Software Assisted Bench Blast Optimization

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Abstract

Blasting activities in mines and quarries have been placing significant emphasis on the ability to tailor fragmentation to improve downstream process. Achieving the optimum blast design for a particular rock mass type can be an expensive and time consuming procedure. Also in many of these operations, the impact of fines and blast design has been clearly identified. The need to be able to predict the degree of fines from blasting has driven the development of an improved engineering model. Over the past few years, many countries such as Australia, USA, Canada, UK and Russia have been using Numerical Modeling softwares for optimize bench blast designing. However, in Sri Lanka up to now, these methods are not being used. In Sri Lanka, ordinary blasting techniques which are based on past experience are practiced. The outcome of this study shows that bench blasting operations can be optimized by means of JKSimBlast software.

Keywords: Blasting, Simulation, Fragmentation, Optimization, Powder Factor, Tonnage

1. Introduction

JKSimBlast is an award-winning, general-purpose software system developed by JK-Tech of Brisbane, Australia [1,2]. The software enables simulation and information management for blasting in mine related operations. The modular system is designed for engineers who need to standardize their control of blasting, by integrating all tasks associated with design, simulation, analysis and optimization, including the storage and manipulation of models, data and results, within one system[3].

In this research, "2DBench" was used which is the open cut blast design module of JKSimBlast. It allows the user to lay out a blast design consisting of blast holes, decks, down hole and surface delays and connections, and then to run a detonation simulation. The design can be further described by strings and polygons [4]. Basic analyses of volume, tonnage, powder factor, component and total costs can be calculated for the design.

Although the design is created in 2D plan, all data is stored with full 3D coordinates in Microsoft Access databases [5]. Added to this database are component details (hole parameters of dip, bearing, diameter, length, burden, spacing), properties of explosives, detonators, primers,

connectors, and detonation timing information.

Metal Mix Pvt Ltd, Galpatha quarry site was selected to execute our research experiments. The objective of this research was to Understand and model the ongoing blast design parameters of a quarry site. Software assisted modeling and simulating of alternative new designs can forecast Air Blast Over Pressure (ABOP) and Ground Vibration with distance in advance.

2. Methodology

Impotent information about the blasting parameters such as space, burden, bench height, diameter of the drill hole, bench level, floor level, under drilling, hole dip, number of rows per blast, number of holes per row, stem height, explosive height, explosive type, number of cartridge per hole were collected during the field visits, to consider as base-line information for this study.

2.1 Rock Testing

The rock samples collected from the site were tested at Rock mechanics Laboratory for their physical properties such as tensile strength, compressive strength and specific gravity.

2.2 Blasting Simulations for Existing Pattern

Next, the blast simulation for the existing blast was run. Input blasting parameters of the existing blast are summarized in Table 1.

The explosive type was selected as **ANFO**, number of cartridge as one and blast pattern as staggered.

Table 1 - Input blasting parameters of the existing blast

Parameter	Value
Burden (m)	1.2
Spacing (m)	1.5
Diameter (mm)	40
Bench height (m)	3.63
Bench level (m)	3.63
Floor level (m)	0
Under drilling(m)	0.36
Hole dip	85
Rows	3
Holes per row	6
Stem height (m)	1st raw-2 2nd raw-1.25 3rd raw-1.5
Explosive height (m)	1st raw-1.8 2nd raw-2.55 3rd raw-2.3

2.3 Blasting Simulations

Over hundred simulations were run to get an optimized bench blast design. Table 2 shows the parameters got for optimized blast design, after running simulations.

Table 2 - Input blasting parameters of the optimized blast

Parameter	Value
Burden (m)	1.2
Spacing (m)	1.6
Diameter (mm)	40
Bench height (m)	3.63
Bench level (m)	3.63
Floor level (m)	0
Under drilling (m)	0.36
Hole dip (degrees)	85
Rows	3
Holes per row	6
Stem height (m)	1st raw-1.75 2nd raw-1.25 3rd raw-1.5
Explosive height (m)	1st raw-2.05 2nd raw-2.55 3rd raw-2.3

Other than above information, the explosive type was selected as ANFO, number of cartridge as one, and blast pattern as staggered from the software. The delay pattern used is shown in Figure 1.

3. Results

Followings are the rock testing results.

-Uniaxial Compressive Strength (UCS) value = 23.99MPa
-Specific Gravity (SG) =2.5
-Tensile Strength = 6.05MPa

Table 3 shows the results obtained by running simulation of the existing blast by means of the software.

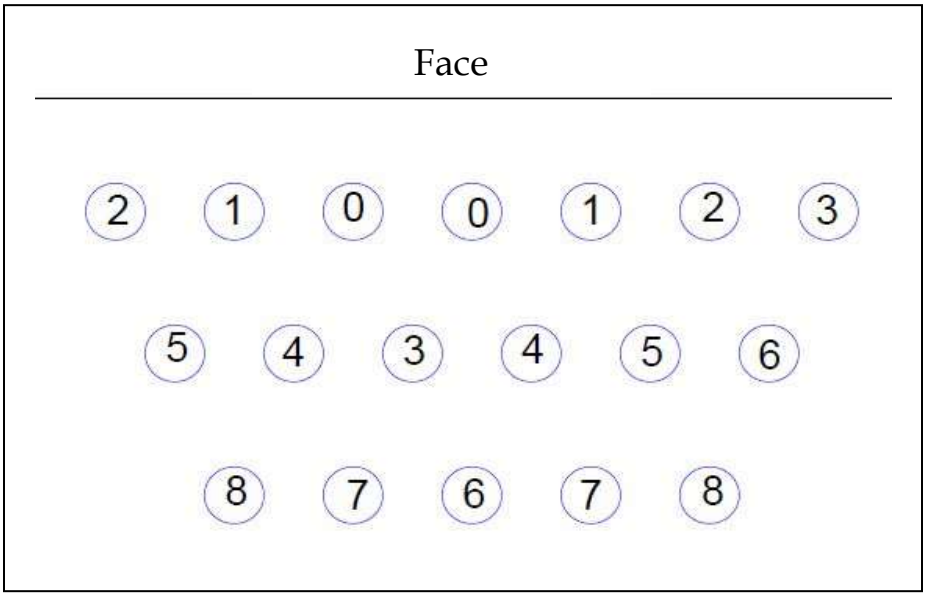

Figure 1 - Delay Pattern (not to scale)

0 – 0 milliseconds, 1 – 25 milliseconds, 2 – 50 milliseconds, 3 – 75 milliseconds, 4 – 100 milliseconds, 5 – 125 milliseconds, 6 – 150 milliseconds, 7 – 175 milliseconds, 8 – 200 milliseconds

Table 3 - Simulation results of the existing blast pattern

Parameter	Value
Volume (m^3)	129.6
Tonnage (tons)	323.9
Powder Factor (Kg/m^3)	0.334
Percentage rejected by grizzly feeder%(< 0.01m)	1.1
Percentage rejected by Jaw crusher% (> 0.5 m)	38.4

Table 4 - Results of the optimize blast pattern

Parameter	Value
Volume (m^3)	138.2
Tonnage (tons)	345.6
Powder Factor (Kg/m^3)	0.319
Percentage rejected by grizzly feeder% (< 0.01m)	0.8
Percentage rejected by Jaw crusher% (> 0.5 m)	39.7

4. Discussion

When selecting an optimized blast design in this research, the variation of following parameters have been considered:

1) Volume and Tonnage
2) Powder Factor(PF)
3) Percentage Rejected by Grizzly Feeder
4) Percentage Rejected by Jaw Crusher
5) Ground Vibration

Cost is one of the main parameters considered, when optimizing a blast. . According to the results, the tonnage does not increase greatly, however the blasting cost was reduced since the powder factor was decreased. Tonnage was increased in the optimized simulation which results increasing of reducing the PF in the optimized design which results in decreasing the total cost of the blast. However, here the amount of boulders has been increased slightly contributing increase of production tonnage since the tonnage increases.

5. Conclusions

As per the research findings of this study, the following conclusions can be made.

- The burden as 1.2m and spacing as 1.6m can be used.
- Stem and explosive heights as shown in Table 5 can be used for an optimized blast.

Table 5 - Stem and explosive heights

Stem height (m)	1st raw-1.75 2nd raw-1.25 3rd raw-1.5
Explosive height (m)	1st raw-2.05 2nd raw-2.55 3rd raw-2.3

- Use only one carriage for one drill hole.
- Use staggered drilling pattern in drilling.
- Use the delay pattern shown in Figure 1.

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References

[1] Alland, L., and Martin, M., Schlumbeger, The history of a technique, John ley & Sons, NY, 1977

[2] Vynne, J.F., (1997). "The application and economic benefits of blast hole drilling monitors", proc. ISEE 23rd Annual Conference on Explosived and technique, Las Vegas.

[3] JKSimBlast Design: 2DBench. 2016. JKSimBlast Design: 2DBench. [ONLINE] Available at:http://www.soft-blast.com/JKSimBlast/2DBench.html , Visited, 15th January 2017

[4] Split Engineering. 2016. JKSimBlast Software - Split Engineering. [ONLINE] Available at:https://www.spliteng.com/products/jksimblast-software/, Visited, 10th January 2017.

[5] JKSimBlast Design: 2DBench. 2016. JKSimBlast Design: 2DBench. [ONLINE] Available at:http://www.soft-blast.com/JKSimBlast/2DBench.html , Visited, 15th January 2017