several related hazards:

The operator's visibility is drastically reduced, especially in direct sunlight or heavy dust.

Gravel-sized quartz sand fragments may rebound into the cabin and injure the operator's eyes.

In the risk-matrix analysis, this condition was assigned a Likelihood score of 4 (frequent, because the unit operates daily) and a Severity score of 5 (fatal consequences if the operator is struck by glass fragments or involved in a collision), producing a total risk score of 20 (High Risk).

3.2.2 Operator and Personnel Behavior

The weak internalization of a safety culture is reflected in the crew's lack of discipline in the field. Many dump-truck operators deliberately unfasten their seat belts, claiming that they restrict movement and feel hot. In addition, checkers who record truck trips often stand too close to the excavator's swing radius without wearing a high-visibility vest or safety helmet. This behavior places workers in heavy-equipment operators' blind spots and may lead to fatal run-over or impact accidents.

3.2.3 Mine Haul-Road Conditions

Visual measurements indicate that haul-road geometry does not meet the technical standards stipulated in mining safety regulations. PT X's haul roads lack adequate edge-protection bunds (the minimum bund height should be three-quarters of the largest vehicle wheel diameter). In addition, the absence of lateral drainage causes surface water to accumulate on the road during rainfall, turning the soil into slippery mud and increasing the risk of dump trucks losing traction, skidding, or overturning down the mine slope.

3.3 Factors Supporting and Hindering JSA Implementation

To understand the root causes, the following are the factors that support or hinder OSH effectiveness at PT X:

Table 1. the factors that support or hinder OSH effectiveness at PT X

Supporting Factors (Enablers)	Hindering Factors (Barriers)
The existence of a formal OHS (K3) organizational structure staffed by a dedicated Safety Officer.	Limited safety culture awareness among workers; safety rules are perceived as an operational burden.
Management has already established a written basic mining OHS (K3) Standard Operating Procedure (SOP).	The absence of certified OHS (K3) training programs for local operators.
The availability of a basic budget for procuring personal protective equipment (PPE) for permanent employees.	Management appears to prioritize daily production targets over safety considerations.
	The lack of a firm sanction system for those who violate the mine's designated safety boundaries.

3.4 Evaluation of Compliance with National OSH Regulations

When the field findings at PT X are compared with Indonesia's mining regulatory framework—particularly Law No. 1 of 1970 on Occupational Safety, Minister of Energy and Mineral Resources Regulation No. 26 of 2018, and Ministerial Decree No. 1827/K/30/MEN/2018—it can be concluded that PT X has a low level of compliance in its technical implementation in the field.

Although the company may initially appear to meet administrative requirements because it has JSA documents, the essence of these regulations is to provide real physical protection in the field. Allowing damaged heavy equipment to operate, maintaining mine roads without safety bunds, and permitting workers to work without PPE are clear violations of an IUP holder's obligation to implement Good Mining Practice.

3.5 Recommendations Based on the Hierarchy of Controls

To reduce hazards from High Risk to Low Risk, PT X must promptly adopt interventions based on the hierarchy of risk controls:

[Engineering Controls] ➔ [Administrative Controls] ➔ [Personal Protective Equipment]

A. Engineering Controls

Stop Operations and Repair Equipment: Temporarily stop the excavator with the broken windshield and replace it with a new cabin windshield that meets the manufacturer's specifications.

Improve Road Geometry: Compact haul roads using crushed stone (gravel), construct safety bunds along the edges of haul-road slopes at a minimum height of 1 meter, and engineer the road crossfall so that water drains quickly into roadside drainage channels.

B. Administrative Controls

Improve Safety Meetings: Require a 10-minute Toolbox Talk (TBT) every morning before the shift begins to review the JSA sheet for that day's specific activities.

Install Mine Signs: Install maximum-speed signs (for example, Max. 20 km/h), warnings for landslide-prone areas, and restricted-entry signs for unauthorized personnel in loading areas.

Graduated Penalty System: Implement a yellow-card and red-card system for workers who violate OSH rules, such as failing to wear seat belts or PPE.

C. Personal Protective Equipment (PPE)

Management must enforce a zero-tolerance policy for the use of complete PPE in operational areas. Everyone entering the mine face must wear:

An ANSI-standard safety helmet.

Safety shoes/boots with steel toe caps.

A high-visibility safety vest with reflective strips.

A respirator mask to filter silica dust particles that can harm operators' lungs.

4. Conclussion

JSA implementation at PT X has so far met administrative documentation requirements but has failed in practical field implementation. The risk assessment shows that 100% of operational hazards fall into the High Risk category, as indicated by damaged heavy-equipment cabin glass, missing road safety barriers, and disregard for safe work practices.

Factors supporting occupational safety at PT X include the presence of a Safety Officer and written SOP reference documents. However, these are outweighed by barriers such as workers' low awareness of safe behavior (unsafe acts), management's excessive focus on production targets, and inadequate maintenance of mining facilities and infrastructure (unsafe conditions).

Compliance with Minister of Energy and Mineral Resources Regulation No. 26 of 2018 and Ministerial Decree No. 1827/K/30/MEN/2018 in implementing JSA at PT X remains inadequate because field risk controls have not been implemented in accordance with the legally mandated hierarchy of hazard controls.

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