Minimization of Secondary Fragmentation with a View to Enhancing the Blasting Economics

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Abstract: Construction materials have a huge demand and become an expensive commodity due to limited quarry activity. Further Research and Development (R and D) is very important in quarry industry in order to minimize the cost of quarry products in Sri Lanka. Cost of secondary fragmentation is a significant factor in this regard. This research is aimed exploring the methods at reducing the fragmentation cost effectively. Formation of the boulders mainly depends on the geological diversity, bench parameters and varying powder factor. Site geology is a natural factor that cannot be adjusted but the bench parameters and the powder factor can be changed over wide range to reduce the boulder formation. Three consecutive blasts were designed by the project team. The bench parameters and powder factor were determined to control the formation of the boulders.The plan views of the blasted muck piles were photographed to analyse the particle size distribution of the muck pile.

Keywords: Bench parameters, Boulders, Powder factor, Secondary fragmentation

1. Introduction

1.1 Mining Industry in Sri Lanka

At present three categories of mining activities can be mainly identified in the Sri Lankan mining industry such as Gem mining, mining of construction material (Graphite, Phosphate, Construction aggregates etc) and Petroleum extraction.

There is a number of government institutions created as regulatory bodies such as, the National Gems and Jewellery Authority (NGJA) for gem mining, The Geological Survey and Mines Bureau (GSMB) for other minerals and the Petroleum Resources Development Secretariat (PRDS) for Petroleum extraction.

Geological Survey and Mines Bureau being the administrator of the mines and minerals act of 1992 issues licenses for mining industry in Sri Lanka namely, exploration license, mining license and trading and transport license. Other than the above a special license should be obtained for mineral exports.

There are two categories of mining licenses such as Artisanal mining license and Industrial mining license.

Under each main category there are three sub categories found as A, B and C. Categorizing has its own limitations imposed on monthly production volume, depth of the borehole and types of machinery and equipment used.

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1.2 Problems Associated with Rock Blasting

Air blast over pressure, ground vibration, dust and non uniformity in fragmentation are the problems encountered with rock blasting. Factors affecting fragmentation can be divided into controllable and uncontrollable parameters. Controllable parameters are the drilling pattern, type of explosive, quantity of explosives, delay time and the firing sequence. Parameters which are not within the control are geological structure and weather conditions. The above factors have a great influence on fragmentation. Over fragmentation with a higher percentage of fines and boulder formation due to under fragmentation both will result in higher cost.

If the fine percentage is very high, that indicates the excess in the explosives used for the blast than what it actually requires for the optimum fragmentation, but formation of boulders mostly depend on incorrect choice of the blasting parameters and geological conditions.

Formation of boulders dictates the need for heavy machinery for secondary breakage, as result of that there are over sizes to the crusher plant. Therefore, secondary fragmentation is needed to facilitate the feeding of the crusher plant and for easy loading and hauling. In this manner, secondary fragmentation increases the total cost of the blast, including the factor of the time.

Under this research programme the problems of boulder formation is discussed with the objective of minimizing secondary fragmentation, minimization of time consuming and enhance the blasting economics with a view of cost reduction.

1.3 Objectives of the Research Project

- Identifying the existing blasting parameters and the cost of blasting.
- Finding out the factors that affect the fragmentation of existing blasting according to the past history.
- Identifying the predominant geological structure which affects fragmentation.
- Monitoring the air blast over pressure and the ground vibration due to the secondary blasting
- Calculating the additional secondary breaking cost
- Finding out the additional time consumption due the secondary breaking.
- Designing a new blasting parameter to minimize the secondary blasting with a view to enhancing the overall blasting economics.

2. Methodology

Study of the existing blasting parameters such as spacing, burden, bore-hole depth specific charge and the geological structure was made at the selected quarry at Mirijjawila, Hambanthota.

The blasting parameter was re designed by the project team with a view to obtain the optimum fragmentation giving due consideration to the powder factor and site geology. Three consecutive blasts were designed to optimize the blasting parameters. Ground vibration and air blast monitoring were carried at for each blast in keeping with the Central Environmental Authority (CEA) stipulated guidelines of maximum air blast over pressure less than 120dB and that ground vibration at 5mm/s.

Muck pile of the blasted rock was photographed from a vantage point above higher elevation to analyse the fragmentation of the blast. During photographing the muck pile, 70 cm coloured visible scale was kept for

fragmentation size evaluation. (At least one dimension if greater than 70 cm is taken as boulders and every below 70cm is treated as undersize)

2.1 Calculation of the volume of boulders

The top view of the muck pile photograph was printed on the international scale A4 and A3 size paper. The oversize boulders have to be identified with respect to the 70cm visible scale and marked on 1mm*1mm scale transparent sheet. The whole surface area of the muck pile was traced on the tracing paper with same scale.
The whole area of the muck was calculated through 1mm*1mm scaled tracing paper and area of the boulders calculated.

Figure 1 - Determination of the Percentage of Bolder

Boulders percentage is given by ratio between total area of the muck pile and the area of the boulder area.

$$\text{Percentage of boulder volume} = \frac{\text{Total area of the boulders}}{\text{Total area of the muck pile}}$$

Total volume of the muck pile is given by:

$$V = S*B*D*N$$

S- Spacing (m)
B- Burden (m)
D- Depth of the borehole (m)
N- Number of boreholes
V- Volume of blasted rock (m^3)

3. Results and discussion

The optimization of the bench parameters such as spacing and burden depends on the percentage of the boulders. The specific charge also depends on the percentage of the boulders.

Table 1- Field data

blast	Spacing (m)	Burden (m)	% of the boulders
no 1	2.30	1.82	15.03
no 2	2.53	2.20	6.11
no 3	2.53	2.20	8.66

The optimum spacing and burden can be obtained from the graph for the above collected data at Mirijjawila Hambanthota quarry.

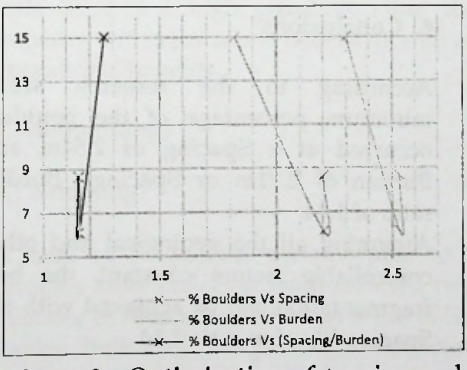

Figure 2 - Optimization of spacing and burden

Required parameters such as the spacing and burden are to minimize the formation of the boulders in the project.

Table 2 – Results

Spacing	2.21
Burden	2.54
Spacing/ Burden	1.14

The formation of the boulders mainly depends on the lots of parameters such as spacing, burden, specific charge, focus direction, chemical composition of rock, structure of the geology, and height of stemming and depth of sub drilling etc. But as in that study spacing and burden were considered to affect the formation of boulders.

The factors except that of spacing and the burden were kept Constant. The structure of the geology and chemical composition of the rock are the major uncontrollable parameters to create the boulders. The powder factor, focus direction, height of stemming and depth of sub drilling are the controllable parameters in designing the blast round. The cost of secondary fragmentation is directly proportional to the volume of over sized boulders. Therefore the cost on secondary fragmentation is an indication of the percentage of the formation of boulders.

4. Conclusions

According to the research study minimum percentage of the boulders occurred at a Spacing of 2.54m and Burden of 2.21m or Spacing/ Burden ratio of 1.14.

Assuming all the geological and other controllable factors constant, the best fragmentation can be achieved with the Spacing/Burden ratio 1.14

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