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## Water-sensitive Properties of Shear Strength of Bijie Red Clay under Direct shear Testing

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# Water-sensitive Properties of Shear Strength of Bijie Red Clay under Direct shear Testing

Juan Fang\*, Jiaai Zhu<sup>a</sup>, Lai Meng<sup>b</sup>

School of civil engineering and Architecture, Gui zhou University of engineering science, Bijie Guizhou, China

\*Corresponding author e-mail: 568641755@qq.com, <sup>a</sup>1489953013@qq.com, <sup>b</sup>1639459853@qq.com

**Abstract.** In order to study the water-sensitive properties of Bijie red clay, the basic physical index test and direct shear test of different water content samples were carried out. The relation between shear strength index and water content of red clay was obtained, and the influence of critical water content on strength was analyzed. The testing results show that the shear strength index of Bijie red clay turns around the natural moisture content, because of the cracks generated with water losing. Then the functional relationship between cohesive force, internal friction angle and water content was established. Based on this relationship, it can reflect the quantitative influence of water content on intensity.

## 1. Introduction

Located in the northwest of guizhou province, Bijie is the junction of sichuan, yunnan and guizhou provinces. Because of the humid north subtropical monsoon climate, the rain is abundant throughout the who year. Just because of the special geographical location and climatic conditions, the Properties of Bijie red clay is different from general clay soil [1] [2]. It is known that the nature of soil is determined by the composition and structure of soil, Liao yiling [3] et al. systematically studied the origin, mineral composition and basic mechanical characteristics of red clay in Guizhou, and they believed that the two stages of the process of red clay soil formation, karst before accumulation and lateralization after accumulation, which controlled the properties of red clay. In previous studies, red clay in Guangxi, Hunan and other places has attracted much attention because of the construction of the project, but, there are great differences in geological characteristics and engineering mechanical properties in different region [4]. Wang Zhongwen et al. studied the water sensitivity of the shear strength of remolded red clay in the Yunfu section of guangwu high-speed railway, and founded that the shear strength decreasing with the increasing of water content, then the concept of "critical moisture content shear strength surface" was put forward. Bi Qingtao [5] et al. carried out the direct shear test of red clay, the results showed that the relation between shear strength index cohesion, internal friction Angle and water content was different. Zhao Yingwen et al. [6] carried out a series of physical and mechanical tests of Guangxi red clay, founded that the mechanical index and expansion and contraction performance control factors were different in different water content ranges, and the water content at the turning point was close to the optimal water content obtained by heavy compaction test.



Existing study results showed that different humidity conditions have great influence on mechanical properties of red clay, which caused by climate, manual slope cutting, foundation excavation in actual engineering, and that led to all kinds of engineering disasters. In recent years, the economy of Bijie has been developing rapidly, and in the meantime, many railway transportation lines and construction projects are constructed. Therefore, it is of great significance and necessary to study the effect of water content on the engineering properties of Bijie red clay.

In this paper, the shear strength parameters with different water content were tested under direct shear testing, and the influence to the shear strength is analyzed, in order to establish a quantitative parameter, describing the relationship between water content and shear strength finally.

## 2. Basic Physical Properties of Bijie Red Clay

### 2.1. Basic physical indicators

The characteristics of the two red clay are as follows: red clay 1 was taken from the side wall of a slope in Gui zhou University of engineering science, 3-4m away from the surface, which is yellowish-brown without stone core. Red clay 2 was taken from the lateral wall of a foundation pit in Yang Jiatang, 6-7m from the surface depth. The basic physical properties of two kinds of red clay were measured by laboratory test, and were plotted as table 1.

**Table 1.** Physical indexes of the two Bijie laterite

Red clay	water content(%)	natural density/(g/cm <sup>3</sup> )	relative density	Void ratio	liquid limit(%)	plastic limit(%)	plastic limit index
1	56	1.63	2.68	1.58	62.4	32.1	30.3
2	55	1.72	2.69	1.45	65.1	31.5	33.6

From the table1, Bijie red clay is characterized by high water content, high porosity ratio and high liquid limit.

### 2.2. Test method and content

Firstly, the soil samples retrieved were made, then the different water content of samples were conducted through air drying or water dripping. The water content of red clay 1 is 50%, 56%, 64%, 67.5%, and that of red clay 2 is 47%, 50%, 55%, 59%. The instrument used in this test is ZJ strain control direct shear instrument produced by Nanjing soil instrument factory, and the specimen size is  $d=61.8\text{mm}$ ,  $h=20\text{mm}$ , rapid shearing.

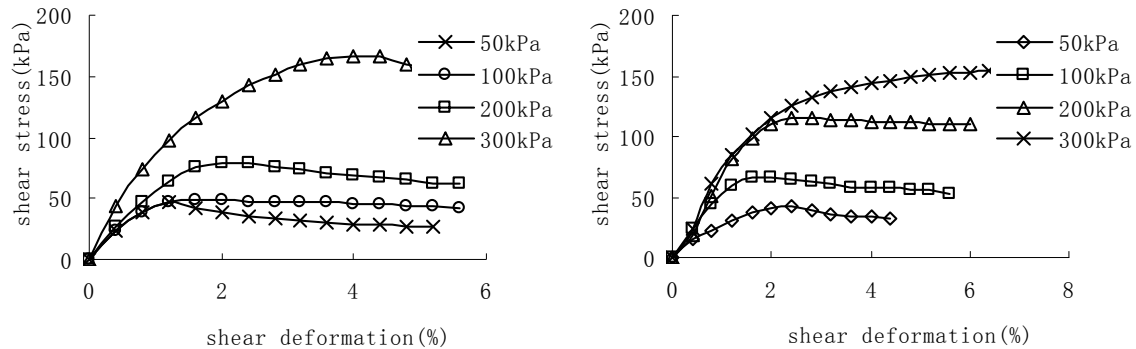
During the test, it was found that the reading of the measuring ring under the action of lower normal stress reached a certain value and then regressed. At this point, it should be continuously recorded until the shear deformation reached 4mm, while at higher normal stress, the reading of the measuring ring increased continuously. At this point, it should be recorded that the shear deformation reached 6mm, and the corresponding shear stress was taken as the shear strength value. These two different situations are due to the different structural performance of soil under hydraulic action.

## 3. Test results and analysis

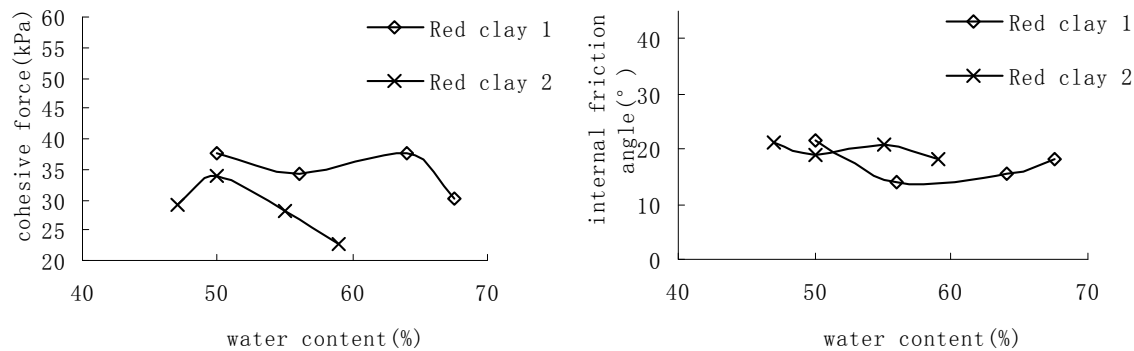
Based on the testing data, the relation curve of shear stress and shear deformation with different water content samples is drawn in Fig. 1.

### 3.1. Relation between cohesive force and water content

According to the test results, the relation curves of moisture content, cohesive force and internal friction angle were drawn, as shown in Fig. 2.



**Figure 1.** The Shear stress and deformation curves of the two red clay with  $w=50\%$



**Figure 2.** The variation curves between the cohesive force, internal friction angle and water content

It can be seen from figure 2 that the cohesive force of red clay decreases with the increase of water content, and the curve presents a first-order exponential decay relationship. The influence of moisture content of red clay on cohesive force is obvious, especially between 50%~64%. Before the moisture content is 50%, the cohesion increases. As red clay contains metal oxides such as iron, aluminum, silicon, and titanium, Bijie red clay with the characteristics of high liquid limit and is rich in a large amount of combined water, the cementation of free iron oxide is not very cohesive. Based on the relation curve, the regression equation was obtained as follows:

$$c = 99.083e^{-0.024w} (47\% \leq w \leq 64\%) \quad (1)$$

### 3.2. The relation between internal friction Angle and moisture content

As is shown in figure 2, the internal friction angle decreases with the increase of moisture content of red clay, and the curve presents a first-order exponential decay relation. With water content between 50% and 64%, the attenuation of the Angle of internal friction is obvious. Based on the relation curve between the Angle of internal friction and the moisture content of red clay, the regression equation was obtained as follows:

$$\varphi = 17.386e^{0.0073w} (47\% \leq w \leq 64\%) \quad (2)$$

From the above formula, it can be described that water content has a certain influence on the angle of internal friction, which is between 50% and 64%. This influence is relatively stable, making the change of the Angle of internal friction subduction not fluctuating much. However, before the moisture content is 50%, the Angle of internal friction increases.

#### 4. Conclusion

According to the test results, the basic physical properties of Bijie red clay are characterized by high water content, high porosity ratio and high liquid limit. Through the direct shear testing of samples with different water content, the cohesive force and internal friction angle were calculated, and the relationship between the above shear strength index and water content was derived. The results show that the cohesion and the internal friction angle decrease with the increasing of water content. When water content is 50%, the cohesion and the internal friction angle both have the maximum value. The relation curves of cohesion and moisture content, internal friction angle and moisture content are first-order exponential relations. The relation of function can be introduced into the calculation of strength and deformation considering the structure of red clay.

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