Study on ratio of similar materials based on coal mass strength

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Abstract

In laboratory, studies on the coal mine hydraulic fracturing principle and crack propagation characteristics require a large amount of coal samples, collection and processing are difficult, based on these, put forward a technical idea that using ratio of similar materials to simulate hydraulic fracturing native structure of coal and catalectic coal. On the basis of raw coal physical and mechanical properties tests, through the orthogonal method to allocate different proportion of cement, coal, gypsum, water and processing sample, then test physical and mechanical parameters including compressive strength, tensile strength modulus of elasticity, Poisson's ratio and so on, regression analysis shows that the higher the proportion of gypsum, the smaller the compressive strength of the material, based on this, we obtained the reasonable ratio of similar materials through trial and error, studies on the condition of the ratio of sample damage characteristics of acoustic emission and comparing with the raw coal, the result shows it is consistent with raw coal. Eventually get the similar material simulation of hydraulic fracturing of coal, cement, gypsum, water ratio: native structure of coal is 2:3:1:3; catalectic coal's is 1:1:1.2:1.3.

Keywords: Coal body structure; Similar material; Orthogonal ratio; Mechanical parameters tests; Acoustic emission

1 Introduction

In recent years, Hydraulic fracturing of the coal mine coal seam anti-reflection as an effective extraction technology has been more widely applied [1-5], but the underground hydraulic fracturing principle and open crack extension characteristics subject to further research, especially in the laboratory research due to coal sample collection, transportation, processing difficulties and other issues, progress is relatively slow [6-12],. Similar simulation experiment with the short cycle, low cost, the results of image visual features, is an important means of indoor research [13]. The model materials' prototype and mechanical properties are similar to the raw materials in similar simulation experiments, made by certain relationship model, it has all or main characteristics of the prototype structures [14]. Similar materials' selection, formula of the physical and mechanical properties of model material has a great influence [15], plays an decisive role in the success of the model test, it has been applied in the study of strata movement and destruction rule of strata [16-18], but it is rare to hydraulic fracturing cracks in coal seam of similar material research. Based on this, in this paper, using mixing different proportion of coal, cement, gypsum, water carry on the similar material research and development, the simulation of hydraulic fracturing implementation object - native structure of coal and cataclastic coal, in order to provide some experience to indoor related research of hydraulic fracturing.

2 The choice of similar materials

Similar material is made from a mix of cement and packing,

and the mechanical properties of cement determine the mechanical properties of the similar material to a large extent. Gypsum as cement has low strength, strong plasticity, elastic modulus and compressive strength of the characteristics of the adjusting range is big, the price is cheap, is the most widely used a similar material. Cement has characteristics of high compressive strength, coagulability strong, the strength grade of 3.25 label is 11MPa compressive strength, has effects of the bonding and support [19]; coal powder as filling material in the similar material, it is not just a skeleton, to a certain extent, represents a similar material, the characteristics of the coal and coal particle size had a great influence on the strength of similar materials, similar material damage usually occurs between coal particles. Based on this, this experiment adopts the cement, gypsum, the particle size of pulverized coal as the ratio of material to similar material, the mechanical strength of cement and plaster sample adjustable, have the effect of the condensate; shredded the particle size of pulverized coal is not only play the role of the skeleton, but also can reflect similar material properties of the coal.

3 Similar material proportioning experiments

3.1 COAL MECHANICAL PROPERTIES TESTS

Hydraulic fracturing of the coal mine, the coal seam itself, is only suitable for the native structure fracture and fracture of coal, coal in the fracture of coal and coal mylonite during hydraulic fracturing, tend to show the puncture, extrusion, it is difficult to form effective open cracks, on the contrary, are also easy to form stress concentration belt, for the safety in production. Based on this, acquisition of Henan energy

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chemical group yonggui energy xintian coal mine f8 # coal seam in primary structure coal and coal processing and test their physical and mechanical properties, as Table 1:

TABLE 1 Raw coal physical and mechanical properties test

coal structure \ parameter	primary coal	fractured coal
σ_c/MPa	7.3064	3.1646
σ_t/MPa	0.4112	——
E/GPa	0.6470	0.4812
μ	0.22	0.26
c/MPa	0.7985	0.6768
Ψ/°	19.56	22.49
ρ/g/cm³	1.56	1.48

3.2 RATIO OF SIMILAR MATERIALLS

As hydraulic fracturing, the fracture pressure and fracture morphology of open fracture and coal of compressive strength, tensile strength, elastic modulus, poison's ratio, cohesion, internal friction angle, density and other related physical and mechanical properties, although pore structure of coal has certain influence to the crack patterns, but often limited to the larger joints and fissures of coal seam, based on this, similar materials aren't just considered in the simulation of coal seam hole crack problems, but more focus on the physical and mechanical properties of coal seam, especially the compressive strength, tensile strength, elastic modulus and Poisson's ratio, etc. Similar materials' matching tests mainly study the influence of the proportion of cement, gypsum, pulverized coal strength of similar materials, because the pulverized coal itself is derived from coal, in a larger extent, is to consider the proportion of cement and plaster, cement strength, high elasticity, low strength of gypsum, strong plasticity, the ratio of the two can simulate the native structure of coal, coal and rupture by three levels orthogonal experiment design, the two factors of components to export the influence of the ratio of uniaxial compressive strength, easy in small range adjustment ratio, thus to more accurate selection of similar material, as shown in Table.2:

TABLE 2 the ratio of factors orthogonal experiment

Set	Each component proportion			ratio
	coal	*cement*	*gypsum*	
1	1	0.5	0.5	211
2	1	0.5	1	212
3	1	0.5	1.5	213
4	1	1	0.5	221
5	1	1	1	111
6	1	1	1.5	223
7	1	1.5	0.5	231
8	1	1.5	1	232
9	1	1.5	1.5	233

3.3 SINILAR MATERIAL SAMPLE PRODUCTION

Mix coal, cement, gypsum, water according to certain proportion(figure2-a),then put in sample molding (figure2-b),in order to ensure there is no hole in the samples after the release, during the continuous casting process insert fine steel bar in condensed-matter sample, so that the discharge of bubbles, set 72h in the wet heat preservation environment;

drill in the sample of not less than five Φ50 mm*100 mm cylinder specimens(figure 2-c),through Cutting, coarse grinding, fine grinding, the samples are shaped(figure2-d),to test the compressive strength, elastic modulus and Poisson's ratio and mechanical properties.
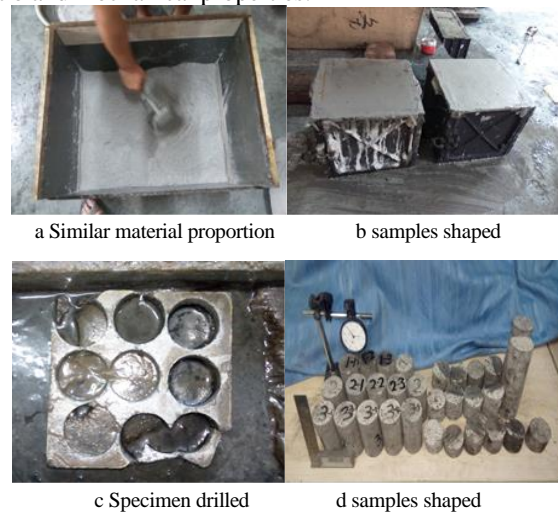

a Similar material proportion   b samples shaped

c Specimen drilled   d samples shaped

FIGURE 1 Similar material sample processing

3.4 TESTING THE MECHANICAL PROPERTIES OF SIMILAR MATERIALS

Japan AG–I250 electronic precision material testing machine; US physical acoustics DISP series 2 channel/card PCI-2 fully digital acoustic emission monitor, the test set of threshold value is 100 dB, acoustic emission sampling interval time of 10 s, frequency of 20 ~ 400 kHz;

FIGURE 2 Experiment equipment

In the ratio of each sample, select not less than three cylindrical specimens, using electronic precision material testing machine into the displacement control load (loading rate 0.05 mm/min), test sample of stress - strain characteristics, the characteristics of acoustic emission signal, observation analysis its destruction form; Adopt the method of stress gages test specimen axial deformation and radial deformation, on the basis of calculating Poisson's ratio in elastic phase; Use acoustic emission monitoring, take the acoustic emission signal ringing count, energy and amplitude parameters reflect the sample dynamic evolution process of the internal micro cracks. By comparing the analysis of samples and related mechanical parameters of raw coal and the fracture morphology, adjust the ratio of sample; draw a reasonable ratio of similar materials.

Based on different proportion of coal, gypsum, cement to test related physical and mechanical properties test, test

results are shown in Table 3.

TABLE 3 the ratio of factors orthogonal experiment

number	σc/MPa	σt/MPa	E/GPa	μ
1	2.9~5.5 5.1	0.3312	0.617	0.17~0.22 0.20
2	2.3~3.16 2.74	0.3032	0.865	0.21~0.30 0.28
3	1.8~2.9 2.15	0.3112	0.667	0.25~0.32 0.30
4	4.8~5.43 5.31	0.7781	0.896	0.18~0.23 0.21
5	3.42~3.56 3.78	0.6772	0.765	0.22~0.26 0.24
6	2.1~2.96 2.34	0.5786	0.615	0.21~0.31 0.27
7	6.91~7.71 7.23	0.8140	0.996	0.16~0.21 0.19
8	4.13~5.32 4.94	0.5562	0.514	0.19~0.25 0.23
9	3.11~3.98 3.46	0.3012	0.612	0.18~0.23 0.21

Through different ratio of similar materials under uniaxial loading, the broken pattern as shown in Figure 3, the figure shows that as the similar material ratio of gypsum content increases, specimen is easy to broken, and forms more complex fracture morphology.

FIGURE 3 Different proportion specimen compression broken pattern

Through mapping plaster, cement, gypsum + cement proportion of similar material and compressive strength of similar materials, the relationship between them as shown below:

Known from figures, with the increase of the proportion of gypsum, similar material specimen compressive strength decreases and tends to stable; with the increase of cement proportion, similar material compressive strength increases gradually and tends to stable; when gypsum and cement account for similar proportion less than 50%, the compressive strength of the specimens and no significant increase or decrease, when the proportion of the sum of a certain, but gypsum and cement their proportion is not timing, specimen compressive strength are increases, but increases with the increase of proportion of cement, decreases with gypsum's proportion decreases. So, through the deployment of the proportion of cement and plaster can meet similar material proportion.
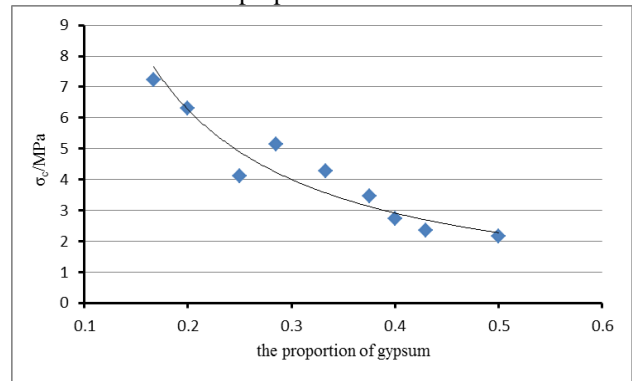

FIGURE 4 Relationship about compressive strength of gypsum's proportion and similar material
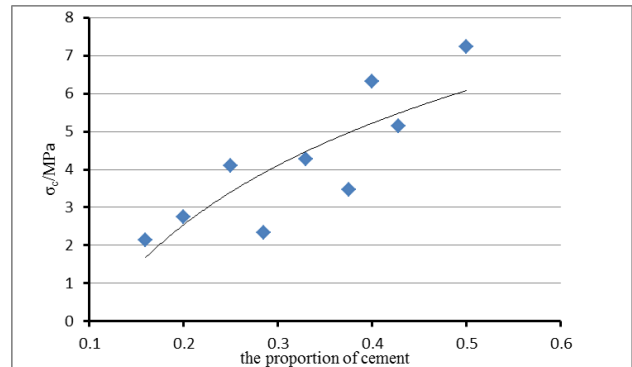

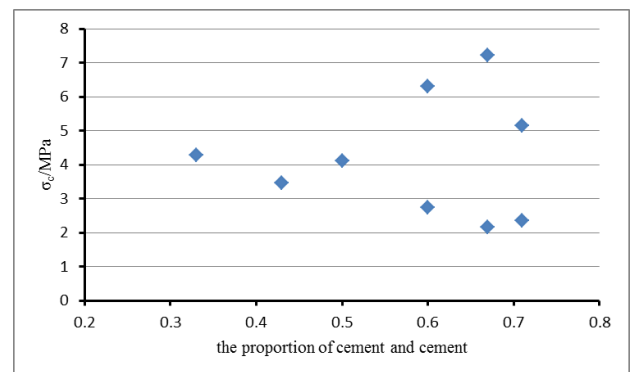FIGURE 5 relationship about compressive strength of cement's proportion and similar material

FIGURE 6 proportion of gypsum and cement relationships with similar material compressive strength

4 Results and discussion

Preparation process by means of similar material, the compressive strength of cement, gypsum, cement + gypsum analysis and other related mechanical properties test, after much trial and error, under the condition of statistic in water, determine the simulated coal ratio of similar materials as the native structure is: coal: cement: gypsum: water=2:3:1:3;similar material simulation cataclastic coal ratio for: coal: cement: gypsum: water=1:1:1.2:1.3.Based on the ratio of the stress - strain under uniaxial loading condition-acoustic emission frequency-amplitude as shown in Figure7 and Figure 8.
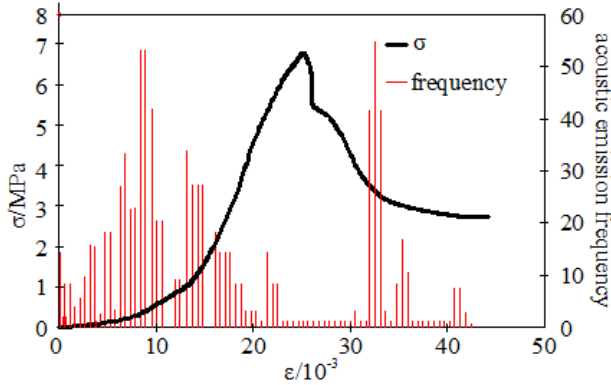
FIGURE 7 Typical coal similar to the native structure materials acoustic emission frequency - energy - stress - strain diagram
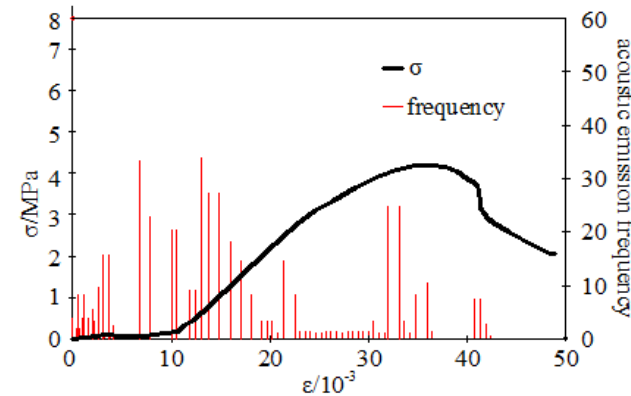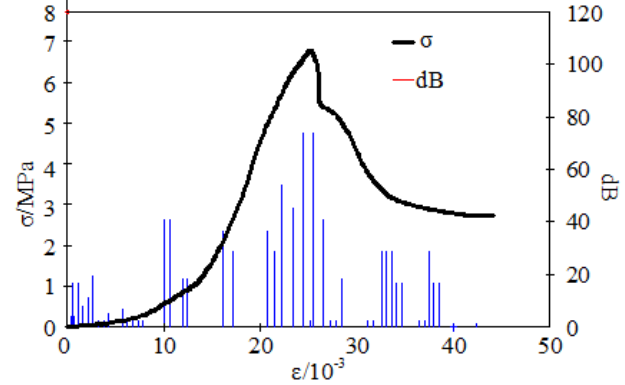
FIGURE 8 Typical fractured coal similar material acoustic emission frequency - energy - stress - strain diagram

Through analysis of structural fractures in coal, Cataclastic coal mechanical properties and the characteristics of acoustic emission, determine the simulated coal ratio of similar materials as the native structure is, coal: cement: gypsum: water=2:3:1:3;similar material simulation cataclastic coal ratio for: cement: gypsum: water=1:1:1.2:1.3.

5 Conclusions

To ensure the smooth operation of the hydraulic fracturing of indoor experiment, on the basis of the analysis of existing similar material properties, coal, cement, gypsum, water is chosen as the simulation of the primary structure coal and cataclastic coal similar material. Native structure in acquisition Xintian mine of coal, coal and rupture test their physical and mechanical properties, make similar material configuration has the basis of standard; using orthogonal experiment method, the configuration of different proportions of pulverized coal, cement, gypsum, through forming, cutting, grinding, drilling and sampling column, mechanical property test, the sample is obtained column of compressive strength, elastic modulus, Poisson's ratio and other related parameters; qualitative analysis is the proportion of cement, gypsum, impact on similar material compressive strength of the specimens. Through mechanical properties test, selecting the appropriate ratio of similar materials, and its processing specimens for acoustic emission frequency, amplitude character description, analysis of raw coal acoustic emission characteristics, it is basic consistent, determine the simulated coal ratio of similar materials as the native structure is, coal: cement: gypsum: water=2:3:1:3; similar material simulation catclastic coal ratio for: cement: gypsum: water=1:1:1.2:1.3.

Acknowledgements

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