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Study On The Performance Of Rock In SHPB Experiment

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Abstract

The crack characteristics of rock 1s investigated in the SHPB test. Analyzed the relation between the character on the Crack Surface of rock and material properties and the impact pressure. Also the multifractal characteristics are given on the Crack Surface of rock The crack distributions of rock are investigated. The crack resistance effects of rock are analyzed from the degree of closenness and uniformity.

Keywords: SHPB; bar; rock; multifractal

1. Introduction

There are two mostly used setups to study the dynamic behaviors of the concrete are the Split Hopkinson pressure bars (SHPB) and the one-stage light gas gun .The dynamic behaviors of concrete-like materials at the strain-rate between 10and 100 s−1 is often studied in the SHPB experiment. The impact experiment equipment is split Hopkinson press bar (SHPB), which offers more accurate measurement of materials performance under impact loading. The technique is based on the theory of one-dimensional wave propagation in an elastic bar. The split-bar configuration was developed by Kolsky [7] following the original introduction by Hopkinson [8] and a comprehensive study by Davies [9]. The early small diameter SHPB (e.g.,10mm) are commonly used for testing metal or macromolecule polymer, and the large diameter SHPB (diameter larger than 30mm) have become more and more popular for the study of dynamic behaviour of concrete since 1980's [10-13].

2. SHPB Experiments

The incident bar , transmission bar and absorbing bar are all in range of elasticity with the typical SHPB experiment(Fig.1).The samples tested have been impacted to the range of plastic nature. The speed measuring laser and dynamic strain instrument are used in the experiment. The incident , transmission and absorbing bars' positions are arranged as the Fig.1.The bars are made up of high strength alloy steels. The depth of parallelism between the bars and the sample are strictly required. When the strike bar go through the laser of the parallel illuminants, the impulse signals are captured by the ondoscope. The time (t) between the impulse signals are obtained. Thus, the velocity of the strike bar are measured.

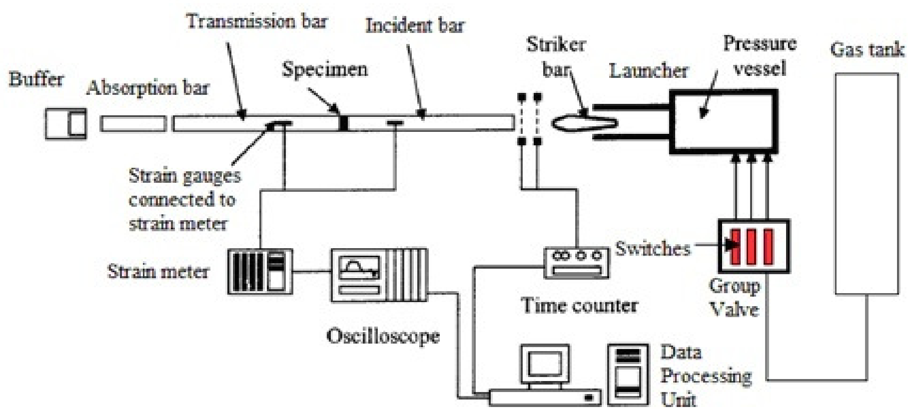

Fig.1 Typical SHPB experimental device

The stresses on the front face ($\sigma_{s1}(t)$) and back face ($\sigma_{s2}(t)$) of the sample varying with the time t have been compared by minishing the thickness of the samples and increasing the speeds of incident bar by Wu etc[6,7] in SHPB experiment. The investigation indicates that the difference between $\sigma_{s1}(t)$ and $\sigma_{s2}(t)$ depends on the thickness of the samples and the speeds of the impact bars. The effective inertias and transmissions have been analyzed .There are few difference between the $\sigma_{s1}(t)$ and $\sigma_{s2}(t)$ in experiment to assure the homogeneous hypothesis by adopting the thin thickness of sample in this paper. It too difficult to use resistance strain gauge to obtain the vivid signals of .The semiconductor strain gauges are used to get the vivid signals of transmission strain-pulse(Fig.2).The equations ofσs1 (t) andσs2 (t) as:

$$\sigma_{s1}(t) = E\frac{A}{A_S}[\varepsilon_i(t) + \varepsilon_r(t)] \qquad (1)$$

$$\sigma_{s2}(t) = E\frac{A}{A_S}\varepsilon_t(t) \qquad (2)$$

Where E is Young's module of compression bar, A is cross-sectional area of compression bar, As is cross-sectional area of the sample, εi(t) is the incident strain-pulse, εr(t) is the reflection strain-pulse, εt(t) is the transmission s train-pulse.

The typical SHPB experiment technique is based on two hypothesis conditions[7-9]:

(1)One dimension stress wave in bar. (2)stresses homogeneous distributes along the sample. On the first hypothesis condition, average stress $\sigma_s(t)$, strain ratio $\dot{\varepsilon}_s(t)$ and strain $\varepsilon_s(t)$ can be described as:

$$\sigma_s(t) = \frac{A}{2A_S}[\sigma_i(t) + \sigma_r(t) + \sigma_t(t)] \quad (3)$$

$$\varepsilon_s(t) = \frac{c_0}{L}(\int_0^t [\varepsilon_i(t) - \varepsilon_r(t) - \varepsilon_t(t)] \quad (4)$$

$$\dot{\varepsilon}_s(t) = \frac{c_0}{L}[\varepsilon_i(t) - \varepsilon_r(t) - \varepsilon_t(t)] \quad (5)$$

Where C0 is sonic speed， L is the initial length of the sample.

The second hypothesis condition can be described as:

$$\sigma_i + \sigma_r = \sigma_t, \varepsilon_i + \varepsilon_r = \varepsilon_t \quad (6)$$

Simultaneous system of equations：

$$\sigma_s(t) = \frac{EA}{A_s}(\varepsilon_t(t)) = \frac{EA}{A_s}[\varepsilon_i(t) + \varepsilon_r(t)] \quad (7)$$

$$\varepsilon_s(t) = -\frac{2c_0}{L}\int_0^t \varepsilon_r(t)dt = \frac{2c_0}{L}\int_0^t [\varepsilon_i(t) - \varepsilon_t(t)]dt \quad (8)$$

$$\dot{\varepsilon}_s(t) = \frac{2c_0}{L}[\varepsilon_i(t) - \varepsilon_t(t)] = -\frac{2c_0}{L}(\varepsilon_r(t)) \quad (9)$$

The dynamic property can be obtained from equations (7),(8) with two of incident strain-pulse, reflection strain-pulse, transmission strain-pulse. Variable quantity time t is expurgated to get the dynamic curve of stress and strain (Fig.4) with high loading ratio. It is obvious that it is difficult to assure the homogeneous distributes hypothesis on high loading ratio conditions. The thin thickness must be adopted to assure the homogeneous distributes(10mm thickness is adopted in the experiment) which has been proved by wu etc. Also, the homogeneous distributes can be checked by comparing the difference of $\sigma_{s1}(t)$ and $\sigma_{s2}(t)$.The typical experiment dynamic curves of stress and strain(Fig.2) under high loading ratio are obtained in this paper.

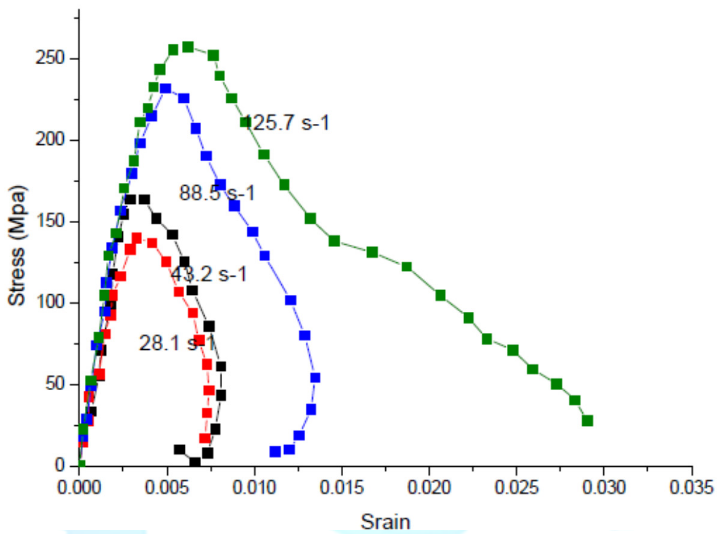

Figure 2 Stress-strain curves of the rock

3. Fractal characteristics of the SHPB experiment

Using a cylindrical block, the different rock are experimented. Rock pictures of the surface cracks (Figure 3) .

Fig.3 Morphological comparison of concrete damage

The Morphological comparison of damage converted to the Black-white bitmap of rock.

Fig.4 The Morphological comparison of damage converted to the Black-white bitmap of rock

The multifractal method[15] is used to study the fractal characteristics of the concretes in SHPB experiments. The results is obtained(Fig.5).

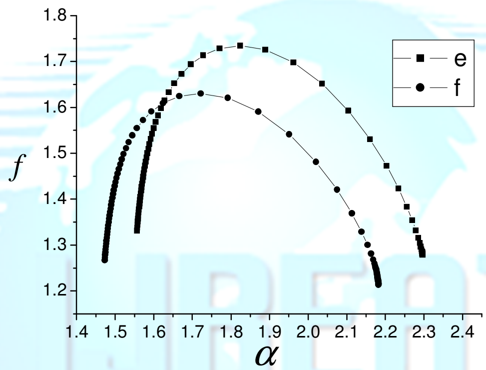

Figure 5 Multifractal spectrum curves

4. Conclusions

1 The incident wave and transmission wave varying with the time have been obtained by SHPB experiment. The energy-absorbing ability of materials is a important data of impact resistant The dissipation of energy in the rock are obtained .The curve of dynamic stress and strain of the rock has also been obtained in this paper.

2 The mechanical properties of rocks is relation with the external loading conditions such as loading rate, load etc.

3 This study is based on fractal surface crack of rock research. In fact, when the impact velocity is large ,the rock is usually the overall damage, even crushed. The study the impact of surface fractal surface crack is often impossible to carry out, It is need to study the three-dimensional fractal.

Acknowledgements

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References:

[1] Gebbeken N., Greulich S. and Pietzsch A. "Hugoniot Properties for Concrete Determined by Full-Scale Detonation Experiments and Flyer-Plate-Impact Tests", Int. J. Impact Engng. 2006, 32, 2017-2031.

[2]Pattofatto S., Poitou A., Tsitsiris H. and Zhao H. "A New Testing Method to Investigate the Compacting Behaviour of Fresh Concretes Under Impact Loading", Exp. Mech. 2006, 46, 377- 386.

[3]Abrams, D.A., 1917. Effect of rate of application of load on the compressive strength of concrete. Journal of ASTM 17 (part II), 364–377.

[4] Abdullah H., Husin S., Umar H. and Rizal S. "The Dynamic Properties Behavior of High Strength Concrete under Different Strain Rate", SPIE 2005, 5852, 56-59.

[5] DENNIS Grady. Shock equation of state properties of concrete. Structures under Shock and Impact IV, Computational Mechanics, Boton, 1996. 405-414

[6] RINEHART E J, WELCH C R. Material properties testing using high explosives. International Journal of Impact Engineering, 1995, 17(7):673-684

[7] BUZAUD E, DON D, CHAPELLE S, et, al. Perforation studies into MB50 concrete slabs. Proceedings of the Ninth international Symposium on Interaction of the Effects of Munitions with Structures, Berlin, Germany, 1999, 407-414

[8] SHI Shaoqiu, WANG Lili. Discussion on Dynamic Mechanical Behaviors of Cement Mortar under Quasi-one and One Dimensional Strain States. Chinese Journal of Rock Mechanics and Engineering, 2001, 20(3): 327-331

[9] YAN Shao-hua, QIAN Qi-hu, ZHOU Zao-sheng, et,al. Experimental Study of Equation of State for High-Strength Concrete and High-Strength Fiber Concrete. Journal of PLA University of Science and Technology, 2000,1(6):49-53 z

[10]Zhang Zhen-yu,Huan Shi. LAGRANGIAN ANALYSIS OF FLOW FIELD IN DETONATION REACTION ZONE OF HIGH EXPLOSIVES [J].Explosion and Shock Waves,1996,16(3):271-277.