Fragmentation Modelling For an 'A' Grade Quarry

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Abstract: This research focuses on the degree of fragmentation resulting from a blast in an 'A' grade quarry. Two blast geometries were tested and verified in this research study. Quarrying industry has a quite long history in Sri Lanka; however it has not achieved significant technical development in comparison with other countries. Still the major concern of this industry is getting the maximum quantity of rock volume from a particular blast. Efficiency of subsequent unit operations such as loading, transportation, especially crushing is neglected. This research aims at achieving higher safety (i.e. fly rocks, air blast) and best fragmentation while minimizing production cost. It is widely accepted that Software tools could be used to improve blast performance, if it is used as a critical evaluation tool for fragmentation quality against any blasting geometries. In this study, software called "Split-Desktop" was used as a tool to estimate blast quality or particle size distribution in a stockpile. Then two blast geometry models such as "decked charging" and "slab hole" models were proposed with the intention of improving fragmentation.

Keywords: Blast geometry, conventional blast, fragmentation, split desktop software

1. Introduction

Adequate rock fragmentation is a major objective of industrial rock blasts. This research serves as a measure to evaluate effectiveness of a rock blast operation. The degree of fragmentation to be achieved should comply with the crusher plant requirements and this has a direct effect on; secondary blasts or use of rock beakers for size reduction to make them feedable for crushers, crusher Production rates, Efficiency of the loading and hauling equipments.

In general, secondary blasting as well as rock breakers are intensively used in Sri Lankan quarrying industry. If the optimum fragmentation is achieved in the initial production blast secondary breakage could be avoided reducing aggregate production cost Crusher plant specifications, especially the feed size of primary crusher (jaw crusher) should be taken into consideration when designing blasting parameters. Although there is no systematic methodology or a tool to

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evaluate degree of fragmentation, this research intends to address this issue with the aim of improving blast productivity by optimizing the fragmentation which will enhance efficiency and profitability of local quarrying industry.

2. Methodology

2.1 Initial site visits

Initial step was few site visits to Lanka Quarries (Pvt.) Ltd to find out the effectiveness of their present blast operations with respect to desired fragmentation requirement of the crusher plant.

2.2 Evaluating the effectiveness of the blasting parameters

Degree of fragmentation was quantified using Split Desktop software and digital images of the stockpile (Figure 1). The percentage of rock particles with sizes greater than the feed size of the jaw crusher was considered as over sizes.

Figure 1- Digital image of stockpile

2.3 Proposing Blast geometries

Based on the results obtained in the initial evaluation, as in the Figure 2 and Figure 3 new blast geometries were introduced to improve the fragmentation.

2.4 Test Blasts (method of verification)

To evaluate the effectiveness of proposed models two test blasts were carried out for the each model.

The effectiveness of the models was determined using degree of fragmentation. Fragmentation analysis technique is unique for every blast that is analysis of digital images of the stockpile using the Split Desktop software. Models were tested using twenty holes blast at a time.

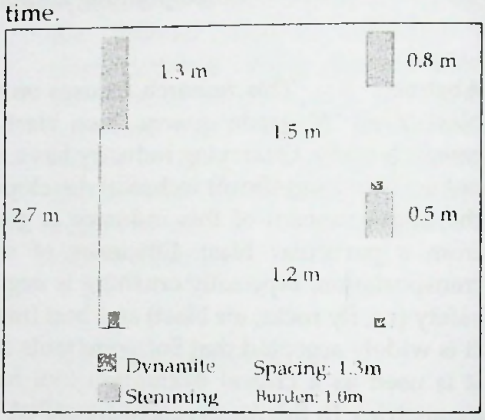

Figure 2 - Side elevation of model 1 (deck charged method)

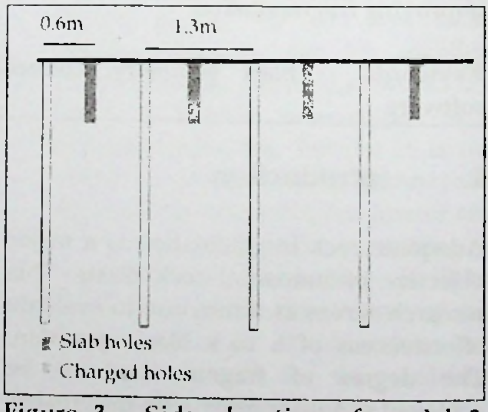

Figure 3 - Side elevation of model 2 (slab hole method)

3 Results

3.1 Conventional blast

Explosive /drilling cost and secondary treatment cost were calculated while analysing fragmentation percentage. This procedure was followed for designed models too.

3.1.1 Cost of conventional Blast

According to the fragmentation analysis for the conventional blasting pattern (Figure 4), amount of feedable aggregates to the crusher plant (<750mm) was determined as 56%.

Table 1- Total drilling and explosive cost for the conventional blast

Agent	*Unit Price(Rs.)*	*Quantity*	*Cost (Rs)*
ED	102 nos.	20 nos.	2040
Dynamite	720/kg	2.5 kg	1800
ANFO	90/kg	60.3 kg	5427
Drilling	55/ft	260 ft	14300
Total cost			23567

Results of the analysis of conventional blast are shown in Table 1.

Explosive and drilling cost for model 1 and model 2 was calculated as Rs.24,587.00 and Rs. 25,657.00, respectively while the amount of feedable aggregate percentage for the model 1 and model 2 was determined as 77% and 69%, respectively.

3.1.2 Fragmentation Analysis

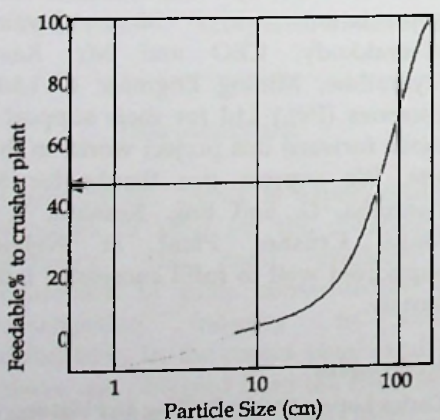

Figure 4 - The fragmentation analysis for conventional blast

3.2 Comparison of fragmentation percentage

Deck charged method and slab hole method had been shown respectively 21% and 14% enhancement of fragmentation with respect to conventional blast.

3.3 Cost comparison for secondary treatment of production blast

Total cost for secondary treatment of oversized boulders from model 1 and model 2 over the conventional blasting method was shown 43% and 29% reduction, respectively.

Table2 - Cost comparison for secondary treatment of production from initial production blast

Blast Method / *Cost*	*Conventional blast*	*Model 1*	*Model 2*
Breaker cost per hour (Rs.)	3500	3500	3500
Total breaker cost (Rs.)	24500	14000	17500
Secondary blast cost (Rs.)	2750	1470	1850
Total cost (Rs.)	**27250**	**15470**	**19350**

Results of the Cost comparison for secondary treatment of production from initial production blast, are shown in Table 2.

3.4 Overall Cost comparison with respect to conventional blast.

Table 3 - Overall cost comparison of conventional blast and developed models

Blast method / *Cost*	*Conventional*	*Model 1*	*Model 2*
Overall cost (Rs.)	50817	40057	45007
Unit cost (Rs./m^3)	763	601	676
Cost reduction (%)	———	21	11

Results of the overall cost comparison of conventional blast and developed models, are shown in Table 3.

Overall cost indicates the summation of explosive/drilling cost and secondary treatment cost. Unit cost for each model was calculated for the production volume of 66.56m³.Because of all of them had twenty charged bore holes.

4. Discussion

Total cost of deck charge method was 21% higher than the conventional blast. This extra cost was happened due to use of two electric detonators for single blast hole. However it could be easily recovered. Because of poor fragmentation is caused to increase the use of secondary blasting and the use of rock breakers. However deck charged method was considerably minimized this extra cost. By saving one rock breaker hour which could the extra cost was incurred in deck charge method.

Also there was 8.8% increment of drilling and explosive cost of slab holes method. This was happened due to extra row of bore holes with free of charge was used in between each to normal charged rows. These uncharged holes were shallower with respect to normal charged bore holes. But drilling feet were increased significantly. Therefore drilling cost was gone high up. Slab holes help to create a good fragmentation of the blast. One test blast for each model was implemented to check their validity. However further test blasts could be gained high accuracy of results. Anyhow those were infeasible due to economic restrictions.

In this study, explosive consumption and the drilling pattern were the major concerns for the development of models. However, consumption of explosives is dependent on various factors such as the compressive strength of the rock, hole depth, discontinuities, stemming material etc. Therefore further studies could be carried out to improve the scientific importance of the models.

5. Conclusion

Results of the model 1(deck charge method) has shown better results. So, it is a better alternative for blasting, where more fragmentation is achieved. The result has shown approximately 90% cost reduction of the cost incurred for the rock breaking and secondary blast activities. Due to these reasons, total cost has been reduced by 21%.Therefore it could be concluded the deck charge method is more cost effective than conventional single column charged method. It can be recommended that deck charge method is best option to practice in 'A' grade quarry. According to results, slab hole method is also efficient blast geometry that could be used in a 'A' grade quarry.

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