EVALUATION OF BLAST FRAGMENTATION OF AN OPENCAST MINE

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ABSTRACT: Fragmentation is one of the critical results of the blasting also treated as first quality demand in most types of blasting which affects all the downstream processes of mine and mill production like loading, hauling, crushing, and milling efficiency and has a great impact on the cost involved in these processes. In this study, the fragmentation analysis of a chromite mine of Boula-Nuasahi Complex belt was conducted using WipFrag fragmentation analysis software. Both single and merged image analysis were done and the merged image analysis was used to evaluate the optimum fragmentation. The mean fragment size of the blasted rock was predicted from the analysis.

Key words: Blast, Optimum Fragmentation, Mean Fragment, Production, WipFrag

INTRODUCTION

Blasting is the most important operation in entire mining processes and plays the pivotal role in the field of mine production and productivity where explosives are used for the liberating the rock from the ground[1, 2]. Although, there is an another alternative to loosen the rock from the bulk of rock mass where cutting machines are deployed directly to the rock face which was highly dominant method in early age of mining[3]. However, the development of explosives has given a new turn to the mining industries in their economic productions[4].

Achievement of optimum fragmentation is the primary quality demand of most types of blasting operation which indicates the quality performance of blasting[5]. A good fragmentation increases not only the efficacy of loading and hauling equipments but also reduces the cost of crushing and milling and hence plays pivotal role in production and productivity of a mine[6,7].

Fragmentation evaluates also the quality planning of production of any surface mine for example designing a proper blast, selection of appropriate explosives, application of suitable initiation system, appropriate delay pattern, direction of blasting, and the blast hole environment also affect the blasting performance and hence the optimum fragmentation[8]. In this study, fragmentation of a chromite mine Boula-Nuasahi Complex belt was analyzed through the analysis the ten images of blasted muckpile taken from different angles and different distances through the WipFrag image analysis software. The WipFrag image analysis software is recently developed granulometry software[9]. It utilizes the technique of measurement of fragmentation with the help of digital images of blasted muck pile.

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METHODOLOGY

Image processing

Image processing is used to transform the image of rock fragments into a binary image consisting of a net of block outlines.

Block Identification

Identification of block edges is done in a two stage process. The first stage uses several conventional image processing techniques, including the use of thresholding and gradient operators. The operators detect the faint shadows between adjacent blocks, and work best on clean images with lightly textured rock surfaces. The second stage uses a number of reconstruction techniques to further identify the edges of the blocks that are only partly delineated during the first stage. These include both knowledge based and arbitrary reconstruction techniques, to complete the net.

Edge Detection Variables (EDV)

For each of the image processing stages, parameters called Edge Detection Variables (EDV)are accessible to the user, to optimize the edge detection process. The user has the choice of adjusting individual variables to optimize one stage of the process, or selecting one of nine preset combinations of EDV. These combinations are arranged in sequence to produce more or fewer edges, depending on the nature of the image. Thus selecting more edges will reduce the number of missing edges in a given image, while selecting fewer edges will reduce the number of false edges in that image.

Editing to improve fidelity of the net

For improved accuracy is required, the fidelity of the net can be increased by manual editing. A set of interactive editing tools, to draw lines and polylines, erase lines, or erase areas, can be used to quickly remove false edges and draw missing edges to complete the net. The net is normally displayed as an overlay on the original rock images, so the fidelity of the net can at all times be evaluated by the user.

Analysis

Having identified a net of fragments outlines WipFrag proceeds with the analysis portion of the measurement which involves a 2 dimensional measurement on the image, reconstruction of the 3 dimensional distributions and the production of graphical output.

Single analysis of images:

All the 10 images are analyzed individually using WipFrag image analysis. The size distribution obtained from the single image analysis cannot provide the optimum size distribution as they do not represent the whole area.

Merged image analysis

The results obtained from the single image analysis are merged and analysis with WipFrag to obtained the optimum size distribution and correct parameters.

Measurement of Fragment Areas

In the final operation on the digital image, the block profile areas and shape factors are measured on the outline net of block edges. All operations are performed sequentially on individual digital images in the computer main memory. At any stage of the analysis, the image or net can be saved on disk for future reference (complete with information such as scaling factors) or printed out on a laser printer to provide a hardcopy for reference.

At this point the list of block profile areas is saved to a compact disk file. Subsequent operations can be done immediately, or later, using one or several files at a time, including merging multiple data files into a single analysis.

Reconstruction from 2-D to 3-D

The initial step in this phase of analysis is to divide the measured 2-dimensional distributions into 40 size classes or "bins". The 2-D to 3-D conversions, using principles of geometric probability (Maerz, 1996), are performed on each bin. Initially the distribution is converted into a 3-D frequency distribution, and then to a weight percent basis. Finally the distribution is converted to a cumulative weight percent distribution.

Graphical and Other Output

WipFrag provides output in terms of graphs and hard copies of analysis results. The user has the option of automatically accepting the default graph during the analysis, or selecting several

RESULT AND ANALYSIS

Single image analysis results

Following the methodology of image analysis in WipFrag system, the results of single image from 1 to 10 are given with the images. The image analysis shows the size distribution. The different notations shown in the image analysis curve are described below.

Dn: Nominal diameter, or equivalent spherical diameter, i.e. the diameter of a sphere with the same volume as that computed for the fragment.

D10: Percentile sizes. For example D10 is the ten-percentile, the value of Dn for which 10% by weight of the sample is finer and 90% coarser in term of sieving or D10 is the size of sieve opening through which 0% by weight of the sample would pass.

D50: The Median or 50-percentile, the value of Dn for which half the sample weight is finer and half coarser.

Mean: Arithmetic mean (average) fragment size, equal to the sum of all equivalent spherical diameters divided by the total number of particles [Dav (m)].

Mode: Most common sized particle, the geometric mean Dn size class interval for the class containing the greatest number of net elements (fragments) [Dn (m)]

N: Rosin-Rammler Uniformity Coefficient, equal to the slope of the Rosin-Rammler straight line fitted to the data in log-log co-ordinates.

Xc: Characteristic Size, the intercept of the Rosin-Rammler straight line fitted to the WipFrag Dn data in log-log co-ordinates. This is equivalent to the $D_{63.2}$.

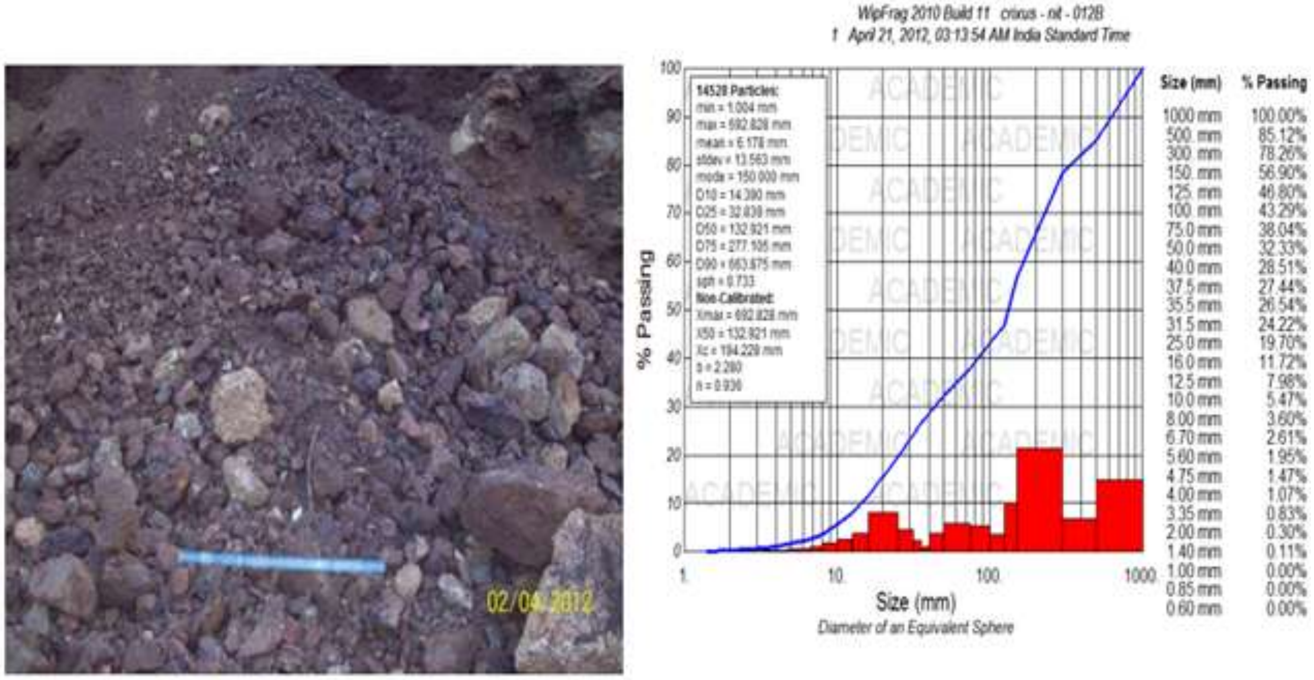
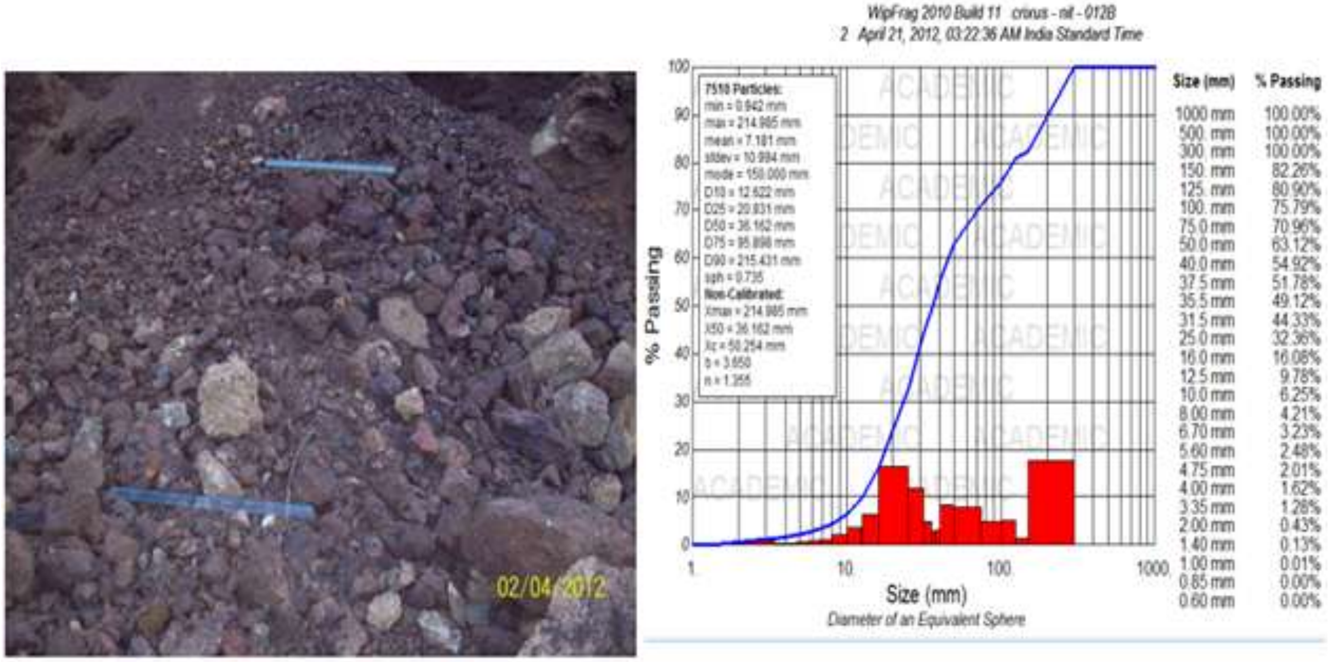
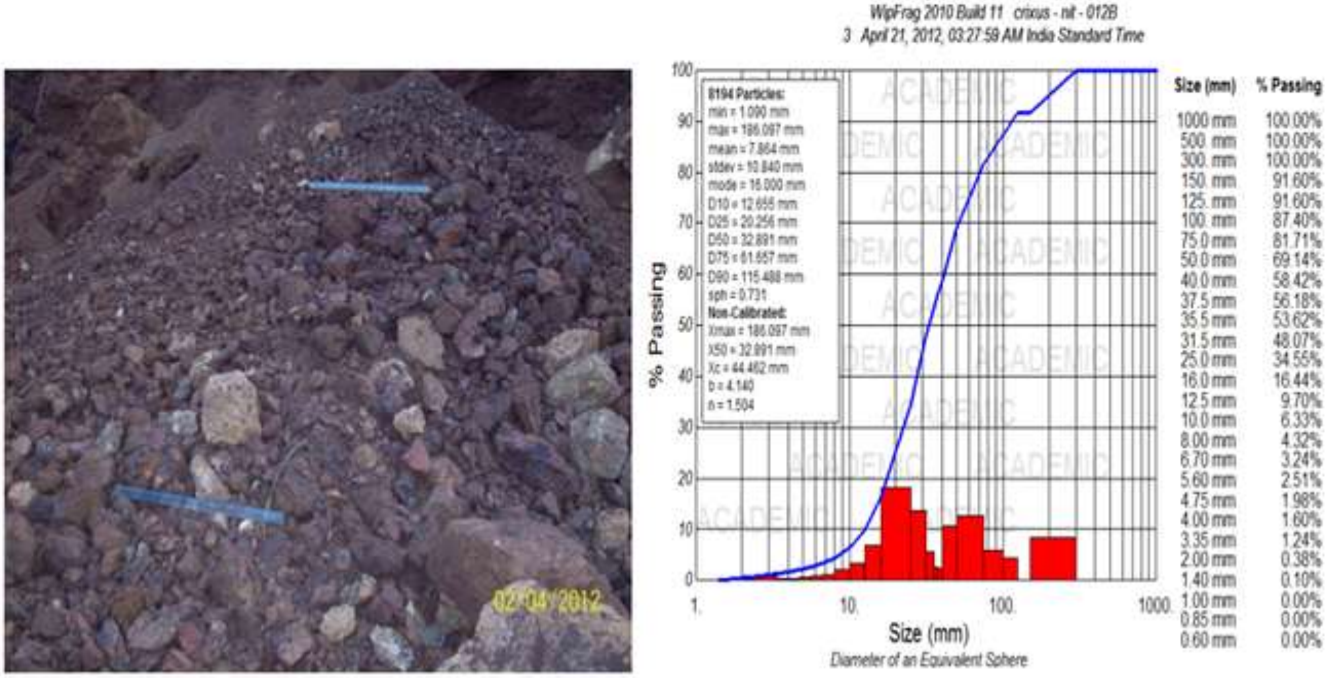


Figure 1. Photograph of muckpile and related size distribution graph



Size (mm)	% Passing
1000 mm	100.00%
500. mm	100.00%
300. mm	100.00%
150. mm	82.26%
125. mm	80.90%
100. mm	75.79%
75.0 mm	70.96%
50.0 mm	63.12%
40.0 mm	54.92%
37.5 mm	51.78%
35.5 mm	49.12%
31.5 mm	44.33%
25.0 mm	32.36%
16.0 mm	16.08%
12.5 mm	9.78%
10.0 mm	6.25%
8.00 mm	4.21%
6.70 mm	3.23%
5.60 mm	2.48%
4.75 mm	2.01%
4.00 mm	1.62%
3.35 mm	1.28%
2.00 mm	0.43%
1.40 mm	0.13%
1.00 mm	0.01%
0.85 mm	0.00%
0.60 mm	0.00%

Figure 2. Photograph of muckpile and related size distribution graph



Size (mm)	% Passing
1000 mm	100.00%
500. mm	100.00%
300. mm	100.00%
150. mm	91.60%
125. mm	91.60%
100. mm	87.40%
75.0 mm	81.71%
50.0 mm	69.14%
40.0 mm	58.42%
37.5 mm	56.18%
35.5 mm	53.62%
31.5 mm	48.07%
25.0 mm	34.55%
16.0 mm	16.44%
12.5 mm	9.70%
10.0 mm	6.33%
8.00 mm	4.32%
6.70 mm	3.24%
5.60 mm	2.51%
4.75 mm	1.98%
4.00 mm	1.60%
3.35 mm	1.24%
2.00 mm	0.38%
1.40 mm	0.10%
1.00 mm	0.00%
0.85 mm	0.00%
0.60 mm	0.00%

Figure 3. Photograph of muckpile and related size distribution curve

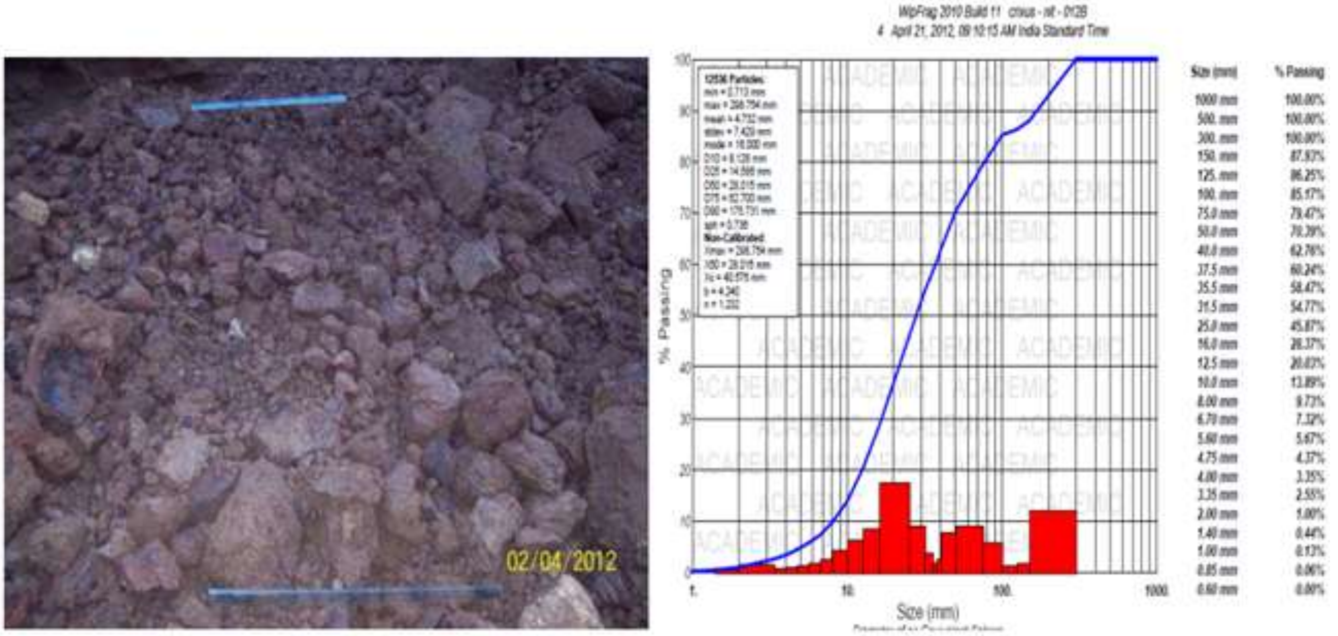


Figure 4. Photograph of muckpile and related size distribution curve

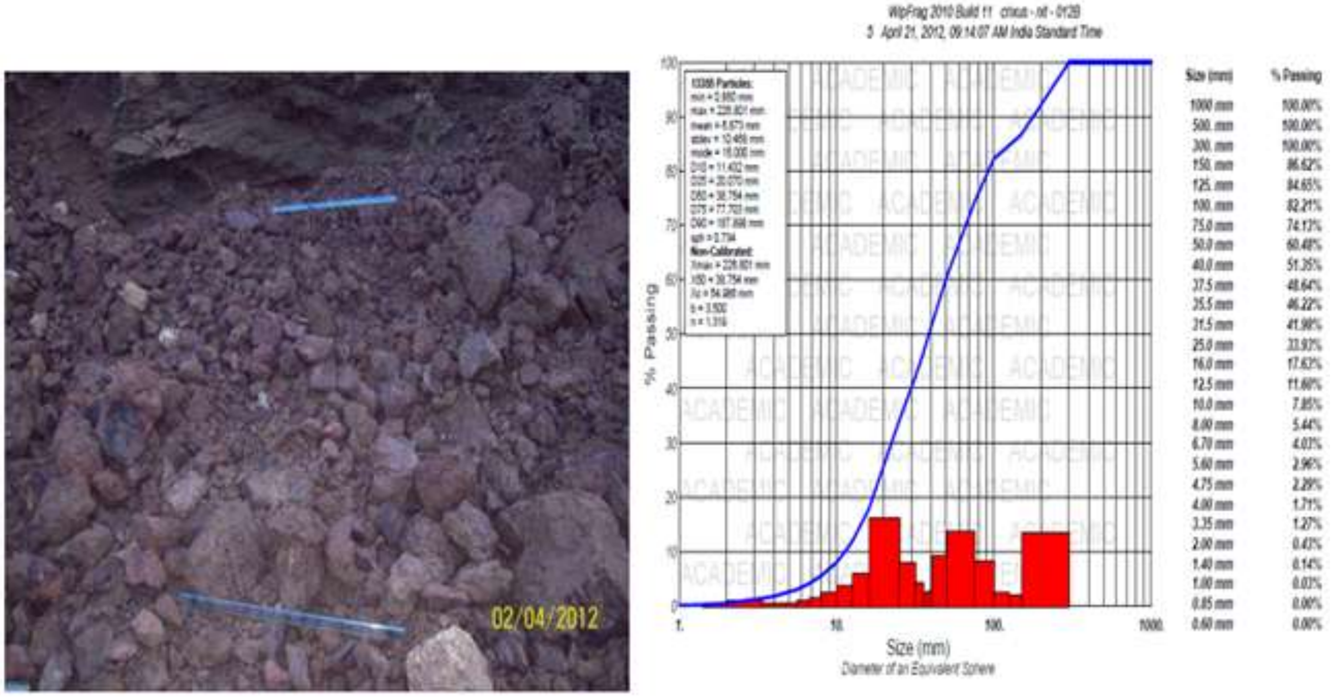


Figure 5. Photograph of muckpile and related size distribution curve

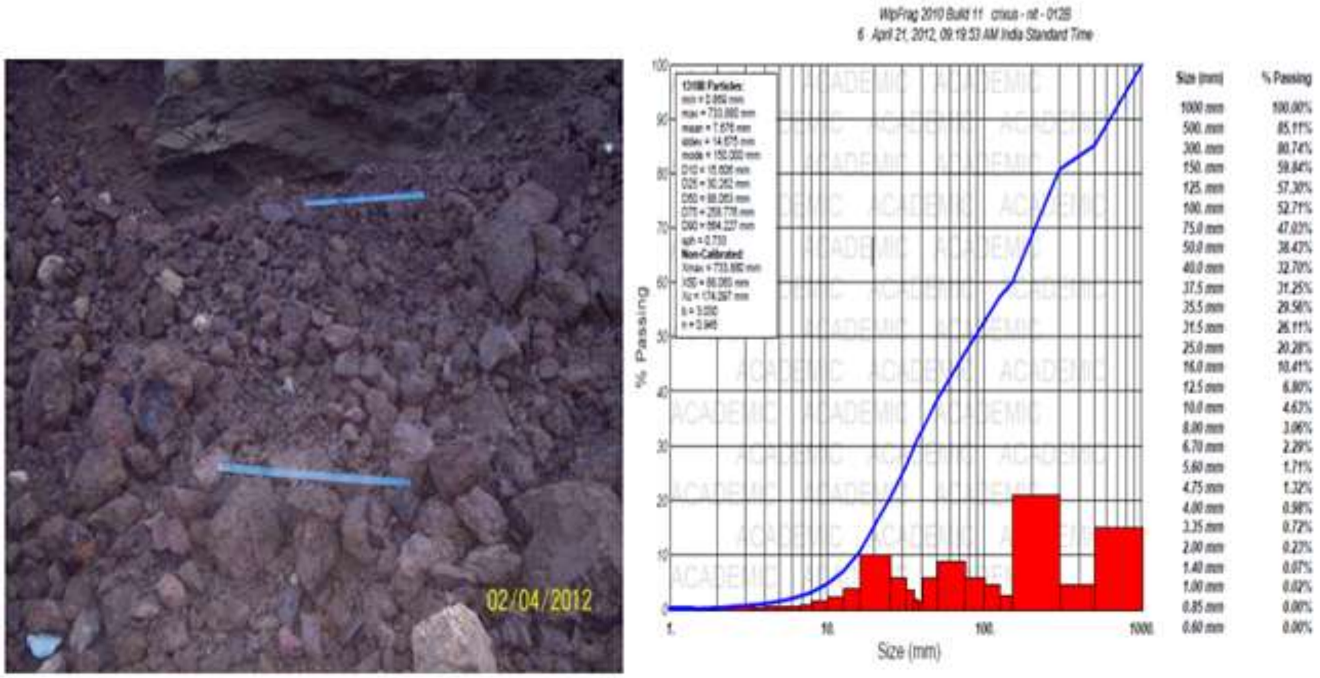


Figure 6. Photograph of muckplie and related size distribution curve

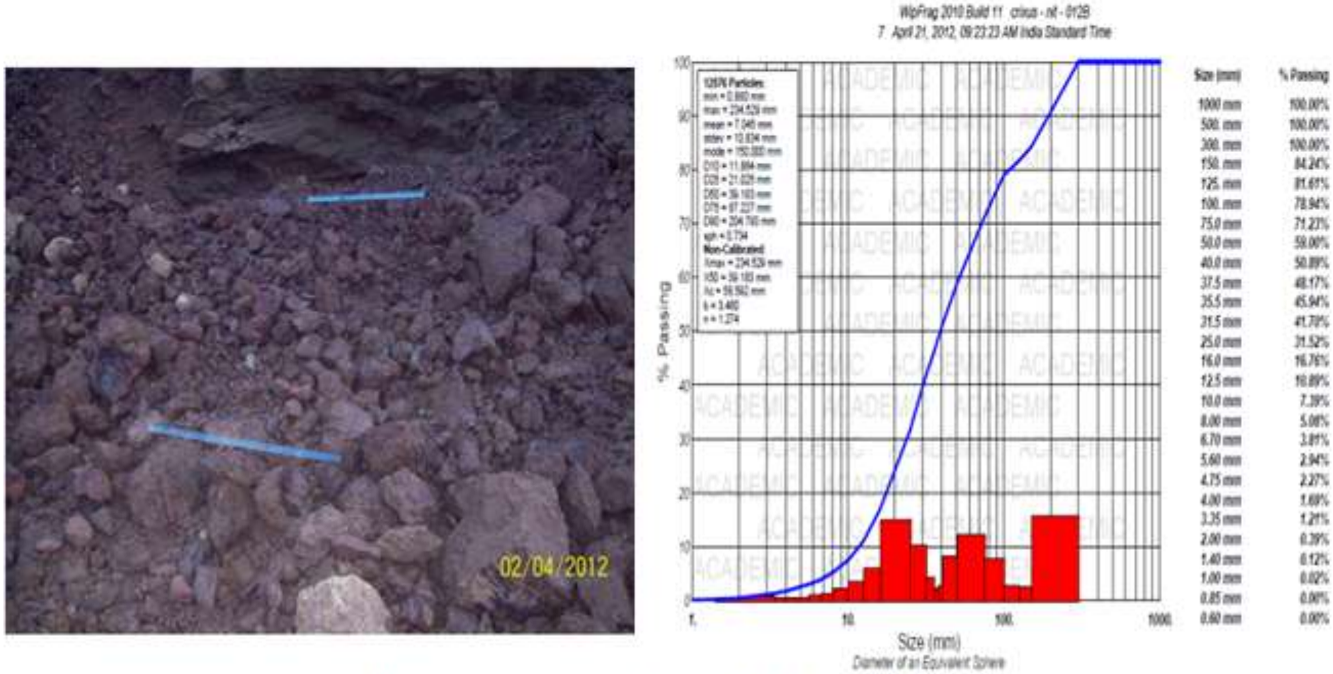


Figure 7. Photograph of muckpile and related size distribution curve

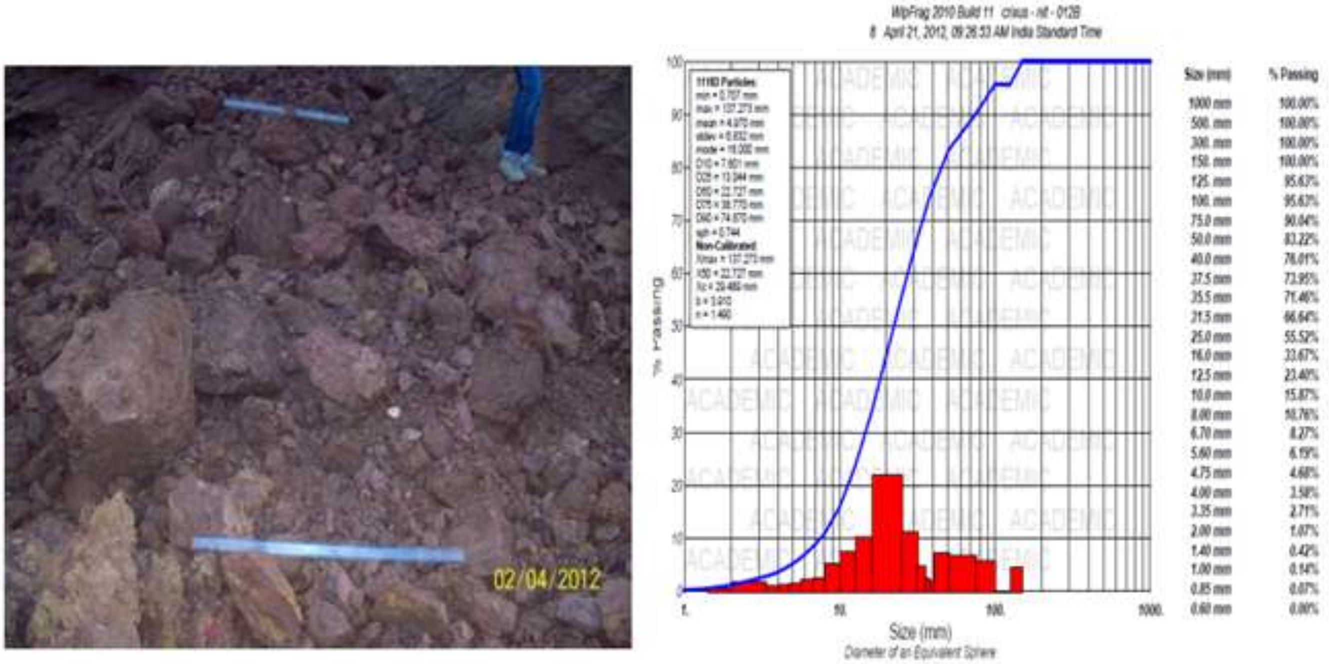


Figure 8. Photograph of muckpile and related size distribution curve

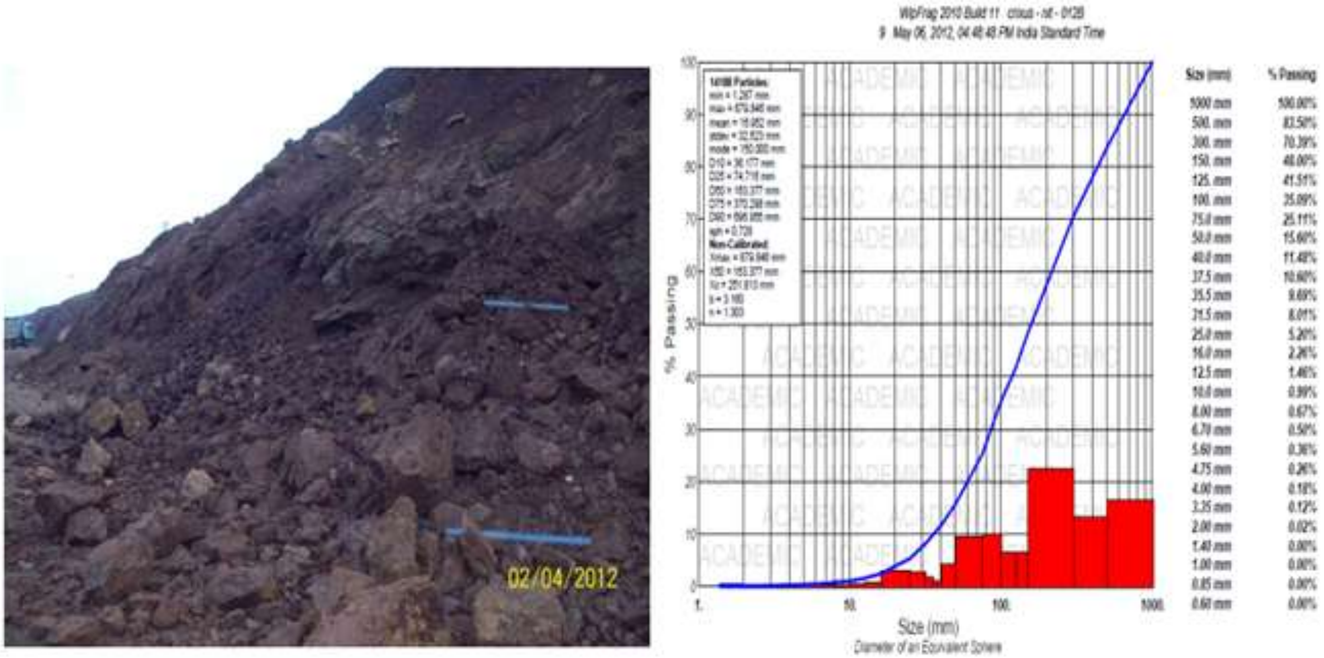
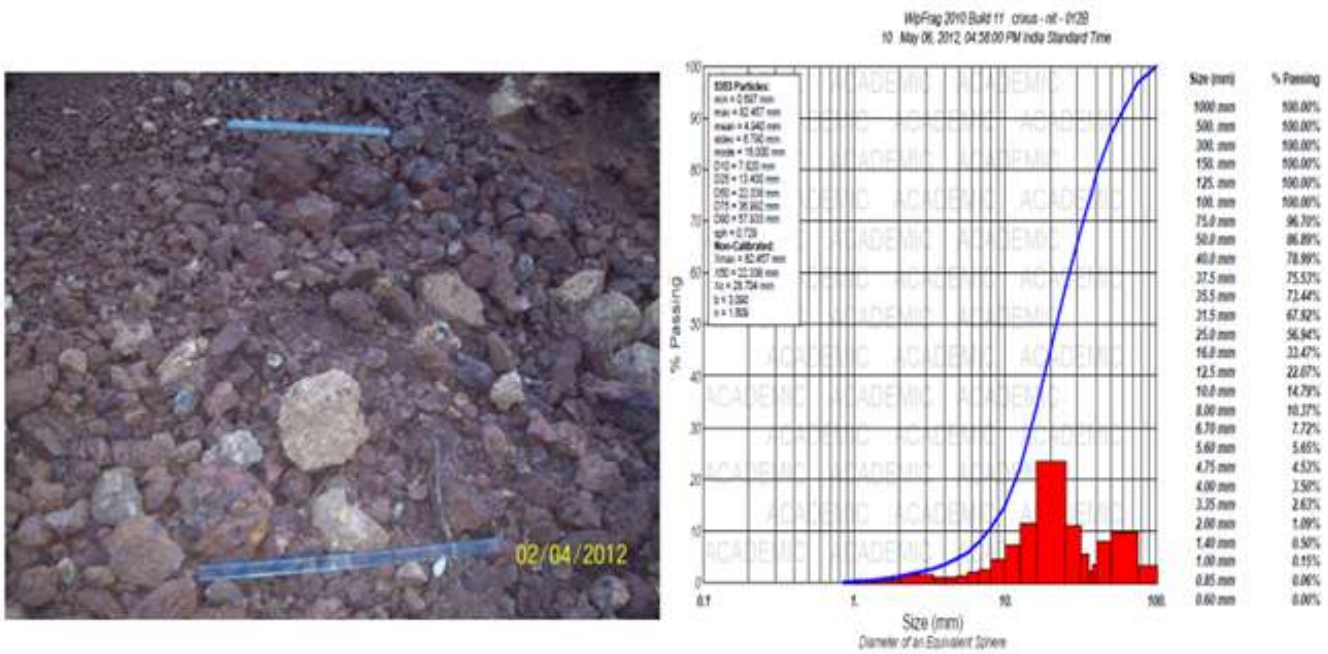


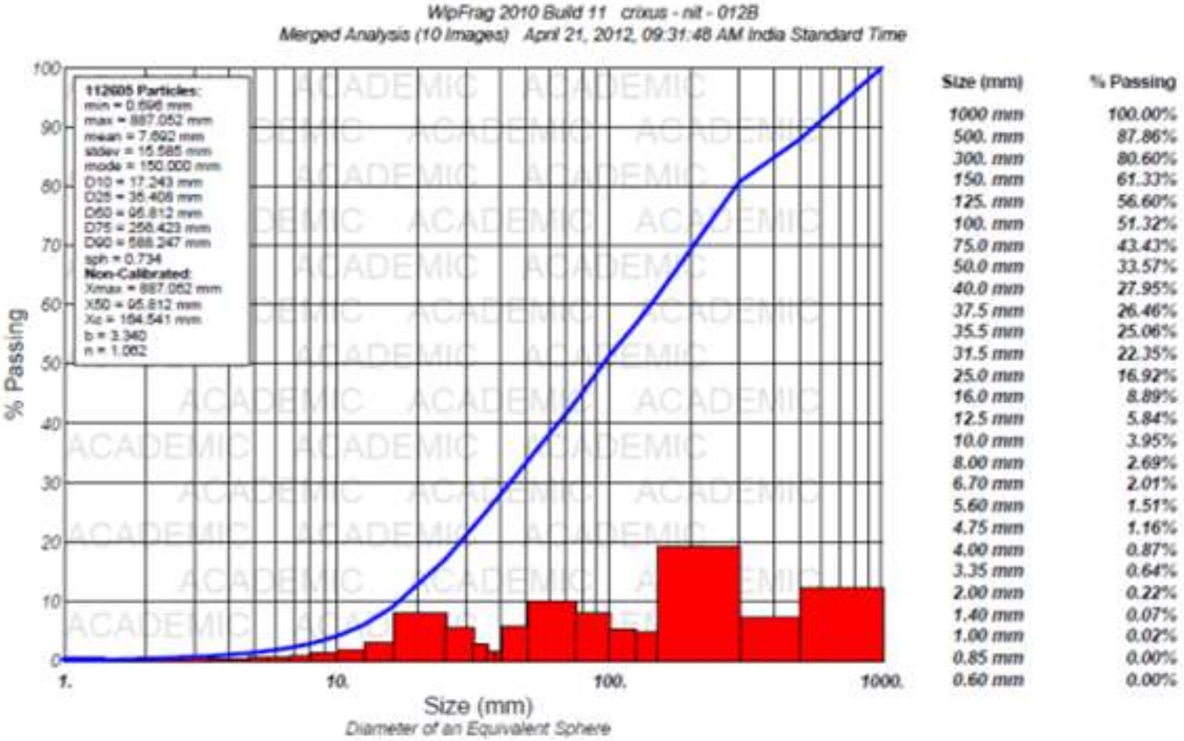
Figure 9. Photgraph of muckpile and related size distribution curve



Size (mm)	% Passing
1000 mm	100.00%
500. mm	100.00%
300. mm	100.00%
150. mm	100.00%
125. mm	100.00%
100. mm	100.00%
75.0 mm	96.70%
50.0 mm	86.89%
40.0 mm	78.99%
37.5 mm	75.53%
35.5 mm	73.44%
31.5 mm	67.92%
25.0 mm	56.94%
16.0 mm	33.47%
12.5 mm	22.07%
10.0 mm	14.79%
8.00 mm	10.37%
6.70 mm	7.72%
5.60 mm	5.65%
4.75 mm	4.53%
4.00 mm	3.50%
3.35 mm	2.63%
2.00 mm	1.09%
1.40 mm	0.50%
1.00 mm	0.15%
0.85 mm	0.06%
0.60 mm	0.00%

Figure 10. Photograph of muckpile and related size distribution curve

Merged image analysis



Size (mm)	% Passing
1000 mm	100.00%
500. mm	87.86%
300. mm	80.60%
150. mm	61.33%
125. mm	56.60%
100. mm	51.32%
75.0 mm	43.43%
50.0 mm	33.57%
40.0 mm	27.95%
37.5 mm	26.46%
35.5 mm	25.06%
31.5 mm	22.35%
25.0 mm	16.92%
16.0 mm	8.89%
12.5 mm	5.84%
10.0 mm	3.95%
8.00 mm	2.69%
6.70 mm	2.01%
5.60 mm	1.51%
4.75 mm	1.16%
4.00 mm	0.87%
3.35 mm	0.64%
2.00 mm	0.22%
1.40 mm	0.07%
1.00 mm	0.02%
0.85 mm	0.00%
0.60 mm	0.00%

Figure 11. Size distribution obtained from merged analysis of the 10 samples.

It was observed that maximum percentage at 47.37 % of material lie between 10mm to 100mmfollowed by material sizes between 100mm to 500mm at 36.54%.

It is also found that
D10=17.243mm
D90=588.247mm
XC=164.541mm
Where, the notations are described earlier.

Merged image analysis results	**Size distribution (%)**			
	500-1000mm	100-500mm	10-100mm	0-10mm
	12.14	36.54	47.37	3.95

Table 4.1

CALCULATION OF UNIFORMITY COEFFICIENT AND COEFFICIENTOF CURVATURE

Uniformity Coefficient Cu (measure of the particle size range)

Cu is also called Hazen Coefficient. Hazen found that the sizes smaller than the effective size affected the functioning of filters more than did the remaining 90 percent of the sizes. To determine whether a material is uniformly graded or well graded he proposed the following:

Cu= D60 / D10

Cu< 5 ----- Very Uniform
Cu = 5-15 ----- Medium Uniform
Cu>15 ----- Non uniform

From the above merged analysis graph (fig 4.21), we found that D60 =149mm
D10=17.243mm

Hence Cu =149/17.243 =8.64

So, it shows that the size distribution is Medium uniform.

Coefficient of Gradation or Coefficient of Curvature Cg

(Measure of the shape of the particle size curve)

Cg= (D30)^2/ (D60 X D10)

Cg from 1 to 3 shows the distribution is well graded or desired sizes.

From the merged analysis graph it is found that D30=45mm

Putting the value of D60 =149mm, D10=17.243mm and D30=45mm in the above given formulae we get the value of Cg=0.79 which is less than 1. So the distribution is poor graded.

CONCLUSIONS

The study was carried out to investigate the efficiency of blasting process of the target mine through fragmentation analysis using WipFrag software. Both single image analysis and merged image analysis were performed and results were used to calculate the Uniformity Coefficient (C_u) and Coefficient of Curvature (Cg) which are the measures of the particle size distribution range and the shape of particle size curve respectively and indicate the uniformity of particles size distribution and graded distribution of the particles respectively. Uniformity coefficient and graded distribution of the particles were obtained from the analysis of the results respectively 8.64 and 0.79 which indicate the medium uniform and poorly graded particles size distribution respectively and hence production and productivity of can't be honored.

In order for the mine to be productive, fragmentation should be very uniformly distributed and well graded because fragmentation affects all the downstream processes like loading and hauling efficiency, crushing and milling efficiency. In order to make the concept “from Mine to Mill production” efficient, there are urgent need to revisit the blasting technology used in the mine and find out the causes of poor fragmentation. There requires to investigate the accuracy of the blast design, proper explosives selection, explosives loading method, system of initiation, delay patterns and direction blast as per the availability of equipments and infrastructures.

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