



# IN SITU FIELD SHEAR TEST OF ROCK MASS PLANE ON FOUNDATION SURFACE OF A HIGH SLOPE IN GUIZHOU PROVINCE

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## ABSTRACT

By using the system of anti-force frame, the problem of support difficult about counteraction bearing is solved in open-air rock mass shear test. When the strength of the foundation surface rock mass is tested in High Rock Slope Engineer, the normal load is provided by anti-force frame, and the horizontal load is supported on steep part of the different rock mass. The shear-break strength parameters and the shear strength parameters of the rock mass are analyzed. The curves of shear (break) normal stress ~ shear stress,  $\tau' \sim u_h$  (uv) and  $\tau \sim u_h$  (uv) are obtained. The experimental results show that the friction angle of the rock mass is  $31.3^\circ$ , close to its natural inclination.

**Keywords:** reaction force beam, shear, foundation surface.

## INTRODUCTION

Engineering rock mass is usually composed of different scales and different types of structural planes. These structural planes largely control the stability of rock mass (Gu, 1979). The shear strength parameter is one of the important mechanical parameters of rock mass, and has an important effect on underground engineering in rock mass (Lin, 2009; Xiang *et al.* 2008). A large number of engineering practices have shown that the failure of rock mass is directly related to the shear strength of the structural plane (Barton *et al.* 1977; Barton *et al.* 2017). In rock mass engineering, the primary and most important and also difficult task for a stability analysis is to determine the reasonable shear strength parameters of rock mass. The indoor testing and field testing are the most reliable means of determining the shear strength parameters. However, the indoor test is limited by the geometry of the specimen, which results in great deviation to specimen. Then the field test is very important in practical application (Bahaaddini *et al.* 2016; Hencher *et al.* 2015; Tang *et al.* 2016).

In the conventional shear strength test, it is necessary to excavate the test hole (test expansion) in the selected part of the project. The test specimen is applied on the rock mass which is affected by the manual removal of the blasting loose. The normal load and parallel load applied by the test are obtained by passing the transmission column to the wall of the test hole (Barton *et al.* 1977). However, in some projects, it is difficult to excavate the ideal test hole because of the site or cost, thereby restricting the field shear strength test. The reaction force beam reaction system developed by our monitoring and testing research institute has solved this problem, which makes it possible to test the shear strength of the rock structural plane under the open conditions.

## MATERIALS AND METHODS

The counter-force beam is an important part of the test equipment. On both sides of the beam, there are two counter-force anchorage holes, 60 millimeters in diameter, 0.8 meters from the center of the beam. The two holes and the center of the specimen are in a straight line. The distance between the center of the specimen and the anchor holes on both sides should be greater than 2 times the length of the specimen. The hole aperture of the counter-force hole is accurate (the error is less than 2mm). The force direction should be perpendicular to the center of the specimen.

Firstly, the upper end of the anchoring head is installed on the anchor bolt steel screw, then the compression steel sleeve is installed on the anchor steel screw, and then the anchorage head end is fixed on the anchor steel screw. Secondly, the anchor steel screw with the upper and lower anchor head and anchor pressing steel sleeve was placed in the two symmetrical reaction holes located at 0.8 meters from the left and right sides of the test point center. Thirdly, in the special installation and commissioning, the end of the load-bearing frame is placed at its end to support it. The two ends of the counter-force beam are inserted into the anchorage and anchorage steel screw. Finally, the left and right ends of the counter-force beam are pressed, leveled and fixed by the counter-force pressing bolts.

Using the principle of expansion bolts, the cone (two) is pressed into the taper sleeve by rotating the main bolt on the anchor through the supporting sleeve. Then the taper sleeve expanded and pressed the rock pore wall (taper sleeve end may also cut into the rock). The longer the distance between the cone and the taper sleeve, the greater the bond force between the cone and the rock mass. Corresponding to 50 cm \* 50 cm specimen, the maximum tensile stress is greater than 4.0 Mpa, which meets the general requirements of soft rock and structural plane shear test. The test device is shown in Figure-1.

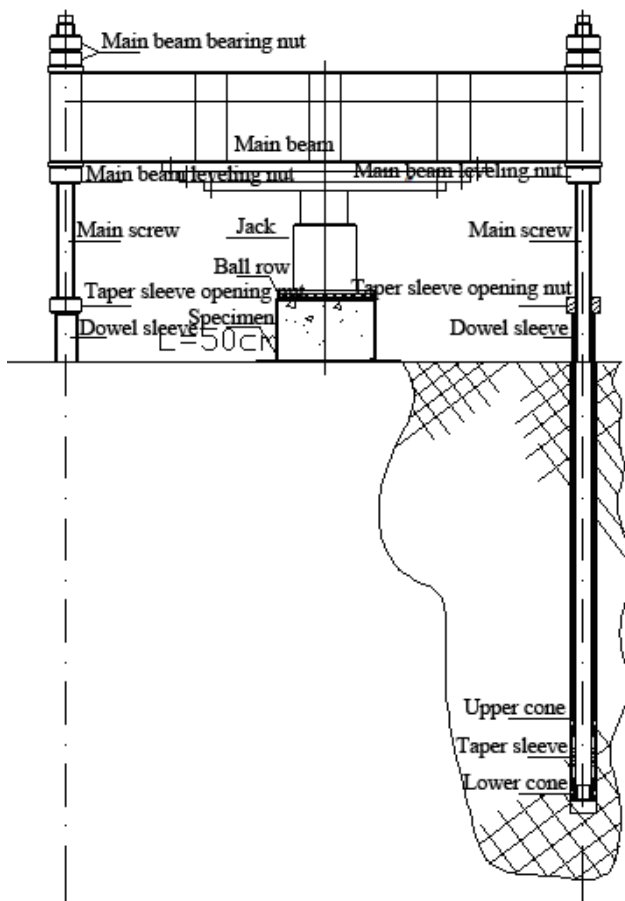


Figure-1. The test device.

## RESULTS AND DISCUSSIONS

### Project overview

A high slope project of Hangrui highway Guizhou section of Bijie to Doug in China is through the valley in the form of deep excavation cutting. The total length of this section is 360 meters. The maximum depth of the original design center pile is 33.3m. On the left side, according to the 1:0.75 slope rate, the maximum slope height is 68m.

The bedrock soil type in the site is single, and the lower is a limestone stratum with good integrity and large layer thickness, and the foundation is stable. The small angle between the rock layer and the rock layer and the slope direction has a great influence on the stability of the slope. The slope angle of the left slope in the site is relatively small. Therefore, the ratio of slope of the left excavation slope is relatively steep. When the angle of slope is larger than that of rock plane, the left side slope may appear local landslide or block caving during the process of external impact load and self stress release.

In order to obtain the shear strength index of the rock formation planes, a large field test about 1 group rock was carried out.

### Test introduction

The test site is selected jointly by the experimental party and the entrusting party, and a good representative rock plane is selected for pilot processing. The test is carried out in the open field. Using the flat push method, the normal load and the horizontal load are applied by the jack. The normal load is supplied by the reaction force beam system of our monitoring and testing research institute, which has the intellectual property right of this system. The horizontal load uses the steep section between different layers of rock mass as the support of the counter-force base. After each specimen was cut first, the shear (friction) test was carried out on the shear plane of each specimen, and then a single point shear test was carried out on the part of the test specimen. The test arrangement and the device are shown in Figure-2.

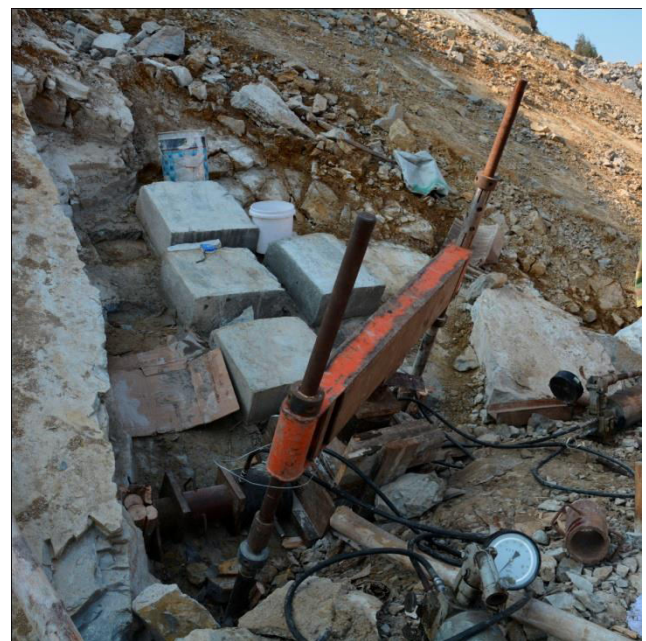


Figure-2. The test arrangement and the device.

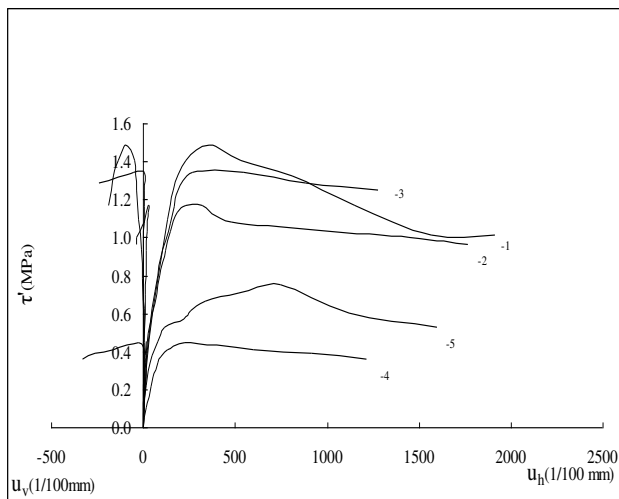
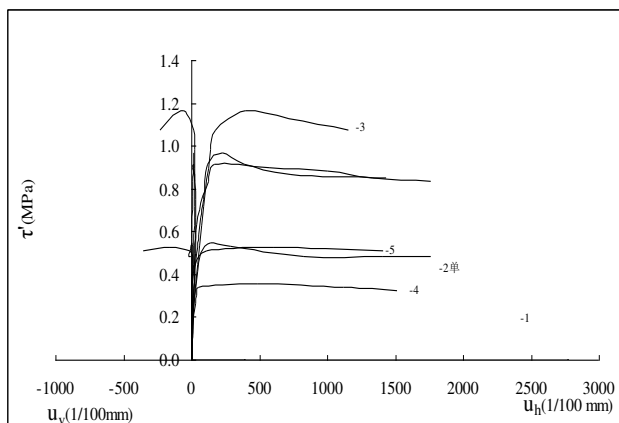
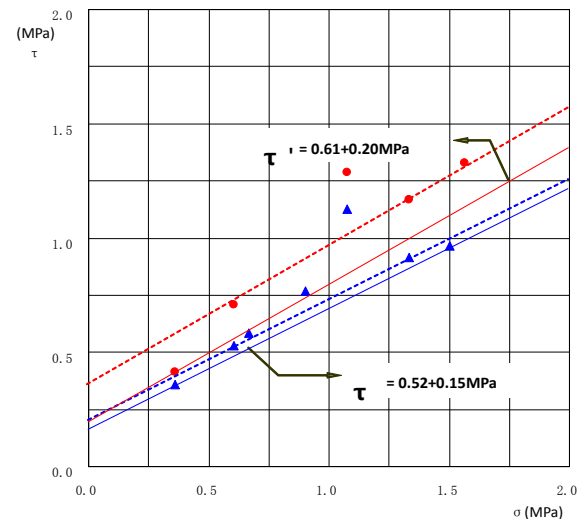
### Results and analysis

The shear is mostly carried along the same plane, and some along between the layers of thin-layer limestone, which are about 1 ~ 2cm high. The shear planes are mostly slightly undulating and rough in a natural dry state, with a small amount of weathering debris. Fluctuation difference is mostly less than 2cm, with a small amount of shear debris, debris and obvious scratches. The results of the field strength test of limestone plane are shown in Table-1.

**Table-1.** The results of shear strength test.

Representative type	Maximum normal stress (MPa)	Shear break strength		Shear strength	
		F'	C'(MPa)	f	C9 (MPa)
Limestone plane	1.56	0.61	0.20	0.52	0.15

The relationship between  $\tau' \sim u_h (uv)$  is shown in Figure-3. The  $\tau \sim u_h (uv)$  curve of shear test is shown in Figure-4 and the curve of  $\tau \sim \sigma$  is shown in Figure-5. The values of  $f$  and  $c$  are determined by graphic method.

**Figure-3.** The curve of  $\tau' \sim u_h (uv)$ .**Figure-4.** The curve of  $\tau \sim u_h (uv)$ .**Figure-5.** The curve of shear (break) normal stress  $\sim$  shear stress.

The plane of rock mass is generally flat, but the maximum fluctuation is up to 3 cm in the size range of the specimen. The plane of rock mass is relatively rough, and the soil and clay pour into the part of plane cracks in a loose state. Most of the fresh rock mass is not filled or filled with only a little weathering debris. The test was carried out in a naturally dry state with a test value of:

$$\begin{aligned} \square f' &= 0.61 & c' &= 0.20 \text{ MPa} \\ \square f &= 0.52 & c &= 0.15 \text{ MPa} \end{aligned}$$

## CONCLUSIONS

The experimental results show that the test rock plane has good representativeness. The analysis also show that the internal friction angle of the rock mass is  $31.3^\circ$ , which is very close to the natural inclination of the rock mass ( $26^\circ < 31^\circ$ ). It is also close to the slope of the whole slope (about  $20^\circ \sim 35^\circ$ ). Considering that the rainy season will increase the water content of the rock mass plane and thus reduce the shear strength, the geological recommended value should be appropriately reduced on the basis of the experimental standard value.

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