Exploration of the Impact of Homogeneity to Rock Fracture by RFPA

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Abstract. This paper simulated 7 kinds of rock uniaxial compression fracture under different homogeneity (each sample size is 3) by RFPA. According to the results of numerical simulation, the failure of rock is analyzed as follow. The study results indicate that with the increase of homogeneity degree, precursory information of the main fracture is significantly reduced, and the stronger of the brittle fracture, the macroscopic fracture mode performance is a concentrated fracture shape. On the contrary, then it will show some diffusivity. Under the same degree of homogeneity conditions, the macro-strength of rock with a certain statistical law, but there is a certain dispersion of the fracture mode.

1 Introduction

Under external loads, the fundamental of rock mechanics development is to make out the basic properties of the rock. As the rock is one substance which contains inhomogeneous structure, understanding the influence of medium's inhomogeneity to the rock mechanics characteristic is extremely necessary.

Sequences of methods of numerical analysis or numerical simulations can be used in computational rock mechanics, each of them have their own unique characteristics. RFPA Rock Failure Process Analysis System software is based on the basic theory of finite element method, coupled with powerful computing data post-processing finite element method to achieve the destruction and deformation of rock failure process simulation from micro to macro.

The rock is one substance which contains inhomogeneous structure, micro defects inside the rock nucleation, expansion and the role of each other determines the macroscopic deformation of rocks, fracture characteristics under external loads. Despite the study of rock destruction achieved many useful results, over the years various theories have been studying local failure based on the homogeneous medium assumption, which neglects the inhomogeneous rock stress caused by their own inhomogeneous structure and thus induced damage.

Rock failure is a process of destruction continues to produce damage and macro crack formation. In this process, micro primitive gradual change attributes have an impact on the macro-mechanical behavior. Therefore, it would be help us to understand mechanisms of damage and destruction if we study the rock failure process from these two levels: the microscopic heterogeneities and the macroscopic mechanical behavior.

2 Establishment and simulation model results

The test uses 7 kinds rock samples with different homogeneous coefficient (the number of samples are 3) to study the effect of homogeneous degree of rupture process. Homogeneous coefficients are classified as 1,2,3,4,5,10,100, elastic modulus are all set to 50000MPa, Phase change intensity mean set to100MPa, Poisson's ratio of 0.25, friction angle of 30 degrees, pressure Rabbi of 10, the residual

strength factor of 0.1, the maximum tensile strain factor of 1.5, the maximum compressive strain factor of 200. Different degree of homogeneity before loading drain is showing in **Fig. 1**.

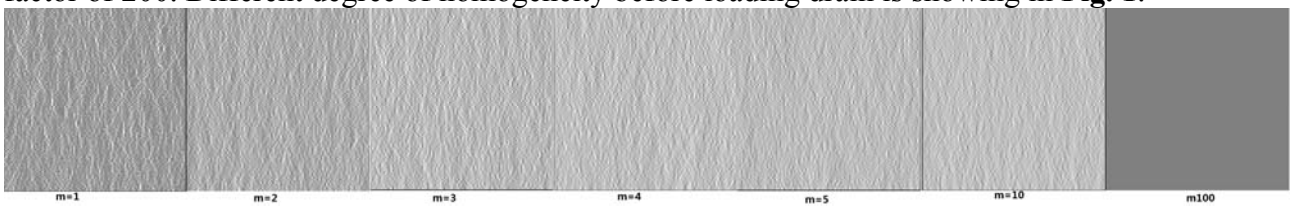

Fig. 1 Different degree of homogeneity before loading drain

This test uses the uniaxial compression with plane stress model, the rock sample size is 100mm ×100mm and this model divided into 100×100 grid. The entire loading process using loading displacement control, each loading displacement is Δs=0.005mm and fixed the horizontal boundary. Loading total number of steps depending on the specific program.

The Fig.2 shows m respectively as 1,2,3,4,5,10,100 when stress —— strain curve and rupture mode. From the overall view of the loading process, each rock samples have undergone load, buckling and residual strength stage. In the loading process, the transition phase between the linear and nonlinear stage of barely visible. It indicated that arrangement pattern material has not yet appeared severely damaged, only a weak statistical fluctuations, no significant effect on the macroscopic behavior in loading the initial stage of low damage. It also can be seen, the linear relationship between load stage of the stress —— strain curve with high homogeneous coefficient will be more obvious than the low's.

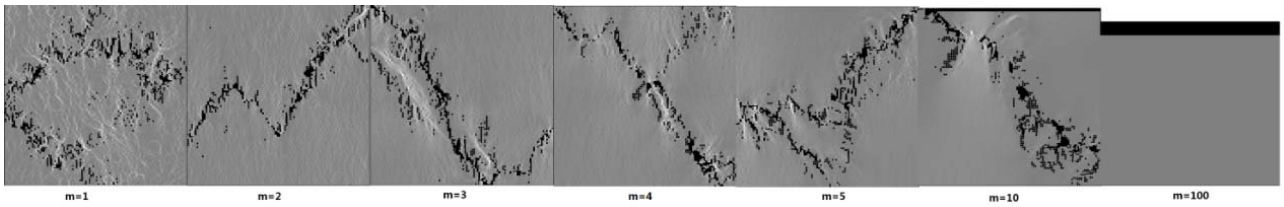

Fig. 2 The main crack of broken rock with different homogeneities

As can be seen from the Fig. 2, the peak stress of rock sample with the gradual increase of the degree of homogeneity is enhanced as m is 1.5,2,3,5,10 respectively. On account of the displacement loading, by the peak of strain can be seen with increasing degree of homogeneities, the mechanical properties of primitives are getting narrow, macro strength and elastic modulus of the rock sample is gradually approaching rock strength and elastic modulus of the average primitive and strain at failure of rock is growing, which indicating that the average intensity of the rock is gradually improving. This phenomenon indicates that the homogeneity of the rock material impact on the overall strength of the rock, the higher homogeneous coefficient is, the greater its intensity will be, while homogeneous coefficient is smaller, the intensity is smaller. The simulation results in the destruction of rock samples with different homogeneities which under uniaxial compression loading process is showing in the Fig. 2.

As can be seen from the previous picture, stress and deformation fields significantly affected by the non-uniformity of the rock. With the improvement of the coefficient of homogeneous deformation by the diffuse distribution gradually concentrated in a particular region, mainly due to high stress field, strongly characterized by brittle fracture. The low coefficient homogeneous rock samples main rupture occurred before the destruction of a larger number of primitives, and its distribution exhibit disordered, random features. Main rupture resulting macroscopic crack branching more and not concentrate. With homogeneous coefficient of increase, the number of primitive gradually less before main rupture, main rupture resulting macroscopic crack reduction and it concentrated in a certain area.

3 Discussions

Studied the mechanical properties of parameter distribution under the same conditions (when the parameter of Weibull distribution function remains unchanged) the impact on the macro-homogeneous degree calculation results. Researches on each sample using three samples were calculated and each sample represents a microscopic structure alignment pattern.

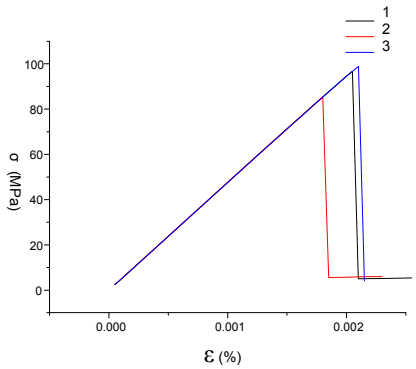

Fig. 3 Mechanics curves of different samples when m=5

From Fig. 3, as can be seen, from the overall loading process, the samples were each experienced a linear, nonlinear, buckling, residual deformation of four stages. The simulation results show that curve coincides very well in the linear stage and partial non-linear stage before reaching the ultimate strength, which indicates that in the early stages of loading arrangement pattern of low damage the material structure is not yet severe damage occurs, only a weak statistical fluctuations, no significant effect on the macroscopic behavior. But then, since micro fracture development, the influence of different material structure alignment pattern began to show up, the macroscopic mechanical behavior of rock samples showed a significant difference, showing samples of personality and behavior. In the residual deformation stage, the residual strength of each curve have some volatility, but tended to develop a certain value. Fig.4 shows the simulation results of three samples of macroscopic fracture mode. The result suggests that even for the same rock sample, the form of macro rupture also showed great randomness, very difficult to have exactly the same form of rupture. The results showed that homogeneous degree of rock-like materials is an important factor affecting the macroscopic fracture mode. It explains the nature reasons rock about sample macro strength and fracture pattern diversity and randomness. So the study of rock fracture, particularly the evolution of broken rock cannot ignore the impact of the non-uniformity of the basic features.

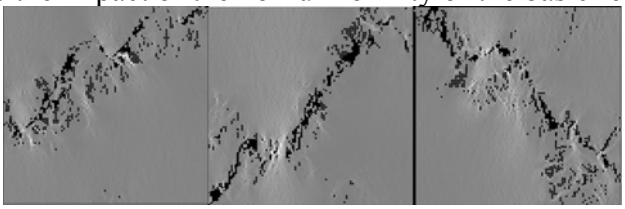

Fig.4 Different forms specimen rupture when m=5

From Fig.2, it can be seen that stress and deformation fields significantly affected by the non-uniformity of the rock. With the improvement of homogeneous coefficient, deformation caused by diffuse distribution gradually concentrated in a specific area, mainly due to high stress field, strongly characterized by brittle failure. With the development of rupture, its migration laws become more complex. When homogeneous coefficient is low, the number of broken primitive is rich before the main rupture occurred, the distribution exhibits disorderly, random features. Main rupture resulting macroscopic crack multi-branch, and it doesn't concentrated. With the improvement of homogeneous coefficient, the number of broken primitive before the main rupture occurred is getting less and main rupture resulting macroscopic crack branches gradually reduced and concentrated in a certain area. Rock samples of macroscopic stiffness and strength significantly affected by the non-uniformity of rock, homogenization was reduced, reducing the overall stiffness of the rock

sample macro strength while also reducing. After the main rupture heterogeneous materials, reduce macro strength is gradual, showing significant nonlinear wave. Homogeneous materials immediately appears unstable failure after reaching peak strength, which shows strong brittle failure characteristics.

4 Conclusions

（1）With the improvement of the homogeneous coefficient, precursory information of the main fracture is significantly reduced, or even without any information, showing brittle failure mode.

（2）With the improvement of the homogeneous coefficient, the macroscopic fracture mode performance is a concentrated fracture shape. On the other hand, then it will show some diffusivities.

（3）Under the same degree of homogeneity conditions, the macro-strength of rock with a certain statistical law, but there is a certain dispersion of the fracture mode.

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