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# Rock Fragmentation Analysis using WIPFRAG

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***Abstract:*** Size of rock fragments subsequent to blasting has direct impact on cost of transportation and processing. The cost increases with the increasing size of the fragments. This necessitates quick and accurate measurements of size distribution of fragmented rocks to decide further course of action for optimizing the cost of entire operation. There are many such measurement methods available and used by industry/researchers but most of the methods are time consuming and not precise. In such scenario WipFrag came as an automated image based granulometry system that uses digital image analysis of rock photographs and video tape images to determine grain size distributions. In this project, images of rock pile samples will be captured at different angles using camera and analysis of cumulative size distribution and optimum rock fragmentation will be carried out using WipFrag.

***Keywords:*** Rock fragmentation, blasting, size distribution, WipFrag, image analysis.

## I. INTRODUCTION

Fragmentation is a process utilized for breaking solid in situ rock masses into smaller particles. The fragmentation of rock is usually performed by blasting or drilling. Various parameters have to be considered while blasting to minimize the effects of the process. The Wipfrag software is used for measuring fragmentation. It uses the digital images of the blasted site to analyze the fragmentation. The fragmentation sizing system, also known as WipFrag, is used in mines and materials handling industries for the evaluation of the efficiency of comminution processes. The images taken by a digital camera or camcorder are transferred to the WipFrag system. WipFrag is a software that automatically captures and displays images from a muck pile. The images are then analyzed using an automatic netting system.

The detailed methodology of fragmentation analysis with a WipFrag system is discussed in further sections

## II. METHODOLOGY

Qualitative visual observation is a field approach that uses a visual interpreter. It is widely used for initial observation. Due to the increasing popularity of digital image processing systems, the sizing of materials is becoming more prevalent. Numerous image processing programs are available to assist in this task.

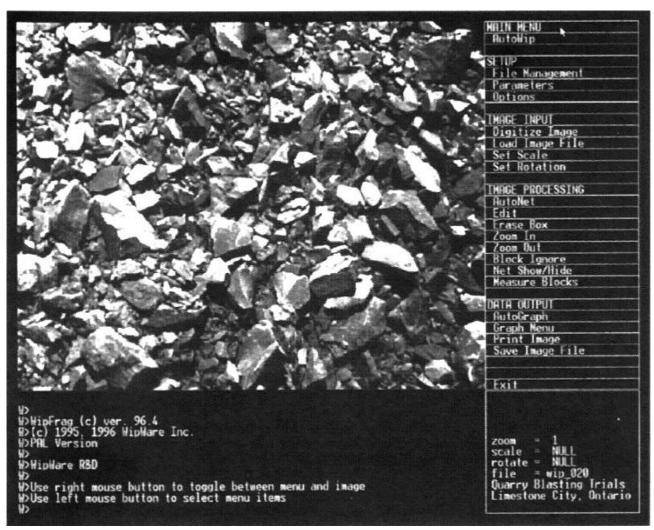


**Fig 1. Wipfrag Main Screen**

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### *2.1. Image Processing*

Image processing is used to transform the image rock fragments (Figure3.4) into a binary image consisting of a net of block outlines

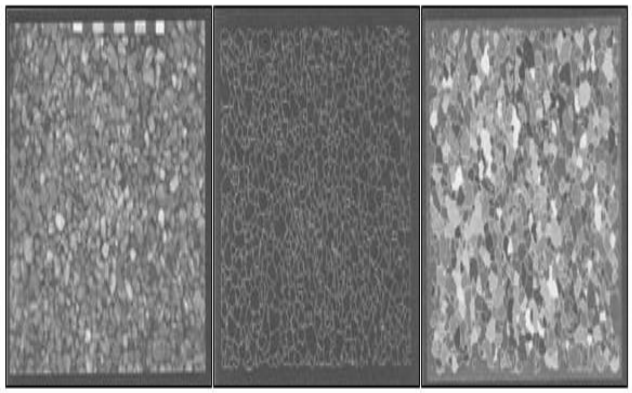

Figure 2.1. Images of pea gravel   Figure 2.2. Net of rock edges   Figure 2.3. Identified rock fragments

### *2.2. Fragment Delineation and Editing*

The generation of binary images from acquired images is done by Wipfrag. It automatically identifies and quantifies the particles in the images.

Editing the images is necessary to enhance their delineation and some manual editing is also required.

### *2.3. Block Identification*

The delineation of blocks in WipFrag involves the identification of block edges. This is done in a two-stage process.

The first stage uses various image processing techniques to image smooth and dark areas. The operators are used to detect the faint shadows between the blocks and provide clean images.
The second stage uses various reconstruction techniques to identify blocks that are only partially outlined in the first stage.

### *2.4. Edge Detection Variables (EDV)*

Edge detection variable (EDV) are used to improve the efficiency of the image processing stages. The user can either select one of nine preset combinations or modify the individual variables.

A representation of Wipfrag software is shown in figure

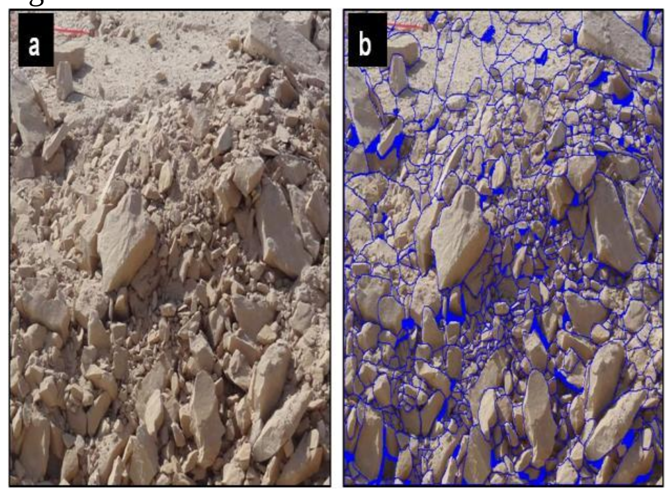


**Fig 3. (a) Field Image for calculation of size distribution and (b) Delineated image.**

### *2.5. Editing to improve the fidelity of the net*

When the net is not as accurate as intended, manual editing is often necessary. This method involves removing false edges and polylines, and then drawing missing edges.

### *2.6. Reconstruction from 2-D to 3-D*

The first step in this process is to divide the 2-D distribution into 40 bin sizes.The first step in this process is to divide the 2-D distribution into 40 bin sizes.

## III. RESULTS AND ANALYSIS

The cumulative size distribution of rock piles is obtained from the multiple image analysis technique. This method is used for optimal rock fragmentation.Validation of results are represented below

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### *3.1. Assessment of Fragmentation for 102 mm Diameter*

Frame 1 Frame 2 Frame 3

**Fig 4.1. Original gray scale images for Blast # 1**

**Table 1. Fragment size distribution for blast # 1 for different frames**

| Photo ID | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, (m) |
|---|---|---|---|---|---|
| Frame 1 | 0.445 | 2.6 | 0.4162 | 265 | 1.000 |
| Frame 2 | 0.266 | 1.82 | 0.2148 | 575 | 0.774 |
| Frame 3 | 0.444 | 2.01 | 0.4409 | 120 | 0.774 |

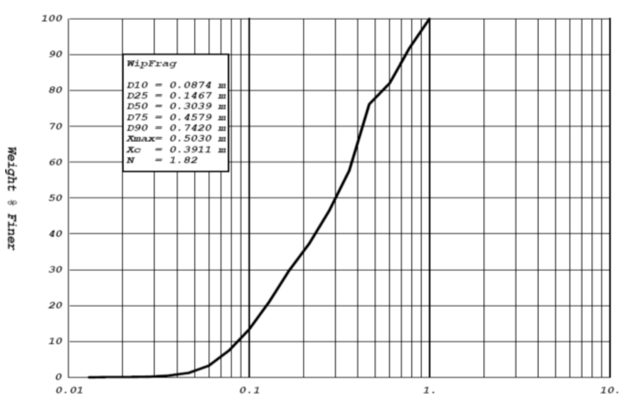


**Fig 4.2. Block size distribution (merged analysis) for Blast # 1**

Frame 1 Frame 2 Frame 3

**Fig 5.1. Original gray scale images for blast # 2**

**Table 2. Fragment size distribution for blast # 2 for different frames**

| Photo ID | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, (m) |
|---|---|---|---|---|---|
| Frame 1 | 0.254 | 2.50 | 0.2321 | 423 | 0.599 |
| Frame 2 | 0.288 | 2.85 | 0.2739 | 412 | 0.774 |
| Frame 3 | 0.401 | 2.42 | 0.4271 | 207 | 0.774 |

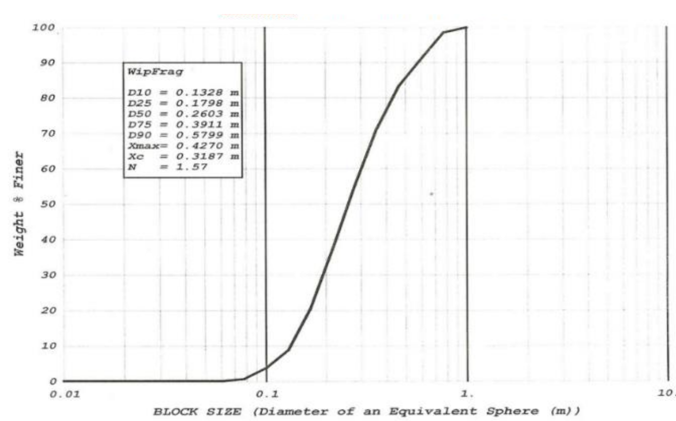


**Fig 5.2. Block size distribution (merged analysis) for Blast # 2**

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**Table 3. Merged Analysis of Size Distribution for Blasts 1 & 2 (102mm)**

| Photo ID | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, m |
|---|---|---|---|---|---|
| Blast 1 | 0.396 | 1.82 | 0.3911 | 962 | 1.0 |
| Blast 2 | 0.306 | 2.19 | 0.2865 | 1044 | 0.8 |

**Table 4. Merged Analysis of Passing Percentage for Blasts 1 & 2(102mm)**

| Blast # | Sieve Size(Mm), Percentage Of Passing | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1000 | 800 | 500 | 300 | 150 | 125 | 100 |
| Blast 1 | 100.0% | 96.5% | 77.0% | 49.50% | 25.8% | 19.8% | 13.3% |
| Blast 2 | 100.0% | 95.2% | 87.5% | 65.4% | 27.6% | 21.8% | 14.7% |

### *3.2. Assessment of Fragmentation for 165 mm Diameter*

The size distribution of the blast is obtained by merging individual frames into a single result. For each blast, an object of known length is taken.(1m x 1m)

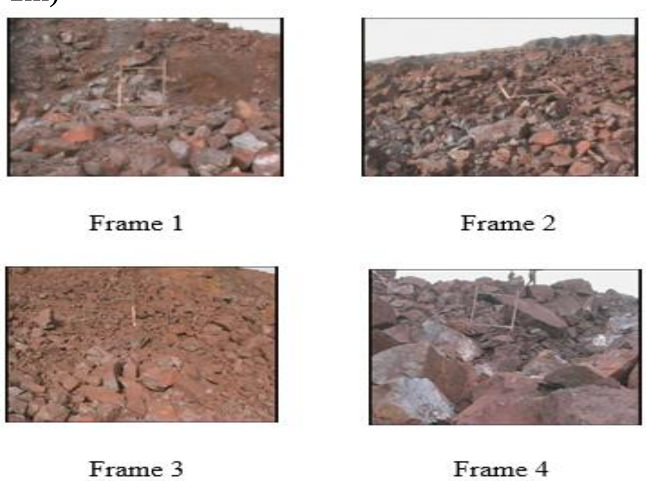


**Fig 6.1. Original Gray Scale Images for Blast # 3**

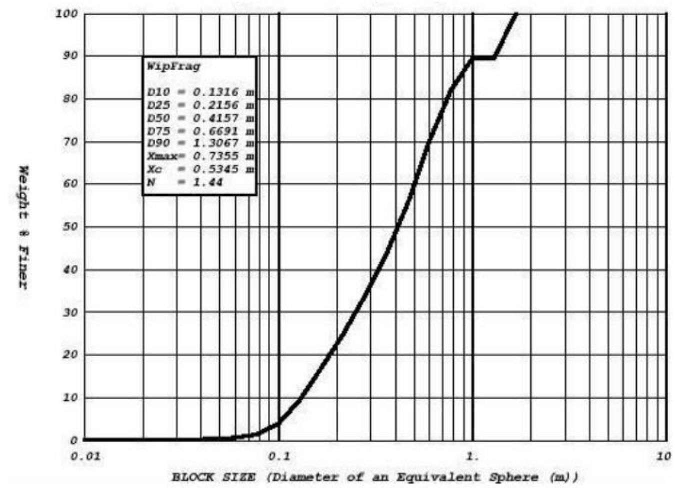


**Fig 6.2. Fragment size distribution Curve forBlast #3**

**Table 5. Fragment size distribution for blast # 3 for different frames**

| Photo ID | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, m |
|---|---|---|---|---|---|
| Frame 1 | 0.406 | 1.48 | 0.4770 | 568 | 0.774 |
| Frame 2 | 0.259 | 2.90 | 0.3103 | 335 | 0.464 |
| Frame 3 | 0.428 | 1.72 | 0.4303 | 700 | 1.000 |
| Frame 4 | 0.964 | 1.52 | 0.9323 | 203 | 1.668 |


**Fig 7.1. Original gray scale for Blast # 4**

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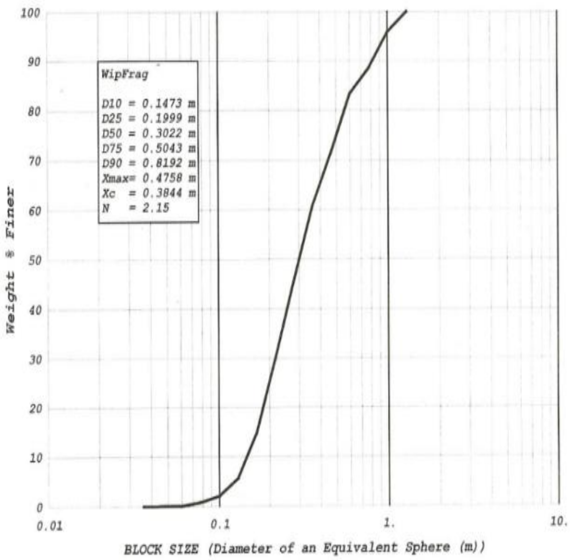


**Fig 7.2. Fragment size distribution curve forBlast # 4**

**Table 6. Fragment size distribution for blast # 4 for different frames**

| Photo ID | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, m |
|---|---|---|---|---|---|
| Frame 1 | 0.570 | 2.04 | 0.5706 | 207 | 1.000 |
| Frame 2 | 0.576 | 1.99 | 0.5739 | 417 | 1.292 |
| Frame 3 | 0.613 | 2.51 | 0.6630 | 186 | 1.000 |
| Frame 4 | 0.405 | 2.23 | 0.3985 | 286 | 1.000 |

**Table 7. Merged Analysis Of Fragment Size Distribution For Blasts 3 & 4 For 165mm**

| Blast # | Mean fragment size, (m) | Uniformity Index, (n) | Characteristic Size, m (Xc) | No of Blocks | Maximum Fragment Size, (m) |
|---|---|---|---|---|---|
| Blast 3 | 0.584 | 1.44 | 0.53 | 1767 | 1.668 |
| Blast 4 | 0.539 | 1.34 | 0.54 | 1130 | 1.292 |

**Table 8. Summary Of Merged Analysis Of Passing Percentage For 165mm.**

| Blast # | SIEVE SIZE(mm), percentage of passing | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1000 | 800 | 500 | 300 | 150 | 125 | 100 |
| Blast 3 | 92.00% | 83.20% | 61.30% | 33.20% | 11.90% | 8.90% | 6.90% |
| Blast 4 | 96.80% | 82.50% | 58.40% | 30.60% | 12.40% | 9.60% | 6.10% |

The results obtained from the individual analysis of the rock pile samples cannot be treated as perfect because the digital images used for analysis cannot reveal the conditions of fragmentation behind the muck pile surface. Hence, it becomes necessary to obtain an average result of the analysis carried out with various samples. For this purpose merging of the individual results is done. The results thus obtained would be precise enough to predict the optimum blast parameters. The results obtained from multiple image analysis are shown in Table 9 below

**Table 9. Mean Passing Percentage(%) of All 4 Blasts**

| SIEVE SIZE(mm), Passing Percentage(%) | | | | | | |
|---|---|---|---|---|---|---|
| 1000mm | 800mm | 500mm | 300mm | 150mm | 125mm | 100mm |
| 97.2% | 89.35% | 71.05% | 44.67% | 19.42% | 15.02% | 10.25% |

## IV. CONCLUSION

The WipFrag is efficient fragmentation analysis software which uses photos to analyze the rock fragments. It is a direct method of fragmentation assessment as compared to the other methods such as the shovel loading rate method, explosive consumption in secondary blasting method or lab sampling method.

Optimum size distribution of the samples are analyzed with multiple image analysis of Wipfrag software and found the passing percentage for 1000mm- 97.2%, 800mm- 89.35%, 500mm-

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71.05%, 300mm- 44.67%, 150mm- 19.42%, 125mm-15.02% and 100mm- 10.25%.

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