Study on Evaluation of Fracture Condition in Rock Mass and Particle Size Prediction of Fragmented Rocks by Using Fractal Dimension

Yuka Ota

Laboratory of Rock Engineering and Mining Machinery

Department of Cooperative Program for Resources Engineering

1. Introduction

In the blasting in mines, understanding the rock mass condition contributes to the efficiency of blasting work. When the fragmented rocks with large size occur, the load of the crusher becomes large and it is necessary to break them by rock breaker. Conversely, in case that the fragmented rocks are too fine, a screen may be clogged up. Therefore, the prediction and control of particle size of fragmented rocks are very important to optimize the mining operation. Moreover, as the fracture condition have an obvious impact on the particle size of fragmented rocks, a simple and accurate method for evaluating fracture condition in rock mass is necessary. From these backgrounds, this study discusses the introduction of fractal dimension as an evaluation method of fracture condition in rock mass and its application to particle size prediction of fragmented rocks.

2. Methodology

Fractal dimension quantifies the self-similarity of a figure, and it increases as the shape becomes more complex. To evaluate fracture condition in rock mass by using fractal dimension, it is necessary to extract fractures from the bench face image. Therefore, an attempt was made to extract fractures through binarization to face images. Subsequently, using the binary images, the fractal dimension was calculated using the Fractal Analysis System 'FRACTAL3'. Furthermore, it was also discussed that the availability of fractal dimension for predicting particle size of fragmented rocks by using Kuznetsov equation which is represented as equation (1).

$$x_m = AK^{-0.8}Q^{1/6} \cdot \left(\frac{115}{RWS}\right)^{19/20} \tag{1}$$

Where, x_m is the particle size of fragmented rocks, A is the rock factor, K is the powder factor, Q is the mass of explosive in a hole, and RWS is the weight strength relative to ANFO.

3. Results and Discussions

Figure 1 illustrates the relationship between fracture density of rock mass and the fractal dimension calculated from binary images of bench faces. It can be said from this figure that there is a correlation between them and the fractal dimension can be used to evaluate the fracture density of rock mass. Moreover, as it had been revealed from the previous study that the fractal dimension also reflects the fracture width, the fracture condition in rock mass can be effectively evaluated by fractal dimension. As the particle size of fragmented rocks is strongly affected by rock mass condition such as fracture condition and type of rock, the applicability of fractal dimension to the prediction of the particle size is discussed by using Kuznetsov equation (see Equation (1)). Figure 2 shows the relationship between the rock factor A, which represents rock type and fracture condition in Kuznetsov equation, and the fractal dimension calculated from binary images of bench face. From this figure, it can be considered that the rock factor A can be determined by fractal dimension and formulas categorized by rock types. The formulas for siliceous rock and tuff are represented as equations (2) and (3), respectively.

$$A_{\text{siliceous}} = -2.134f + 4.501 \tag{2}$$

$$A_{\text{tuff}} = -2.159f + 4.830 \tag{3}$$

Where, f is the fractal dimension of a beach face. By implementing these formulas of the rock factor A into Kuznetsov equation, the particle size of fragmented rocks can be predicted only based on the face images and blasting standards. Moreover, it is also possible to adjust the blasting standards to achieve the desired particle size of fragmented rocks.

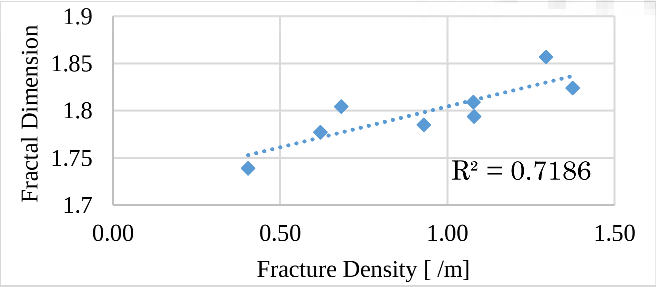

Fig.1 Fracture density and fractal dimension of the binarized image.

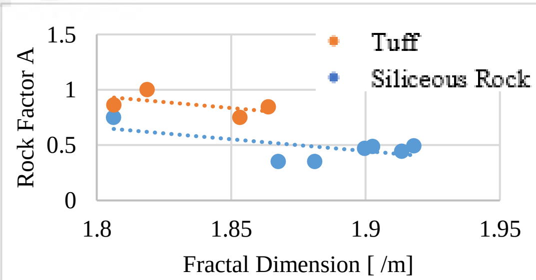

Fig.2 Rock factor and fractal dimension of the binarized image.