

# **Technical, Socio-environmental & Procedural Limitations in Sri Lankan Quarry Industry from Mining Professionals Perspective**

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## **Abstract**

Over 2500 quarry sites are currently in operation to cater the large requirement of rock aggregates in Sri Lanka. The concerns of this industry are not limited to the environmental and social aspects but significantly influence its own functionality. Even though such instances are common and under regular discussions, documented evidence and efforts to methodically resolve them finds to be limited. Hence, only the adverse effects of the quarrying industry are mostly highlighted, sidelining the opportunities for sustainable development. This research attempts to systematically document the issues in the quarrying industry in Sri Lanka to address them based on three categories; Technical, Socio-environmental and Procedural. As an initial exercise the collected survey data was categorized on district basis, quarry grade, respondent's skill level and the nature of the interviews conducted. Through cross analysis of these data clusters the most common concerns were extracted to prioritize according to the level of significance. Afterwards, statistical significance of the relationships among the issues so far identified was computed mainly using Chi-squared-test and Binary Logistic Regression. Findings of this pilot study can be used for future policy development, even though they are dominantly represented by the Colombo, Kalutara and Gampaha districts.

**Keywords:** Aggregates, Binary-Logistic-Regression, Chi-squared-test, Mining industry

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## **1. Introduction**

Increasing demand of aggregates for the infrastructure development of the country is unavoidable despite the impact to the social and environmental systems. Hence, development of sustainable quarrying industry becomes the responsibility of the mining professionals to minimize such negative impacts.

In the context of Sri Lanka, Annual report produced by Geological survey and Mines Bureau in 2010, shows the presence of 2570 aggregate quarries in Sri Lanka that results in annual production of 7.28 million m<sup>3</sup> [1] and generate over LKR 200 million per annum for the government in the form of royalty [2]. Although, these aggregate quarries are disseminated throughout the country to cater the increasing demand [3], lack of awareness of how to handle risks

related to technical, socio-economic, environmental and procedural limitations acts as a barrier for prospective investors [4]. Further, mistakes of present investments or false accusation industry faces might be left as a permanent scar if the root causes are not found.

Thus, this study is an attempt to document the issues that hinder the mining operations in the perspective of mining professional and develop recommendations which will act as a guideline for the prospective investors to achieve sustainable mining operations that results in win-win situation to all the stakeholders.

## 2. Methodology

### 2.1 Study Population and Sample

Mining professionals involve in the activities of IML A type metal quarries in Sri Lanka were selected. This was selected based on the rate of production and relative impact it creates in the socio-environment and technical and procedural restrictions it faces.

In order to find the Technical, Socio-environmental concerns and procedural restrictions that hinder the mining operations questionnaire survey was carried out among mining professionals.

The questionnaire comprised both close-ended (Dichotomous Questions/ Multiple-choice Questions) and open-ended questions.

Convenient sampling was used under non-probability sampling and sample size is 79 (consists both mining engineers and regulatory authority engineers). The distribution of State of experience and locations of participants are given in Figure 1 and 2 respectively.

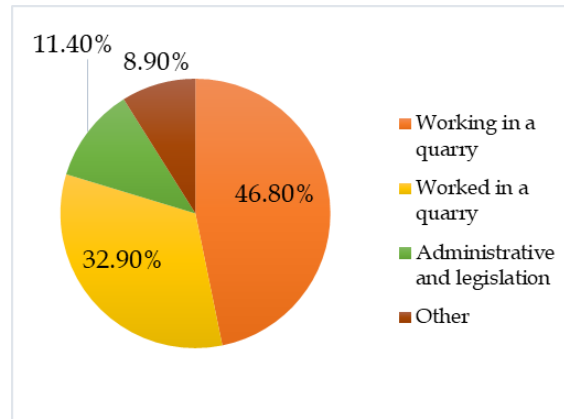


Figure. 1: The questionnaire responses according to the respondent's state of experience.

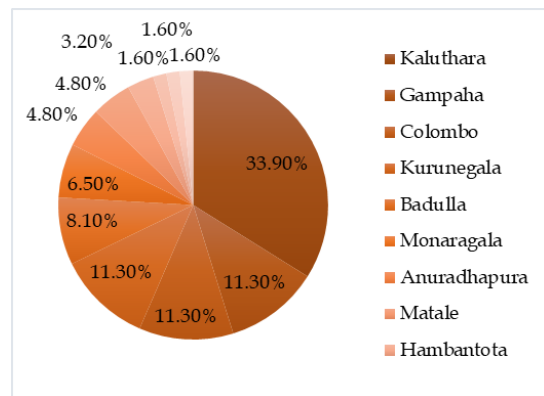


Figure. 2: The questionnaire responses according to the districts of the respondents quarry experiences.

### 2.2 Analysis

Significant problems faced by mining professionals were initially revealed through the responses for close-ended questions.

In order to determine the difference between best practices of the industry and the rest of the practices further analysis was performed.

Chi-squared test of independence was performed at 5% significance level to check whether there is a significant association between any two responses selected from the list of variables. The hypothesis for the chi-squared test was taken as follows.

$H_0$ : No significant relationship exists between the two variables (1)

$H_1$ : There is a relationship between the two variables (2)

Binary logistic regression is then performed to check how the variables made significant contributions towards a selected response variable at 5% significance level.

Based on these analyses, good practices that help to overcome the technical, Socio-environmental and procedural limitations were statistically identified. In addition to this, consequences of the malpractices were also highlighted.

### 3. Results

#### 3.1 Preliminary Analysis of Variables

##### 3.1.1 Technical concerns

- **Uncertainties related to Monitoring methods**

The majority of the participants expressed that current monitoring methods are not sufficient and think that improved monitoring would assist managing public complaints even at their own cost.

Regarding monitoring, 55.3% indicated that ground vibration monitoring methods does not accurately determine the effect of blasting on surrounding structures while 59.1% stated ABOP measurement are accurate and sufficient.

More than 70% of the participants expressed the need of proper crack survey to address public complaints, and has conducted crack survey before starting the mining activities and during the activities. However, 65.8% of the participants' questions whether crack surveys properly reflect the effect of blasting.

- **Malpractices in quarrying operations**

Although 57.5% use some kind of covering method for blasting, 62.7% had experienced fly rock incidents. Reason

behind not using covering methods is given in Figure 3.

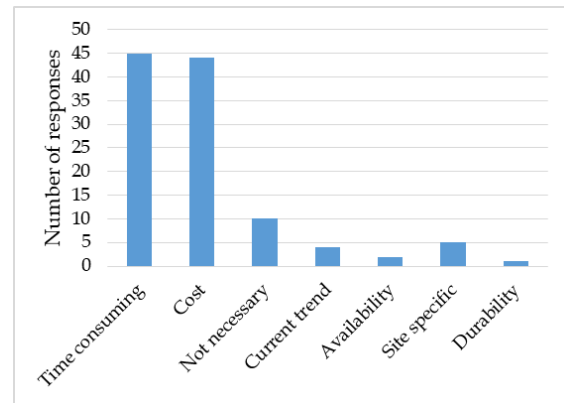


Figure. 3: Reasons for not using a covering medium.

- **Impact on water resources**

93.5% of the participants stated that mining has an impact on water levels and quality and above 55% feels that existing procedures and guideline related to protecting water resources are adequate and carry out tests related to water resources. When it comes to public complaints 46.7% has received complaints related to reducing water levels.

- **Availability of Labors and OHSC**

Nearly 60% are satisfied with the availability of skilled labors and their technical knowledge, but they also mentioned that finding skilled labor for drilling is difficult. Although, majority satisfied with their labors, 83.6% suggested mechanizing is suitable for local industry.

While 98.6% responded that they make the employees aware of Occupational Health and Safety procedures, 65.7% only have an induction program for newly recruited employees.

- **Views related to Royalty Calculation**

Half of the respondents mentioned that current royalty calculation method is reasonable and 66.7% stated that they get the calculated production from the explosives used.

### 3.1.2 Socio-environmental concerns

- **Public Complaints and Impact on operations**

Out of total participants, 96.1% received public complaints on the mining activities. Even though 84.9% mentioned complaints are reasonable, 91.9% stated that they have experienced false complaints from the community to gain benefits.

Around 70% use monitoring data to evaluate the significance of the complaints and 91.4% reveal the monitoring data and negotiate with the public when complaints are received.

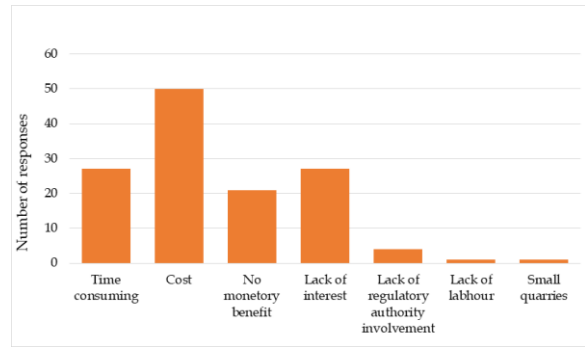
- **Reasons behind public unrest and suggestions to obtain social license**

Although, half of the participants think that the public understands the importance of metal quarrying, they also believe bad impression on metal quarries, lack of communication and information sharing with the local community results in complaints and 89.2% felt this also effects monitoring.

In order to minimize public unrest, 94.7% recommends the need of educating the public on the quarry industry and 85.1% think the local community should be encouraged to work in the quarry.

- **Views on Environmental Friendly Mining Practices**

Although 95.9% mentioned there is a rehabilitation plan for their quarry site, 69.4% think that sustainable mining concepts are not encouraged in the Sri Lankan quarrying industry. 95.7% recommends establishing an evaluation method (point scheme) to encourage adhering sustainable mining concepts. Factors that restrict rehabilitation activities according to the participants are given in Figure 4.



**Figure. 4: Factors that restrict rehabilitation activities.**

Further, 87.3% think it is possible to conduct mining activities with minimal disturbances to the environment and society. However, 61.8% only follow any environmentally friendly mining concepts.

### 3.1.3 Procedural Restrictions

Above average satisfied with restrictions enforced by the mining licence, information sharing among regulatory authorities, how authorities recognize and promotes the organizations who conduct quarry operations according to the mining licence conditions. Further, 82.5% stated that conditions in license are practically implemented and 85.2% said that authorities check the history of the quarry operations when renewing a mining license.

However, 87.9% stated they have to submit the same information for several authorities and around 60% mentioned they have experienced instances where governing authorities acting beyond their scope and contradictory decisions/instructions given by the regulatory authorities.

Only 38.1% of the respondents are satisfied with the level of inspection by the regulatory authorities.

### 3.2 Comparison of Having a Best practice vs. not having the same

#### 3.2.1 Relationship between the selected response variable and significant independent variables

Results are tabulated in Table 1 of the significance of relationships between the response variable and independent variables.

**Table 1: Results of Chi-squared independence test between a set of questions**

Questions within which association is checked	p-value
Experienced fly rock	0*
Cover the blast face during blasting (response)	
Crack surveys are accurate	0.002*
Public understands the importance of metal quarrying	0.005*
Induction program for the newly recruited employees	0.008*

\*implies there exist significant relationship

Chi-squared test indicated the significance of associations between the above variables at 5% significance level.

#### 3.2.2 Modelling of association between the response variable and significant independent variables

A Binary Logistic Model was generated based on the results of Table 1. The results of the model are given in Table 2. Here, "Not covering the blast face during blasting" was the level of response taken as the baseline for odds ratio calculations.

**Table 2: Binary Logistic Model generated based on the variables Table 1**

	Variables in the Equation			
	Sig.	Exp(B)	95% C.I. for Exp(B)	
			Low.	Up.
Experienced fly rock	0.005*	7.632	1.828	31.862
Crack surveys are accurate	0.009*	7.548	1.655	34.439
Induction program	0.011*	6.383	1.541	26.430
Public understanding	0.009*	6.562	1.613	26.686
Constant	0.000	0.016		

\*implies there exist significant association

**Table 3: Model Diagnostics**

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
58.973	0.381	0.512

Based on model generated, it is evident through the odds ratios calculated (Table 2) that those who say do not use any type of covering method for blasting has;

- 7.6 times higher the chance of saying they have experienced fly rock incidents compared to those who use a covering method.
- 7.5 times higher the chance of saying they think the crack surveys properly reflect the effect of blasting compared to those who use covering method.
- 6.4 times higher the chance of saying they have an induction program for the newly recruited employees compared to those who use a covering method.
- 6.6 times higher the chance of saying that they think the public understands the importance of metal quarrying compared to those who use a covering method.

The binary logistic regression models were generated similarly for two other response variables as well. Through all these models

four main reasons were revealed for the problems experienced by the mining professionals. They are; Lack of confidence in monitoring, malpractices in mining operations, shortage of skilled labors and lack of training/proper induction.

#### **4. Discussion**

##### **4.1 Technical concerns**

Results of survey reveals lack of confidence in monitoring, inadequacy of monitoring intervals and malpractices due to ignorance as the main problems under this section. Reasons behind this mindset and possible solutions are discussed below.

Rigid limits for Ground vibration (5mm/s) and ABOP (120dB) [5] without considering factors such as, frequency, type of construction/ structure, local geology and geography, human perception, other vibration sources [6] results in lack of confidence to both professionals and public during blasting. A comprehensive section of limits can be given for varying situations as a solution for this issue.

Further, stringent and timely monitoring of noise and ground vibration experienced during quarrying activities other than blasting is also important. Developing limits for all quarrying activities and making it available for professional and public will help to improve the image among public while assisting in maintaining standards of worker health and safety.

Failure of crack survey to prove whether the cracks are developed due to quarrying activities or other factors is another limitation industry faces. Considering Natural environmental influences - ground settlement, type of construction - foundation condition, age of the building, type of ground, geology - type of rocks and human produced transients from everyday activities [7] will improve the confidence in the results of crack survey. Developing a

data base considering all the dependent factors mentioned above and properly documenting them, identifying causes and structural defects that have the potential of worsening, informing the property owner on such scenarios and conducting yearly crack surveys and developing a comparison report can help in solving this problem.

Covering has been neglected by most of the professionals for various reasons mentioned in Figure 3, but, this ignorance results in significant problem in quarrying activities which is known as fly rock. Although professionals states consumption of time and cost as main reason for not covering their blast faces, mandatory covering of blast faces in populated area should be recommended by authorities. Further, maintaining proper blast design and stemming throughout the lifetime of quarrying activity should be monitored.

Proper background study prior to operations and frequency of monitoring needs to be given importance. In addition to these, industry should be encouraged to monitor their sites consistently in their own and develop a database which is transparent to public.

##### **4.2 Socio-environmental concerns**

According to professional it is evident that the bad impression on quarries among public results in unrest, this implies lack of capability to obtain social license.

Quarrying activities should be carried out transparently under proper controls and should be done smoothly, this will eliminate the triggering incidents for the public to make complaints. Keeping public informed of activities and timings, educating them on quarrying activities, maintain proper public relation, generating job opportunities and developing infrastructure of surrounding for both quarrying activities and wellbeing of public will help industry to win public

trust. This approach will help public to reach psychological identification where they start feeling themselves part of the entity [8].

Considering environmental aspects, although professionals are aware of importance of environmental friendly mining activities including rehabilitation, motivation to practice green mining is lacking. Lack of recognition and promotion for such activities by authorities, cost, time, impracticality and lack of labor can be seen as reasons. Developing a point scheme or awarding mechanism might encourage professionals to practice environmental friendly activities.

#### 4.3 Procedural restrictions

Duplication of information for several authorities, contradictory instructions by regulatory authorities and lack of inspection by authorities are the main issues professionals highlighted.

Developing proper network among all the authorities and sharing data within them will reduce the time, cost and effort professional spent in paper works, this will help both authority and professionals to be focussed on developing sustainable industry, in addition, this will also encourage investments in the quarrying industry. Further, improving the transparency of procedures and proper monitoring will help public to approach the correct authority when issue arise.

#### 5. Conclusions

This study focused on the views of professionals about issues aggregate quarrying industry faces. Results were derived based on their views in the context of IML A quarry.

Descriptive statistics reveals that majority of the professionals are concerned about accuracy and frequency of monitoring, malpractices due to ignorance, difficulty in obtaining social license, lack of motivation

to practice environmental friendly mining practices, lack of information sharing among regulatory authorities and contradictory instructions given by authorities.

Outcomes of binary logistic models emphasized majority of the professionals are with the opinion that; lack of confidence in monitoring, malpractices in mining operations, shortage of skilled labors and lack of training as the root causes behind most of the problems that hinders sustainable path.

Addressing these problems will also reduce uncertainties involved in the industry which will motivate professionals and prospective investors to develop better mining practices. Thus, it can be concluded that addressing these major concerns will eventually assist in reaching sustainability of the quarrying industry.

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