Experimental Study on the Relationship between Compressive Strength and Point Load of Red Mudstone in Sichuan

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Abstract

So far, through the establishment of a linear relationship between the rock point load strength and uniaxial compressive strength to get the rock point load strength more easily is a better method to determine the rock uniaxial compressive. But because the linear relation has a superior regional characteristic, every single place has its own experienced formula .So, in order to get the linear relationship between rock point load strength and uniaxial compressive strength in Sichuan area, in this paper, through the indoor point loading strength test and uniaxial compressive strength test of red mudstone specimen in Sichuan , we get a statistical data, and in this data, we found that in point loading strength test as the usage of loading methods change, the results are different. In general, the axial loading sample > irregular loading sample>radial loading sample. Therefore, in order to get a more comprehensive regional and empirical formula, we respectively established a linear relationship between the point load strength and uniaxial compressive strength of the irregular sample loading, the axial load and the radial load, which provides a good reference for the division of the hard degree and the evaluation of the quality of red mudstone in Sichuan area.

Keywords

Red mudstone, point load strength, uniaxial compressive strength, linear relationship.

1. Introduction

In many areas of engineering construction, the uniaxial compressive strength of rock not only is an important indicator to divide the hard degree of the rock and evaluate the quality of the engineering rock mass, but also is one of the most important parameters of the rock physical mechanics properties [14,15]; For the determination of the conventional rock uniaxial compressive strength ,because there are many external factors in the course of making samples(field sampling, indoor grinding and so on) which caused deviation of data results. Besides, indoor tests which are time-consuming and expensive are fewer, which is difficult to meet the needs of practical engineering design and construction [15,17].While Rock point load strength test has many advantages, for example, simple , reliable ,rapid and cheap [1-21], which currently widely used in practical engineering, especially through the establishment of the empirical formula of rock point load strength and uniaxial compressive strength to determine the point load strength simply and conveniently to get the corresponding rock uniaxial compressive strength [1,2,4,6-10,15,16,19-21]. According to the current research, we can know that the correlation is regional, and the empirical formula used in different places is different [9,17,19]. In summary, the establishment of the empirical formula of the rock uniaxial compressive strength and the point load strength of Sichuan red mudstone is meaningful, through the uniaxial compressive strength and the point load strength of indoor test of the red mudstone in Sichuan, this paper trying to establish a linear relationship between the two parameters in the analysis of large amounts of data, and provide a reference for the red mudstone engineering design and construction in this area.

2. Test Materials and Test Methods

2.1 Sample Preparation

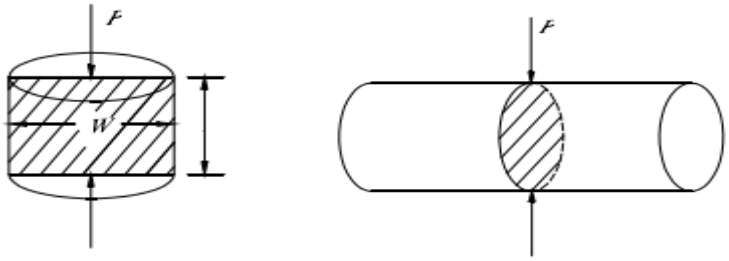
Samples are from a foundation pit in Chengdu, Sichuan. The rock samples are intense weathered, medium weathered and weak weathered sandstone, mudstone and siltstone. In order to explore the difference between irregular samples and the standard cylinder specimens, the intense weathered red bed soft rock point load specimen shape respectively adopt the irregular and cylinder test, medium weathered and the weak weathered sandstone breeze of red bed soft rock specimen shape all use cylinder. Indoor cylinder point loading strength test is divided into radial and axial test method according to the different shape of samples; the ratio of the length L and the diameter D L / D >1 using radial loading, L / D $\leq$ 1 by axial loading and L $\geq$30mm.

Fig. 1 cylinder and irregular sample

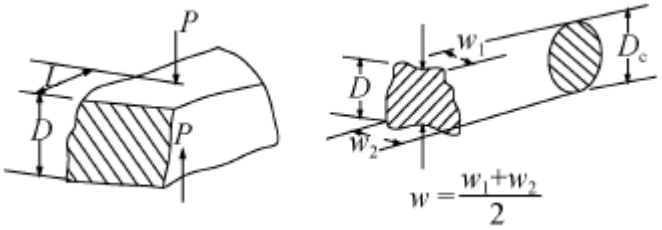
2.2 Sample Method

(1) Point load test

Indoor point load test adopts STDZ series digital rock point load test instrument. First, put the center of the ready-made specimen on the conical indenter which is at the lower end of the point load instrument , control hydraulic jack manually so that the surface of the specimen and the conical indenter which is at the upper end of the point load instrument are in contact, then zero the electronic display, and control jack manually to impose concentrated load on the specimen until the specimen is destroyed ,and then use electronic vernier caliper to measure load P, D and W_f from the destroyed sample directly. Axial, radial and irregular loading methods are showed in Figure 2.



(a) cylinder axial loading (b) cylindrical radial loading



(c) irregular sample loading

Fig. 2 loading modes of different shapes of specimen

(2) Uniaxial compressive strength test

Indoor uniaxial compressive strength test uses electro-hydraulic servo testing machine controlled by microcomputer for unconfined uniaxial compression to cylindrical samples. First, put the ready-made column sample on the center of the chassis of the press horizontally, let the computer control hydraulic device to make the chassis rise to the level that the surface of the sample just touches the top plate of the press, and after this suspension, start loading until the specimen destructed, then record breaking load F, cylinder specimen height h and diameter d measured by electronic vernier caliper.

Figure3 cylinder rock uniaxial compressive test

3. Laboratory Test Data Analysis

3.1 statistics of test data

The statistics of the point load strength of the irregular sample and the cylinder specimen of the strongly weathered red mudstone are shown in Table 2. From the table, point load strength of red mudstone in cylinder can be computed (including axial and radial) for 0.143MPawe can reach a conclusion that the point load strength of the red mudstone specimens in cylinder and those in irregular are the same; at the same time we also can draw a conclusion that point load in irregular, in axial and in radial shapes have different point load strength because of the stress condition, and intensity is axial > irregular > radial.

Table 2 Comparison of load intensity (MPa) of strongly weathered red mudstone in different shapes

shape		amount	Maximum value	minimum value	average value	standard deviation	standard value
irregularity		126	0.676	0.014	0.162	0.1	0.147
cylinder	axial	206	0.873	0.012	0.206	0.13	0.191
	radial	196	0.127	0.023	0.107	0.11	0.094

Table 4 statistical data of uniaxial compressive strength of red mudstone with different weathering degree

weathering degree	amount	Maximum value	minimum value	average value	standard deviation	standard value
Strong weathered	67	6.664	0.418	1.328	1.054	1.107
Medium weathered	23	8.515	0.875	2.782	2.426	1.899
Weak weathered	8	14.53	2.122	8.419	3.999	5.717

According to the uniaxial compressive strength of red mudstone with different weathering degree in Table 4, we can know that the red mudstone is a kind of extreme soft rock. Due to the management of the construction sites, the number of medium weathered and weak weathered samples are not so

many as the strong weathered samples, but after a reasonable statistic of the data, it has little effect on the establishment of the empirical relationship.

3.2 establish empirical formula

From the above analysis, we can know that in the indoor point loading strength test, if we adopt different loading methods, the red bed mudstone point load strength values are not the same, so in order to provide a more comprehensive empirical formula of the point load strength and the uniaxial compressive strength of the red mudstone , we not only established a linear relationship between point load strength and uniaxial compressive strength of red mudstone, but also those in different loading forms as showed in Figure 4. Due to the uniaxial compressive strength data and point load strength data are too many, and data correspondence is not very strong, so we select various point and various elevation to obtain the average value of the uniaxial compressive strength data and point load strength data, use Origin software to fit, and then to establish the linear relationship between the uniaxial compressive strength and point load strength of the red mudstone.

Relationship between point load strength and uniaxial compressive strength under axial load of red mudstone:

$$y=16.04x-0.9 \quad (1)$$

Relationship between point load strength and uniaxial compressive strength under radial load of red mudstone:

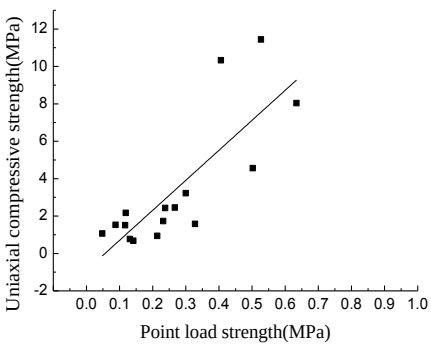
$$y=11.65x-0.1 \quad (2)$$

Relationship between point load strength and uniaxial compressive strength of irregular specimen of red mudstone:

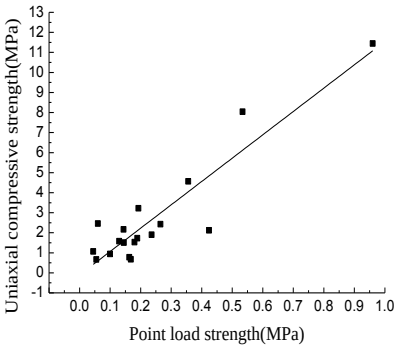
$$y=3.23x+0.382 \quad (3)$$

Y - Red mudstone uniaxial compressive strength (MPa);

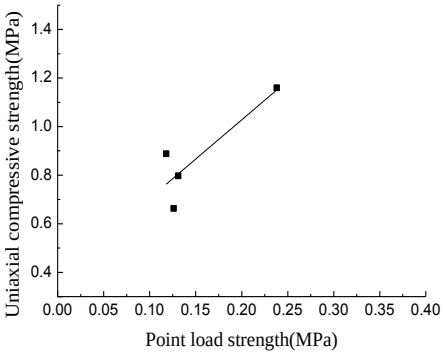
X -The point load strength (MPa) of red mudstone under different loading conditions.



(a)cylinder axial loading



(b)cylindrical radial loading



(c) irregular sample loading

Fig. 4 linear relationship between load intensity and uniaxial compressive strength of red mudstone under different loading ways

Through the above three formulas and Figure 4, we can be learned that the loading of specimens in different shapes will lead to different mechanical characteristics and failure modes, which leads to different test results .therefore, establishing empirical formula under different failure modes can give a more comprehensive reference for the actual engineering design and construction.

4. Conclusion

According to the "standard methods for testing of engineering rock mass, we had an indoor point loading strength test and a uniaxial compressive strength test of red mudstone specimen in Sichuan ,and after the statistics and analysis of the data , following conclusions are obtained:

The shape of the samples has certain effect on the point loading strength test results of the red mudstone. According to the statistical results, we can know the point loading strength relationship among the cylinder specimens with axial load, the cylinder specimens with radial load and the irregular specimens. That is, axial > irregular > radial, so in determining the rock point load strength, we need to choose the shape of the specimen reasonably.

Red mudstone belongs to a kind of extremely soft rock, so in the course of determining the empirical relationships of point load strength and uniaxial compressive strength of red mudstone, we have no need for distinguishing the difference between hard rock and soft rock. Strong weathering, medium weathering and weak weathering are unified into an experience formula.

Through establishing three kinds of loading mode, the axial, radial and irregular sample, empirical formula can be obtained between point load strength and uniaxial compressive strength of red mudstone, which provides a wonderful reference for the division of the hardness degree of red mudstone and the evaluation of the quality of red mudstone.

References

[1] Lin Fei: Study on the correlation of point load strength index, Western Exploration Engineering, Vol. 1 (2011) No.1, p. 5-7.

[2] Fu Zhiliang, Wang Liang: Comparison test of rock point load strength and tensile and compressive strength of coal seam roof and floor, Chinese Journal of Rock Mechanics and Engineering, Vol. 1 (2013) No. 32, p. 88-96.

[3] He Fengyu: Test and Analysis on the relationship between the intensity and the intensity of the point load test, Resource Environment and Engineering, Vol. 2 (2009) No. 23, p. 138-140.

[4] Su Chengdong, Tang Xu, Ni Xiaoming: Experimental study on the relationship between the compressive strength and tensile strength of coal samples, Mining and Safety Engineering, Vol. 4 (2012) No. 29, p. 511-515.

[5] Wei Qiang Duan, Zhang Xiaoqiang: Live rock point load test analysis, Geotechnical Investigation & Surveying, (2009), p. 66-70.

[6] Qi Yujun, Hou Kepeng, Guo Cheng Peng: Rock point load strength and the standard compressive strength correlation, Mining Research and Development, Vol. 3 (2012) No. 32, p. 36-38.

[7] Li Anping, Liu Yangshu, Zhou Ming, et al: Study on the relationship between rock point load strength and uniaxial compressive strength, Nonferrous Metals (Mining Section), Vol. 3 (2014) No. 66, p. 53-58.

[8] Singh T N Kainthola A Venkatesh A: Correlation Between Point Load Index and Uniaxial Compressive Strength for Different Rock Types, Annals of the Rheumatic Diseases, Vol. 5 (2012) No. 71, p. 707-709.

[9] Tan Guohuan, Li Qiguang, Xu Yue, et al: The relationship between the hardness of the Hongkong rock and the point load index and the strength of the, Rock and Soil Mechanics, Vol. 2 (1999) No. 20, p. 52-56.

[10] He Lubin, Fu Zhiliang, Wang Qiang, et al: Linear relationship between rock point load strength and uniaxial compressive strength, Coal Field Geology and Exploration, Vol. 3 (2014) No. 42, p. 68-73.

[11] Li Maolan, Zhong Guangzhou: Rock point load test and its application (Sichuan, Southwest Jiao Tong University, 1994).
[12] Tang Da Ming, Yang Shoucheng: Study on size effect of uniaxial compressive strength of rock, Sichuan Water Power, Vol. 1 (2011) No. 30, p. 119-124.
[13] [Cai Wenjuan, Li Wei, Liu Dawei, et al: Design of Intelligent Rock Point Load Tester, Coal Mine Machinery, Vol. 12 (2006) No. 27, p. 24-26.
[14] Yang Libin, Wang Wang: Application of point load test in the investigation of broken rock strata, Hanzhoung Science and Technology, (2006) p. 50-52.
[15] Yang Fan, Xie Yongli: The effect of point load test to determine rock strength index, Journal of Guangxi Universit: Natural Science Edition, Vol. 1 (2013) No. 38, p. 138-143.
[16] Wang Xianghou, Li Ming Yong, Yu Luofei: Point load test of rock strength using irregular test piece of research and discussion, Rock and Soil Mechanics, Vol. 4(1995) No. 16, p. 46-56.
[17] Wang Chengchun: The value of the compressive strength of the irregular rock point load test, Engineering Survey, Vol. 3 (2015) No. 43.
[18] Singh T N Kainthola A Venkatesh A: Correlation Between Point Load Index and Uniaxial Compressive Strength for Different Rock Types, Annals of the Rheumatic Diseases, Vol. 5 (2012) No. 71, p. 707-9.
[19] M. heidari, G. R. Khanlari, Mehdi Torabi Kaveh, et al: Predicting the Uniaxial compressive and tensile strengths of gypsum rock by point load Testing, Rock Mechanics and Rock Engineering, Vol. 5 (2012) No. 45, p. 1127-1130.
[20] Jiao Shoulin, Jiang Lili: Determination of rock compressive strength by point load strength test, Shandong Coal Science and Technology, (2011), p. 91-92.
[21] Gu Jiangqiang: Talk about the practical application of Gu Jianqiang rock point load strength and the compressive strength of the relationship between the, Shanxi Building, Vol. 30 (2007) No. 33, p. 130-131.