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Research on the Surface Fractal Characteristic of the Rock with Rockburst Proneness

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Abstract

In order to strengthen the prediction of rockburst and inquire the relationship between the rockburst proneness of rock and its surface fractal characteristic, the surface fractal of the rock was studied by fractal method and uniaxial compression test. The change rules of surface fractal of different types of rock were compared by calculating its fractal dimension of rock before experiment and after experiment. Based on this, we found that the dimension after test is bigger than before test for four kinds of rocks. The rock with stronger rockburst proneness has more intense failure in the loading process and its crack morphology is more complex.

Keywords: *Fractal, Rockburst, Rockburst proneness, Uniaxial compression*

1. Introduction

With the great progress of social and economic, more and more underground engineering gradually developed deeper. Rockburst is increasingly becoming one of the major geological disasters in the development of underground engineering. Rockburst is a nonlinear dynamic phenomenon that rock mass along the international airport of excavation surface release energy [1]. It is a complicated problem and there is neither a set of mature theory in use of prediction in nor systematic and comprehensive understanding its reasons because of complicated problems existing in the rockburst and different theories of grading. Many scholars consider the rockburst as a unique property of rock itself [2]. Fractal geometry was introduced to analysis the rock damage and fracture by Xie Heping, and it indicates a new development direction for rockburst [3]. Recent researches showed that the fractal phenomenon is remarkable during the breaking process of rock fracture. The distribution and geometry of the fracture have fractal structure [4]. The change of fractal dimension of rock during its deformation process was in concert with its stress state, mechanical properties, physical and chemical properties after many researches [5]. In this paper, we selected marble, granite, hornfels and skarn to carry out uniaxial compression experiment. We study the change rule of rock's surface fractal dimension by collecting and analyzing the surface characteristic of rock before and after test. Based on this, we study the relationship between surface fractal dimension and the rockburst proneness.

2. Experimental

2.1. Mechanics Experiment on Rockburst Proneness

In order to study the characteristics of surface fractal of different rocks, the experiment selects marble, granite, hornfels and skarn to conduct uniaxial compression test. Our samples are conventional standard cylinder with a size of Φ50mm×100mm.

In this experiment we use burst energy index and elastic deformation energy index to measure the strength of rockburst proneness [6, 7].

Uiaxial compression test used MTS815.04-type rock mechanics test system developed by Wuhan Institute of Rock and Soil Mechanics, Chinese Academy of Sciences.

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Figure 1. MTS815.04-type rock mechanics test system

The value of each rockburst proneness index of each rock was calculated by using MATLAB. The result is given in Table.1.

From the table we can see that granite had a strong tendency to rockburst and the rockburst proneness of hornstone and skarn were relatively weak, the marble's rockburst proneness was weakest. The strength of rockburst proneness of three rocks arrange in order of: granite> hornstone> skarn >marble.

Table 1. The result of burst energy index and elastic deformation energy index of each rock

sample	uniaxial compressive strength（Mpa）	burst energy index	elastic deformation energy index
DH4	54.74	1.50	-
DH5	53.15	1.32	-
DH8	54.84	1.06	-
DH6	92.32	-	1.91
DH9	83.62	-	1.72
HB1	117.18	2.31	-
HB2	311.24	3.00	-
HB4	189.20	1.71	-
HB6	151.34	-	6.15
HB7	245.60	-	6.17
JY3	109.86	1.10	-
JY4	84.18	2.00	-
JY8	125.61	-	5.21
X3	97.38	-	2.16
X4	113.99	1.22	-
X6	98.26	-	2.17
X8	146.95	1.42	-
X10	85.98	1.37	-

3. Results and Disscusion

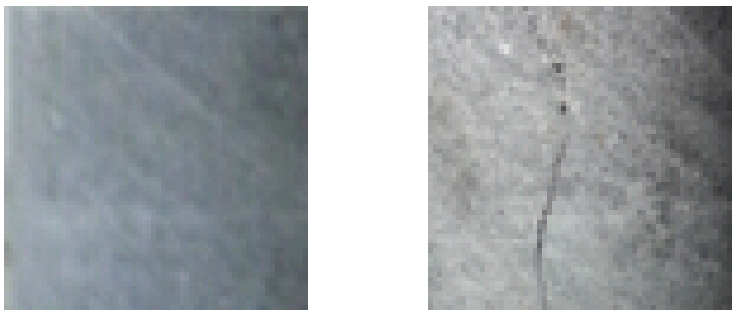
3.1. The Extraction of the Surface Characteristics of Rock

We have to take pictures of four rocks before and after test. In order to obtain surface features of rock before and after the test as far as possible we must use the professional digital camera. Try to make sure the picture have the high image definition and uniform brightness in case of a large area of the shadow. To be sure the camera lens is perpendicular to the surface in case image deformation. In order to ensure the consistency of the image before and after the test we should placed the specimens in the same position [8]. We selected the same position of the specimen as far as possible to analysis the surface fractal feature and the picture after test contains at least one crack. Then we used MATLAB software to further manipulation the chosen picture. The whole process is: choose the surface image of rock→convert the image to binary image→edge detection→the calculation of fractal dimension. The analysis processes of a sample chosen from marble are as follows.

The surface image of rock was selected by using a 64 x 64 pixel block. The specific operations are as follows.

before test after test

Figure 2. The selected position of surface feature before and after test of marble



before test after test

Figure 3. The image of surface feature before and after test of marble

In the Figure 2, the red block is the part of surface feature we selected. The image after extraction is show in Figure 3.

The image in the Figure 3 was processed by our own image–processing program which programmed by MATLAB8.0. The image noise reduction is the first step of processing. The surface feature of rock is more distinct after this step so it is facilitate to the next step of the work. The processed image is show in Figure 4.

before test after test

Figure 4. The processed image of surface feature before and after test of marble (step1)

The next step is converting the denoised image into binary image so the fractal dimension can be calculated by MATLAB8.0. The binary image is show in Figure 5.

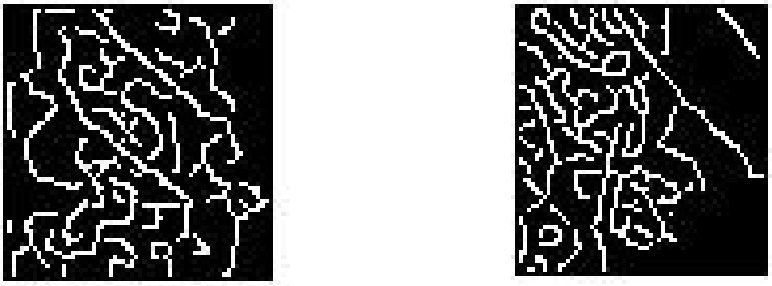


Figure 5. The binary image of surface feature before and after test of marble (step2)

3.2. The Calculation of Fractal Dimension of Rock before and after Test

The image in Figure 5 is divided by 2x2 pixels block, 3x3 pixels block,…, 64x64 pixels block. W is the number of non empty square partition in the graph and r is measurement scale (the scale of block). The dimension can be determined by the linear regression of the W and r in the double logarithmic coordinate. The value of dimension is the absolute value of the slope of the line fitting. The result of calculating is show in Figure 6.

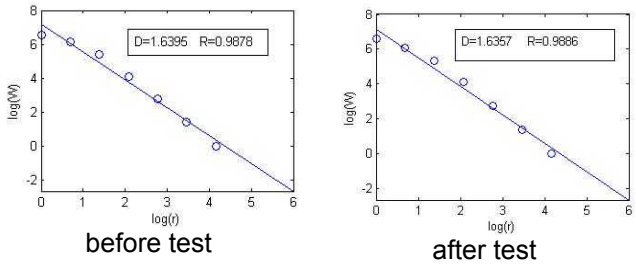


Figure 6. The result of calculating of fractal dimension of marble

The Figure 6 shows that the correlation coefficient of surface fractal dimension fitting chart of granite are more than 0.98. The fitting result means that the surface of rock shows the fractal characteristics. Repeat the above steps to calculate the dimension of others rocks and the result is show in Table 2.

Table 2. Result of surface fractal dimension of each rock

type	Nu-mber	dimension before test		dimension after test		change of dimension.
		dimensi-on	ave-rage	dimen-sion	ave-rage	
mar-ble	DH5	1.6391	1.6380	1.6357	1.6450	0.0070
	DH6	1.6538		1.6986		
	DH8	1.5998		1.5896		
	DH9	1.6590		1.6560		
gran-ite	HB6	1.6190	1.6231	1.6611	1.6552	0.0321
	HB7	1.6271		1.6492		
hornstone	JY4	1.6759	1.6587	1.6540	1.6664	0.0077
	JY8	1.6414		1.6787		
skarn	X3	1.5756	1.6272	1.6091	1.6470	0.0198
	X6	1.6305		1.6058		
	X10	1.6756		1.6945		

In the Table 2 it shows that the surface fractal dimensions of four rocks have increased. The amplification of granite is about 2% and the amplification of skarn is about 1%. The amplification of marble and hornstone are both below 1%. The strength of rockburst proneness of three rocks arrange in order of: granite> hornstone> skarn >marble. According to the result the rock of stronger rockburst proneness have bigger change of dimension between before an after test. The dimension after test is bigger than before test for four kinds of rocks. That is because the surfaces of rock cracked after test and have more complex features. The more complex surface has a bigger dimension. The rock with stronger rockburst proneness has more intense failure in the loading process and its crack morphology is more complex. So its change of dimension during the test is bigger. Given all that, the change of dimension during the uniaxial compression can be used to judge the strength of rockburst proneness of rock.

4. Conclusion

Calculated four kinds of rock's surface fractal dimension during the uniaxial compression and found that the dimension after test is bigger than before test for four kinds of rocks. The rock with stronger rockburst proneness has more intense failure in the loading process and its crack morphology is more complex. The change of dimension during the uniaxial compression can be used to judge the strength of rockburst proneness of rock. In this paper, when the change of dimension over 0.03 the rock have stronger rockburst proneness.

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