Mine Safety Issues in Quarry Industry: Case Studies of Recent Fatal Accidents in Sri Lanka

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Abstract

Sri Lankan metal quarries supply almost all grades of aggregates throughout the country for the construction industry. But the future of these metal quarries may look bleak owing to the rise in the number of mine accidents being reported. The Geological Survey and Mines Bureau (GSMB) is the main regulatory body that regulates the mineral industry, issues licenses to almost all quarries in Sri Lanka. When considering the industrial mining licenses, there are four types of mining licenses, i.e., type-A, type-B, type-C, and type-D, issued by the GSMB. Of the four types of categories, the multi borehole blasting method can be adopted for type-A and type-B category mining licenses, while the single borehole blasting method is adopted for the type C and type D categories. Of the two types of initiation methods majority of cases with regard to accidents being reported from the single borehole blasting method. But they were not properly documented earlier. However, with the dawn of the Mining Safety Unit, these cases were documented. Of the cases being documented, five cases, i.e., fatalities, occurred due to fly rock, falling to a lower level, collapsing rock overhang on to the people who work underneath it, burning of explosives, and unintentional blasting due to lightning were described in this paper for risk assessment. When these cases are analysed, it is observed that among the contributory factors, excessive face height and human negligence are the most predominant factors for these incidents. At the end, it is mentioned that how this method is unsafe and proposed a multi-hole blasting method under the guidance of a suitable person.

Keywords: Aggregate quarries, Mine accidents, Mine safety

1. Introduction

As a government regulatory body for the mineral industry, the GSMB issues mining licenses for conducting mining activities in quarries in Sri Lanka. For conducting mining activities, the GSMB issues two types of mining licenses, namely Industrial and artisanal mining licenses for all categories of minerals. Of the two types of licenses, the number of artisanal licenses gradually decreases and currently, they are limited to a few due to difficulty in executing blasting activities. In this paper, risk assessment is done for quarries owing to lots of fatalities being reported in quarries. Though lots of mine accidents have occurred in Sri Lankan Metal quarries, they were not properly documented. However, with the inception

of the mine safety unit in the GSMB, these incidents are documented in such a way that it could be helpful for authorities to take appropriate actions to improve the mine safety of these quarries. In this connection, this paper is presented to highlight the number of fatal accidents that occurred in Sri Lankan quarries and what factors contributed to these incidents occurring and who is at risk and what remedial actions should be taken to prevent these incidents. Of all documented cases, five incidents are taken for assessment.

1.1 Case #1

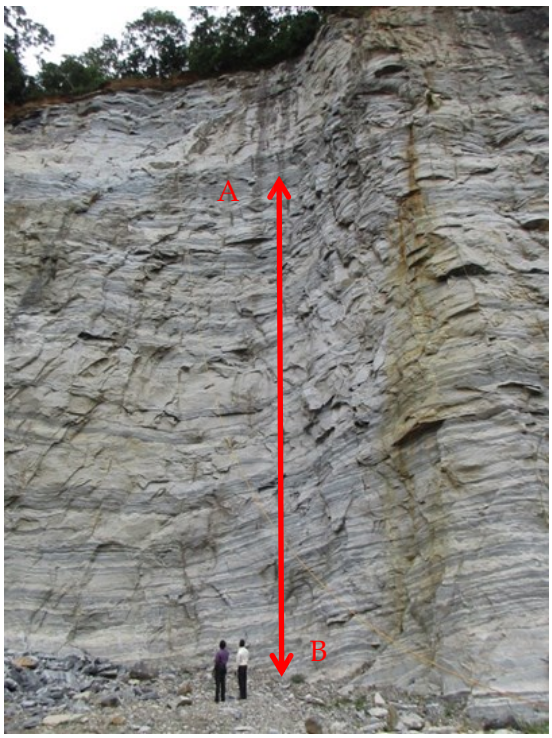

Figure 1: Place of the Incident

A- The place where the Deceased people were engaging in drilling
B- The place where the Deceased people have fallen
AB-70m-80m

Two fatalities were reported in a quarry on 09-07-2021, where the license-IML/C/COL/N/025/R/01 was issued. One of the victims was 42 years old resident of Kaduwela, while the other one was 51 years old resident of Yatiyanthota. Two victims were casual labourers of the quarry and had been working in the quarry for more than ten years. The licensee has been operating the quarry for more than twelve years. It has only one face with a bench height of more than 200 feet. Workers normally reach the top of the face by the ropes since there is no any other access path to reach the blasting location. The place where the incident occurred is shown in Figure 1.

1.2 Case # 2

The quarry where the incident occurred is located Diyagampola GS division of Divulapitiya AGA division of Gampaha District. The GSMB has issued an IML/C/HO/N/9030/LR/5 to this quarry. This incident took place while two employees and the deceased were engaging in removing loosen boulder; suddenly, the loosen bolder started to move down slowly. At that time other two had managed to hold the rope and narrowly escaped with injuries. But the deceased, who was sitting idling at the time, lost his balance and fell under the rubble and was killed. The cause of the death was cited as multiple injuries to the internal organ of the body of the deceased.

1.3 Case # 3

This incident belongs to two quarries located at Paragoda GS division of Divulapitiya AGA division of Gampaha District. The GSMB has issued an IML/C/GM/N/13 & IML/C /GM /N/14 for both quarries, and both licenses were valid when this incident took place. This incident took place when three workers were engaged in welding a metal door inside the explosive storage cabin. While the trio were engaging in welding, sparks came out, and a large fire was broken out inside the cabin. The trio fell victims to the fire.

According to the investigations, it has been revealed that some amount of Black Powder and pieces of safety fuse were laid on the floor of the compartment while they were engaging in welding. Due to sparks, black powder started to burn almost instantaneously. Black Power is a mixture of potassium nitrate, charcoal and

sulfur, which is very sensitive to flams and sparks. Therefore it is undoubtedly said that black powder was ignited by sparks. It is therefore undoubtedly said that considering the severity of the incident, some amount of black powder was stacked on the floor of the compartment at that time.

1.4 Case # 4

The quarry where the incident occurred is located at 399/A Pananwela GS division of Dompe AGA division of Gampaha District. The GSMB has issued an IML/C/GM/N/46 to this quarry. This incident took place when the deceased was removing loosen boulders and suddenly lost his balance and was fallen onto the floor of the quarry and was killed. At the time of the incident, the deceased was not tightened to the rope, and he was fallen at the height of about 15 feet onto the floor. The cause of the death was cited as multiple injuries to internal organs due to falling from a height.

1.5 Case # 5

The quarry where the incident occurred is located at Kalahagala in Thamankaduwa AGA division of Polonnaruwa District. The GSMB has issued an IML/A/HO /1535/LR/8 to this quarry. According to the statements given by workers, this incident took place when they were charging the blast holes thunder shower started at once. At that moment, lightning was being experienced in the area where the quarry is located, and they all except the deceased fled away to the shed in fear. In a few moments, they heard the large explosion at the place where they charged the blast holes, and they only saw the mutilated body of the deceased lying under rubbles. They suspected that blast was triggered by lightning

2. Methodology

In the proceeding chapters, what leading factors contributed to these incidents are highlighted. The objective of this risk analysis is to identify risk factors that are dominant in metal quarries and to find ways to remove these risks. In this connection, risks are analyzed qualitatively and quantitatively.

Table 1: Reported fatalities against each reason and its probability of occurrences.

Reason	**Fatalities occurred due to each reason during 2020 and 2021, respectively and Probability of Occurrence**
Falling rock overhang	1 2 17.6%
Improper explosive management	3 0 5.8%
Accidental Falling	2 5 41.1%
Embankment failure	1 1 11.6%
Fly Rocks incidents	0 1 5.8%
Unintentional detonation due to lightning	1 0 5.8%
Falling to water-filled unprotected pits	1 0 5.8%
Vehicle Toppling incidents	1 0 5.8%

To analyze the risks number of cases within a year and its frequency and probability of occurrences are taken. All reported fatalities shown in Table 1 happened due to the following eight reasons. Tables 2 and 3 describe the probability of occurrence against each category of license and the probability of occurrence against the mode of blasting, respectively.

- Falling rock overhang on to employees
- Improper explosive management
- Falling from a height
- Embankment failure
- Projectiles (fly rocks)
- Unintentional detonation triggered due to lightening
- Falling to water-filled unprotected pits
- Toppling of vehicles

Table 2: Number of reported fatalities (and its probability of occurrence) against each category of licenses.

Licence category	Number of Fatalities (Probability of occurrence)
IML(A)	2 (10.64%)
IML(B)	1 (5.3%)
IML(C)	16 (84.2%)
IML(D)	0 (0%)

Table 3: Reported fatalities against each mode of blasting (and its probability of occurrence).

Mode of Blasting	Number of Fatalities
Single-shot Bore blasting	17 (89.4%)
Multi borehole Blasting	02(10.6%)

3. Risk Ratings

During the calculation, the eight reasons leading to fatalities are rated. Rating is taken based on the number of occurrences of cases reported in 2020 and 2021 and the number of fatalities reported in each case. In this table, Accidental Falling, Falling rock overhangs, Embankment failure and Improper Explosive Management is considered as most severe incidents in quarries, and hence the value of rating is taken as 3 while the value of other cases is taken as 1 due to insignificance and are reported occasionally, and the valve of rating against each case is shown in Table 4.

Table 4: Risk Ratings.

Rating	Case
3	Accidental Falling
3	Falling rock overhang
3	Embankment failure
3	Improper Explosive Management
1	All other cases

3.1 Calculation of Risk

The risk of the above eight reasons leading to fatalities in any quarry is basically a function of the probability of occurrences and the rating. Therefore the risk is calculated according to:

Risk=Probability of occurrences of each reason * Rating

and these calculated risk values are shown in Table 5.

Table 5: Value of the risk of each reason.

Risk Category	Risk
Accidental Falling	1.233
Falling rock overhang	0.528
Embankment Failure	0.348
Improper Explosive Management	0.116
All Other Cases	0.058

According to these values, Accidental falling, failing rock overhang on to employees and Embankment failure are the most dominant factors leading to most fatalities to happen and all are reported from the quarries where the single borehole blasting method is adopted.

4. Risk Factors that could lead to these incidents

According to the above statistics of the reported cases, 89% of cases are from IML/C and IML/B type metal quarries. Blasting activities of these types of metal quarries have been adopted by the single-shot borehole blasting method, while blasts are initiated by a plain detonator, safety fuse arrangement. According to the regulations (GSMB), this method allows license holders to fire only one charged

borehole at a time. Therefore this blasting method does facilitate limited opportunity to excavate in the manner in which create benches. Therefore excessive bench height (more than 15 feet) could be seen in these types of quarries. On the other hand, people working in these types of quarries choose to engage in blasting activities that would create excessive face height aiming for higher yield as well. As a result of excessive face heights, it is almost impossible to remove rock overhangs created from the previous blasting as the excavator cannot reach the desired location, whereas removing rock overhangs manually is too risky and impossible due to inaccessibility, heaviness etc. Poor weather conditions also contribute to escalating the situation. During the rainy season, runoff water seeps through fracture plains and builds up pressure on the cracking plains to loosen the boulder from the face of the quarry. Therefore as long as they are working in these types of quarries have to bear the risk of accidental falling over rock overhangs onto them.

On the other hand, these types of metal quarries have one or two working face/s, and people have to be on the face during drilling and charging times. The face angle of these quarries normally has 70°-80° to the horizontal. During this time, people are vulnerable to falling over the face accidentally. Due to excessive face heights and no ramps to reach to blasting location, people used to reach the desired location by the use of ropes without using PPE's. Therefore as long as they are working in these types of quarries have to bear the risk of accidental falling to a lower level.

This situation is further aggravated by the lethargic attitudes and knowledge of the people. Most of the people engaging in this industry are unskilled laborers who have little or no knowledge regarding mine safety and always undermine the safety while carrying out their duties. Even if they are provided safety gear, they do not use it. Therefore not wearing PPE's is also contributed to these fatalities.

Of the reported cases mishandling of explosives and poor blasting practice have led to catastrophic incidents. Some sort of knowledge and experience is required to handle matters related to explosives and blasting activities. But people who are dealing with explosives have little or no knowledge about explosives & blasting activities, and they deal with them without taking adequate safety measures ultimately have to sacrifice their own life as well as surrounding people, and it led to property damages as well.

5. Methods of reducing the above mentioned risk

Following methods can be adopted to reduce the risks.

- Blasting activities should be carried out in a manner in which create a face height of at least 10 feet in such a way that the machine could remove rock overhangs.
- Removed overburden must be stored and stabilized at least 5m away from the edge of the face to avoid falling
- Fence should be erected along the periphery of the quarry to avoid accidental falling by outsiders and animals.
- Workers should always wear a harness with a helmet and boots during working time.
- Blasting activities should be carried out by a competent person. Therefore a blasting foreman should be recruited for each and every quarry to avoid recurrence of these incidents.
- Only the optimum quantity of explosives should be used for each and every blasting.
- Blasts initiation by unrecognized means should be avoided.
- An officer should be appointed to deal with mine safety on a full-time basis by the license holder.
- Meetings should be periodically arranged so that workers become aware of mine safety.

- Workers must be given adequate training by sending them to training courses.
- Notice boards should be put up at strategic locations in the quarry so that workers become aware of mine safety.
- Use of Good quality safety gear by all workers.
- Every accident that occurred in a quarry should be recorded, updated and reviewed.

6. Role of the GSMB

The fatalities reported in the quarries where the single-shot blasting method is adopted shows a sad state that needs to address quickly by the authorities. As a regulatory, the GSMB should revise its strategies to regulate mining activities of these quarries back on track. In this connection following steps can be taken by the GSMB.

- The GSMB should increase the frequency of monitoring of activities of these quarries.
- Stern actions like cancelling of license should be taken against license condition violators.
- Awareness programs/ workshops/ training programs in respect of mine safety must be arranged for workers
- Before issuing licenses, the technical feasibility of license holders should be assessed.
- To encourage license holders to shift to multi borehole blasting method wherever possible.

7. Conclusion

As the majority of fatalities are reported from the quarries where the single-shot blasting method is adopted, as a regulatory body, it is high time to take appropriate actions to reduce the risks as people engaging in this industry are more vulnerable to accidents.

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