Study on the Crack Morphology of Rock under Three Axis Stress

Xigen Lu[1, *], Zhaohe Meng[2], Zhenliang Zhang[2], Lei Xia[2]

[1]School of Civil and Resources, University of Science and Technology Beijing, Beiging 100083, China
[2]Baodian Coal Mine, Shandong Yanzhou Coal Mining Co, Ltd, Zoucheng, Shandong 273512, China

*Corresponding author e-mail: lubinyan89@126.com

Abstract. According to the three triaxial mechanics test of marble, granite and iron ore, the deformation characteristics of rock strength was analyzed , rock failure crack was acquisition by plastic casing , on the basis of box dimension theory, the relationship between rock crack dimension and rock confining pressure was analyzed. It was found that crack dimension decreases with the increasing of confining pressure, the crack dimension reversible analysis of rock stress state; based on stone weight on plastic casing, the concept of gravel coefficient was put forward, gravel and rock that confining pressure was positively correlated.

1. Introduction

A lot of research work has been carried out to reveal the formation and expansion mechanism of rock fracture cracks at home and abroad. Warpinski made a study on influence of layered reservoir of the vertical extension of cracks [1]. Huang Fuqiong and companion add up quantitative observation of cracks in test pieces of core cracks and fracture tests, the statistical method for the crack parameters was introduced, and the mathematical expressions of calculating the volume density and the crack porosity of the drilling core are established [2]. Sato and other studied the law of crack propagation of rock by using DDM method, and analyzed the influence mechanism of the existing crack at the crack propagation [3]. The crack propagation process of prefabricated and slit rock samples with different dip angle, length and spacing was observed by Wong and other [4]. Ren Jianxi and other [5] analyzed the damage and crack initiation and development of granite and sandstone under unloading and three axial compression based on CT scanning test. Li Tingchun and other [6] used CT scanning technique and model material to study the propagation law of rock cracks under three axis loading. Yang Shengqi and other [7] studied the volumetric strain axial variation curves of marble under discontinuous prefabricated cracks under different confining pressures, and analyzed the influence of confining pressure on the dilatancy characteristics of marble with discontinuous prefabricated cracks. In order to describe the morphology of the cracks, a fractal dimension description method is proposed for the fracture system [8-10]. The above studies have played a very good role in helping people understand the mechanism of crack propagation in rock failure.

Three axis experiments with different groups of different confining pressures have been carried out in this paper. Based on image processing technology and statistical principle, the characteristics of the

powder from rock mass breakage and the crack distribution are extracted. According to these features, crushing impact powder and impact to damage were studied under the three axis experiment of marble, granite and iron ore.

2. Test survey

2.1. Sample preparation

According to ISRM, hard marble, granite and iron ore were made to be a standard specimen, specification is 50mm*100mm. test pieces with similar wave speed was screen out by using NM-4B acoustic wave instrument, and it was ensured there is no big crack in the specimen (Figure 1).

Figure 1. Specimen and plastic casing

2.2. Rock deformation and failure test

A rigid servo test machine is used to pressurize, and the experimental process is controlled by deformation, and the rate is kept at 0.06mm/min. The rock confining pressure is classified as 2MPa, 10MPa and 30MPa.

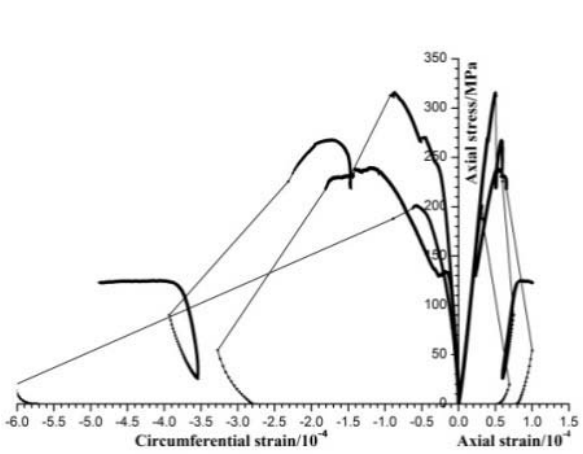
3. Analysis of test results

3.1. Analysis of strength curve

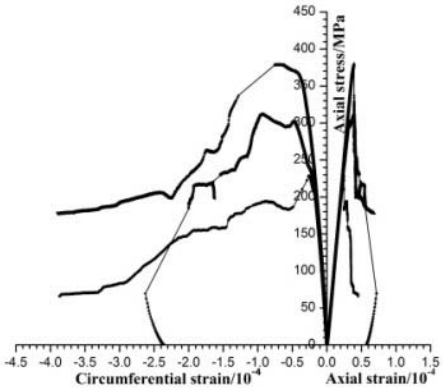
The relationship of strength of the specimen and deformation in different surrounding rock were shown in Figure 2: the strength of rock increases with the axial deformation, after a relatively short time the deformation get into the elastic phase, then with the intensity increasing, rock failure reached its peak, and residual strength of rock is smaller after the destruction.

During the process of deformation and failure, the strength limit of rock increases and the elastic modulus increases as well as the increase of confining pressure. However, after reach the peak, the rock has a certain stress drop, and the lateral deformation of rock suddenly increases, and there is a clear sound of bursting in the experimental process. The rocks reach the peak after the dump, but did not completely destroy the rock, it still has good compressive strength, with the increase of axial deformation, lateral deformation of rock is slow, and high-pressure specimens is ruptured again, accompanied by shock sound, rock strength reduced. Under low confining pressure, the specimen has some ductility in the peak later, when the deformation reaches a certain time, rock get into failure. The

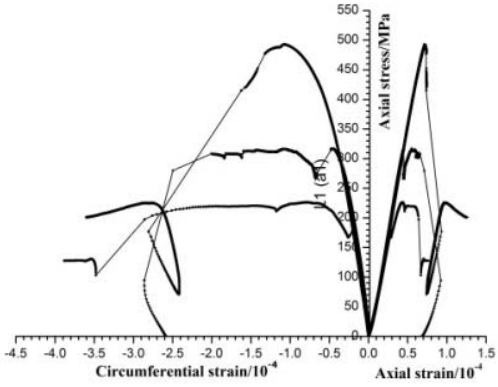
rock failure is mainly shear failure, there are more cracks in the specimen, the damage angle is approximately 45 degrees.



a) Strength curve of marble



b) Strength curve of granite



c) Strength curve of iron ore

Figure 2. Triaxial stress-strain curves under different confining pressures

3.2. Characteristics of crack distribution in three axis rock mass

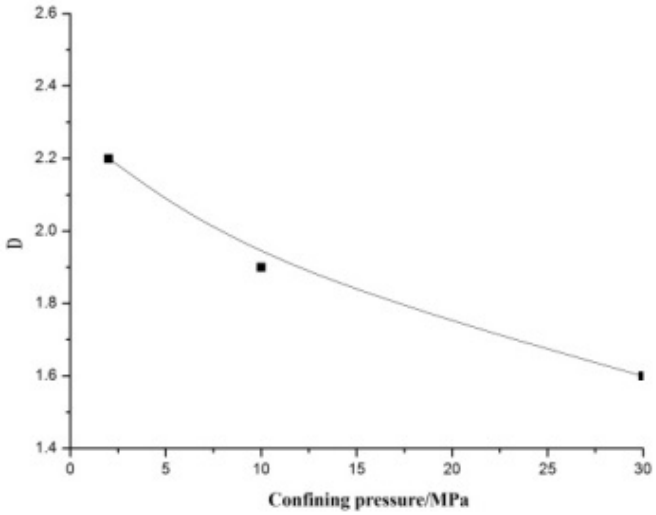
In the three axis experiment, a rock crack is recorded by a plastic casing, there is an obvious difference between the creases left on the plastic tube and the rock powder after the rupture of the specimen. Fractal dimension is used for analysis by rock crack by made the crack image into binarization (Figure 3).

Figure 3. Crack marks on a plastic casing damaged by rock destruction

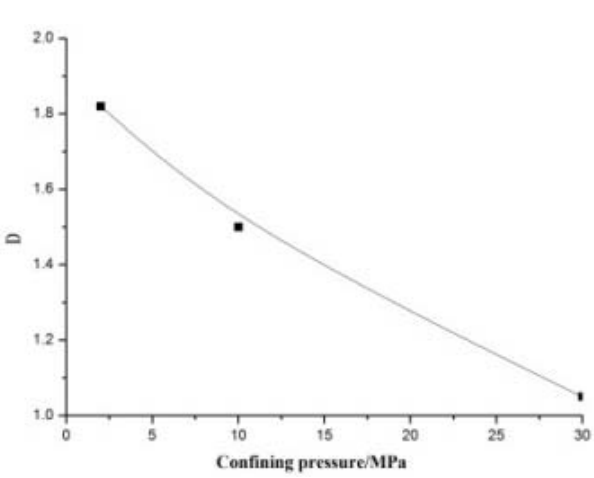
The most important concept of fractal geometry is fractal dimension (fractal dimension), which is referred to as fractal dimension, was first proposed by Hausdorff in 1919. The definition of capacity dimension (also called box dimension) is defined as: N (epsilon) is the smallest number of cube boxes that can cover the F of a point set, and the volume dimension of the point set is defined.

$$D=\lim_{\varepsilon\to\infty}\frac{\lg N(\varepsilon)}{-\lg\varepsilon} \tag{1}$$

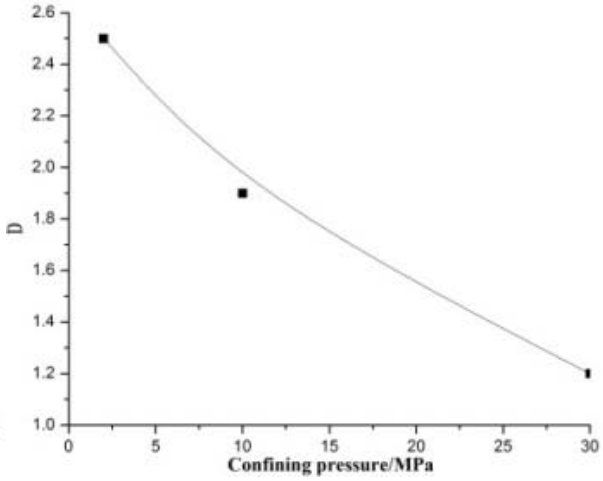
According to fractal dimension statistics, three sets of rock crack data are processed, and two dimensional values are processed in matable, and the crack dimensions of rock under confining pressure are calculated. The calculated results are as figure 4.



a) Fractal dimension of marble



b) Fractal dimension of granite



c) Fractal dimension of iron orecoefficient

Figure 4. Relationship between rock specimen and confining pressure

The fractal dimension of the crack decreases with the increase of confining pressure, when the confining pressure is low, rock failure is dominated by splitting and fracture, with complex cracks and more small cracks; with the increase of confining pressure, the failure mode of the specimens develop into shear failure, the fractal dimension decreases, it shows that the shape of failure crack tends to be regular, the crack curve changes from rough to relatively smooth, and small cracks decrease, and there

are several long straight straight cracks in two-dimensional cross-sectional images. When the confining pressure is increased (>20MPa), the failure form of the specimen is still dominated by shear failure.

3.3. The relationship between the strength and the strength of the three axis rock fracture

When the rock is damaged, there is a crack mark on the plastic ring, and the gravel is attached to the crack mark, the relation between the weight of rock and the strength of confining pressure was found under analysis of weighing and analysis of rock lithotripsy, the greater the confining pressure, the greater the weight of the gravel. Therefore, the coefficient of lithotripsy (fv).is proposed.

$$fv = \mathrm{f}_t/\mathrm{f}_g \tag{2}$$

In the formula, $f_t$is the weight of the crushed stone; f_g is the weight of the specimen

According to the experiment, the fv of the specimen is obviously increased, with the increase of the confining pressure (Figure 5).

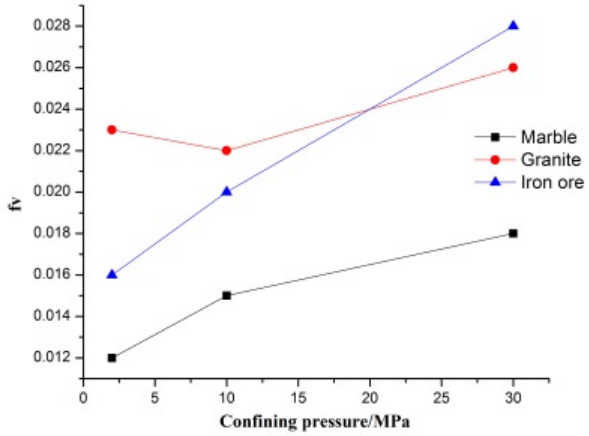


Figure 5. The relationship between rock lithotripsy and confining pressure

4. Conclusion

(1) The compressive ability of marble, granite and iron ore is enhanced with the increase of confining pressure, and the peak deformation of rock were increased.

(2) Rock crack of three axis rock experiment were fully recorded by plastic casing, it was analyzed through fractal box dimension, the fractal dimension of the crack decreases with the increase of confining pressure.

(3) In the process of rock experiment, the lithotripsy were retained on the plastic casing. Therefore, the concept of the degree of lithotripsy was put forward, *fv* increases with the increase of the confining pressure.

Acknowledgments

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