Experimental Study On The Mechanical Parameters Of Red Layer Soft Rock In Chengdu Area

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Abstract

The red layer soft rock has the characteristics of strong hydrophily,weak water permeability, low strength, easy shrinkage of water loss and water softening (or expansion). The self stabilization ability of the mountain with the cut slope formed by excavation and embankment filling embankment slope is poor,and often induce the slide collapse of the red bed slope. Especially in the rainy season, it is more likely to happen a large number of landslides and other geological disasters.The main content of this paper is by operating the unconsolidated-undrained quick direct shear test of the red bed soft rock in Chengdu to determine the shear strength parameters of red layer soft rock under different water cut conditions, that is internal friction angle and cohesive force and to further verify the law of their changes.

Keywords

Red layer soft rock; Direct shear test; Mechanical parameters; Moisture content.

1. Introduction

Red layer soft rock refers to the Jurassic, cretaceous and tertiary sandstone, mudstone, shale and sandstone, mudstone and shale interbeds and soft hard alternated layered rock mass. The engineering geological properties of red bed soft rock is poor, and the strength of rock is low, the rock stratum are brown red, purplish red and dark red.it has the characteristics of strong hydrophilic, weak water permeability and easy to produce disintegration after losing water.r, etc[4].In China, the red layer soft rock is widely distributed, the total area of the exposed surface is about 46×104km^2, which accounts for 5% of China's land area, and is mainly distributed in the west of China, such as Sichuan, Yunnan and Gansu[5].

The factors that affect the shear strength of soft rock of red beds are very complex, and the influence of water content is very important. The stability of weathered residual soil slope in the red layer is especially sensitive to the change of soil moisture content. When the soil moisture content is high, the stability of the slope is often poor, and the natural disasters such as landslides often occur. Because of the mineral composition of the red soil layer generally contains more hydrophilic clay mineral composition, the shear strength of the red soil layer is closely related to the water content of the soil, the small changes in the soil moisture content may drastically reduce the shear strength of the soil, especially the shear strength of the original rock structure and it may cause the collapse of the red soil slope[3].According to the statistics, the soft rock in Western China is about 1/4 of the total number of landslides[5],the landslide of red bed soft rock has the characteristics of wide distribution, sudden strong, severe disaster, which seriously threaten the safety of life and property of the state and people.

Because of the influence of water content on the shear strength of soft rock in the red layer is very important, in the area of frequent rainfall area of red layer soft rock zone, it is prone to landslides and other disasters. In the face of this situation, it is very important to grasp the mechanical parameters of soft rock at the time of rainfall as well as the strength and stability of the surrounding ground which can be targeted for reinforcement. The basic index to determine the strength and stability of foundation is the internal friction φ angle and cohesion c of soil. In this experiment, the basic parameters of the foundation strength and stability are provided by the fast shear test of the red layer soft rock in Chengdu area: the internal friction φ angle and the cohesion c .By determining the change of shear strength of soft rock of red layer under different moisture content, the change law of c and φ of the red layer soft rock is further verified.

2. Indoor Test

2.1 Test Principle

The damage of soil belongs to shear failure and the strength of soil particles is much greater than the strength of the particles. Under the action of shear stress, the soil will along a surface that is greater than or equal to shear strength, and produce relative displacement, dislocation and destroy of each other. The basic law of shear strength of soil can be expressed by Coulomb's law, for cohesive soil, it can be expressed as:

$$\tau_f = c + \sigma \tan\varphi$$

Where:

τ_f -Shear strength of soil(kPa);

σ -normal stress of shear sliding surface(kPa);

c -Cohesive force of soil(kPa);

φ -Internal friction angle of soil(°).

2.2 Test Purpose

In this experiment, by conducting the direct shear test of the red layer soft rock under 5 different moisture content to determine the internal friction angle φ and cohesion c ,and draw the relationship curve of shear displacement and shear stress as well as the relationship curve of shear strength and vertical pressure.

2.3 Test Instrument and Equipment

①Strain controlled direct shear apparatus、shear box、displacement measurement system、loading equipment、shear transmission device.

②Ring knife: inner diameter of 61.8mm, high 20mm, volume 60cm^3, cross-sectional area of 30cm^2;

③Displacement measurement equipment：dial indicator, range 10mm, minimum degree is 0.01mm.

④Other equipment: balance, wire saw, glass, etc.

2.4 Test sample

The test sample comes from a slope of Chengdu, which is a strong weathered red layer soft rock,the major components are fine sandstone, siltstone, sandstone, coarse sandstone, carbonaceous mudstone and sandy mudstone. Field sampling we use Luoyang shovel, small shovel and other tools, with special box loaded from a certain amount of red layer soft rock and sealed with plastic wrap and then sent to the laboratory.

2.5 Test Procedure

Take out a sufficient number of the red layer soft rock and put it in a ventilated place to dry, and put the air drying soft rock on the rubber plate with grinding grinding away,and then let the grinding air drying soil samples through the sieve pore size of 1.25 mm.

Configuration 5 kinds of samples of different moisture content, each set of soil sample preparation 6 samples,of which 2 were reserved.

Align the upper and lower box and insert the retaining pin, the lower boxes are placed in the water permeable plate and hard plastic film, ring knife down flat and align the shear box. put the hard plastic film and permeable plate on the ring blade in turn. Push the specimen into the shear box slowly and cover the upload plate.

Rotational the bolt at the back of direct shear apparatus and Push forward against the dynamometer, make the steel ball at the top of the dynamometer just contact with the front end of the shear box,and then adjust the dynamometer to make the readings is zero.

According to the design of experiments ,the vertical pressure of 100kPa, 200kPa, 400kPa, and 200kPa was applied to a group of four specimens respectively. Pull off the retaining pin immediately after applying pressure, start the direct shear apparatus at the rate of 12rad/min and record the dynamometer shows at the unit of circle. When the test force is stable or in a significant retreat, indicate that the sample has been cut off, and the stop the test.

At the end of the shear,absorb the water in the box,recede the shear stress and vertical stress, remove the load, the power frame and the gland,then take out the sample, test the moisture content and brush the net shear box.

2.6 Test Result

Record the data obtained in the test and the shear strength of each specimen was calculated according to the formula.

$$\tau = KR$$

Where:

τ -Shear stress of specimen (kPa);

K-Strain circle coefficient (kPa/per 0.01mm);

R-The difference between the final reading and the initial reading of the force gauge when shear failure, $R = (R_m - R_0)$.

$$\Delta L = 0.2n - R$$

Where:

n -Handwheel number;

ΔL -Hand rotary displacement of the lap, 0.2mm.

Taking the shear stress as the vertical coordinate, the shear displacement as the horizontal coordinate, and draw the relationship curve of shear displacement and shear stress.The peak shear stress of the curve is shear strength, when there is no peak value, take the shear stress as shear strength when the shear displacement corresponding 4mm.

Taking the shear strength as the vertical coordinate, the vertical stress as the horizontal coordinate, mark the shear stress values of the experimental results corresponding to the vertical pressure on the coordinates and fit into a straight line, that is, the shear strength line, wherein the slope of the line is the friction angle and the ordinate intercept is cohesion. Relationship curves of shear displacement and shear stress as well as shear strength and vertical pressure of red layer soft rock under different moisture content are shown in figure.

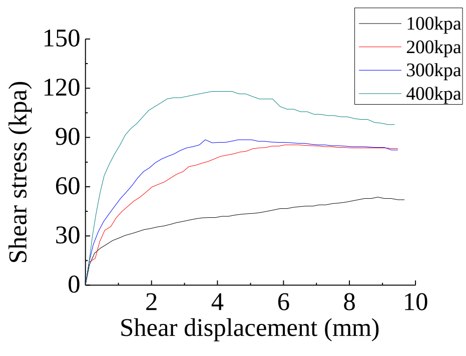

Figure 1 Relationship curve of shear displacement and shear stress when the moisture content is 20.42%

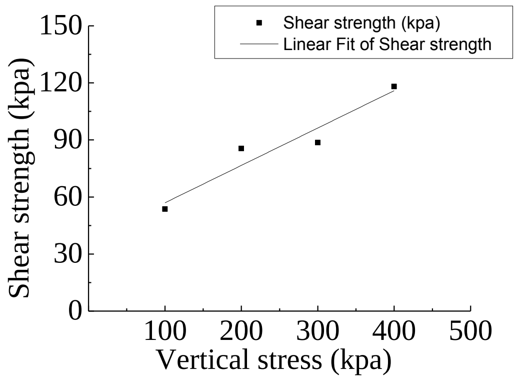

Figure 2 Relationship curve of shear strength and vertical pressure when the moisture content is 20.42%

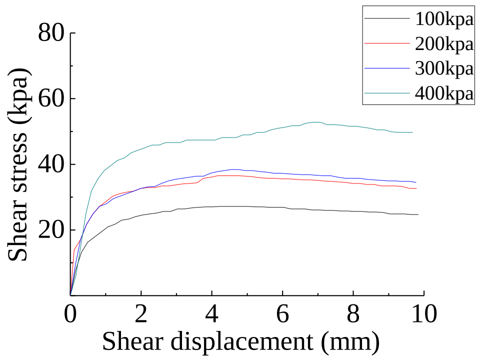

Figure 3 Relationship curve of shear displacement and shear stress when the moisture content is 25.13%

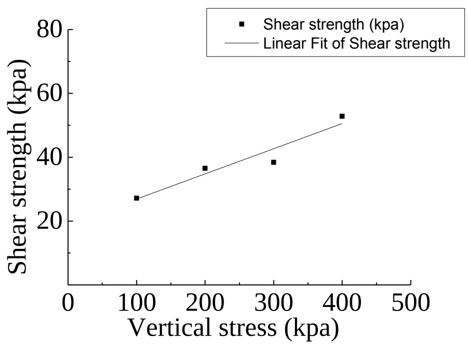

Figure 4 Relationship curve of shear strength and vertical pressure when the moisture content is 25.13%

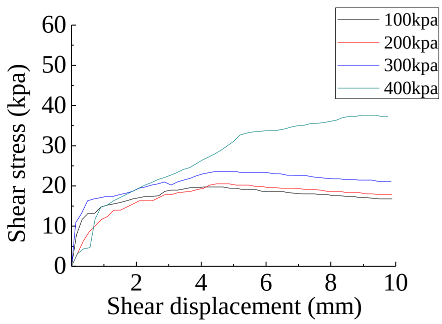

Figure 5 Relationship curve of shear displacement and shear stress when the moisture content is 29.54%

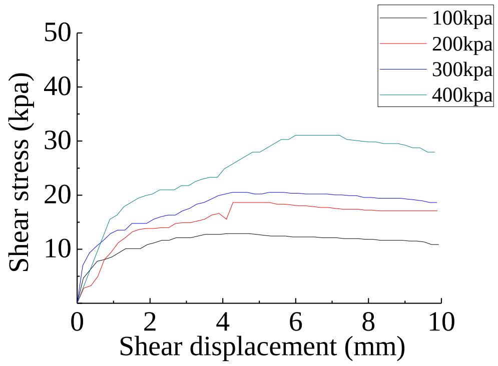

Figure 7 Relationship curve of shear displacement and shear stress when the moisture content is 32.35%

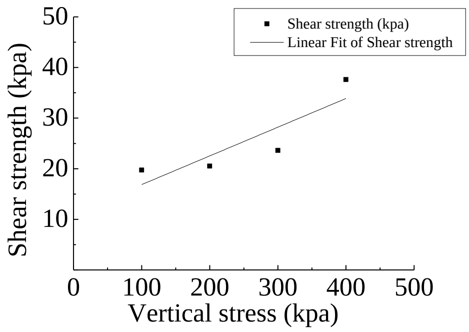

Figure 6 Relationship curve of shear strength and vertical pressure when the moisture content is 29.54%

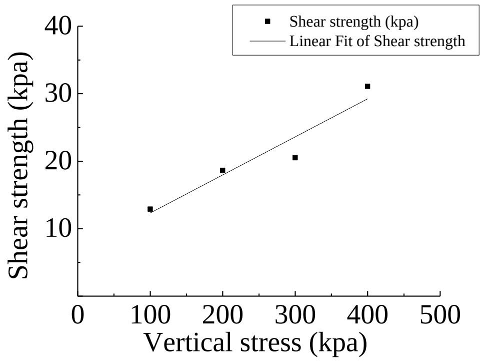

Figure 8 Relationship curve of shear strength and vertical pressure when the moisture content is 32.35%

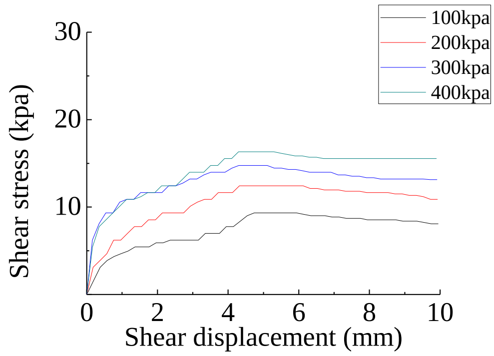

Figure 9 Relationship curve of shear displacement and shear stress when the moisture content is 34.75%

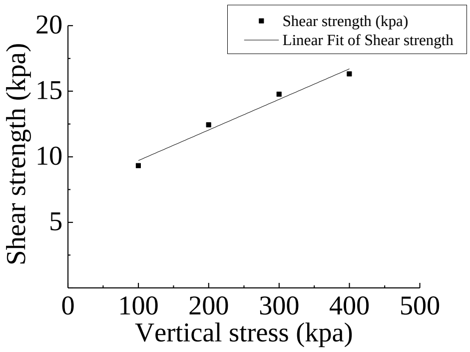

Figure 10 Relationship curve of shear strength and vertical pressure when the moisture content is 34.75%

From the figure, it is clear that under the same moisture content, the shear stress of the red layer soft rock increases with the increase of the vertical pressure, after the maximum shear stress, the curve begins to fall, which indicates that the sample has been cut down. When the vertical pressure is constant, the shear stress of the red layer soft rock decreases with the increase of moisture content. According to the relationship curves between shear strength and vertical pressure, the shear strength index of red layer soft rock under different moisture content can be obtained, that is, the internal friction angle φ and cohesion c ,and their change rule as shown in table 1.

Table 1 Statistical table of the shear strength index of red layer soft rock under different moisture content

Shear strength index of red layer soft rock with different moisture content					
Moisture content(%)	20.42	25.13	29.54	32.35	34.75
Cohesion c (kPa)	37.30	19.04	11.19	8.68	7.38
Internal friction angle φ (degree)	12.22	7.34	4.96	5.13	3.05
$\tan\varphi$	0.2166	0.1289	0.0867	0.0898	0.0533

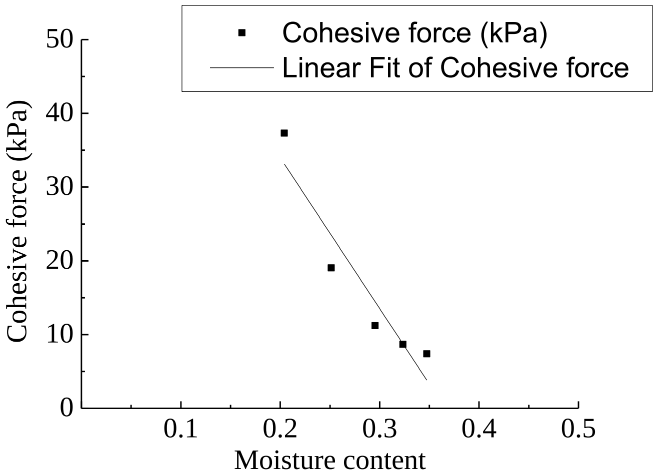

Figure 11 Relationship curve of moisture content and cohesive

From table 1, in a certain range, the cohesion c of the red layer soft rock decreased with the increase of moisture content, especially when the moisture content increases from 20.42% to 25.13%, the cohesion decreases sharply, but after the moisture content continues to increase, the cohesion slightly slow down.The internal friction angle has a downward trend in general except for a slight increase.

The relationship between moisture content and cohesion c can be expressed by figure 10,by linear regression analysis of data, the function of decreasing function can be expressed as: $y_1 = -204.5628x_1 + 74.8916$;which y_1 indicates the cohesion c (kPa); x_1 indicates the moisture content(%).

The relationship between moisture content and internal friction angle φ can be expressed by figure 12, the function of decreasing function can be expressed as: $y_2 = -58.875x_2 + 23.283$; which y_2 indicates the internal friction angle φ (degree); x_2 indicates the moisture content(%).

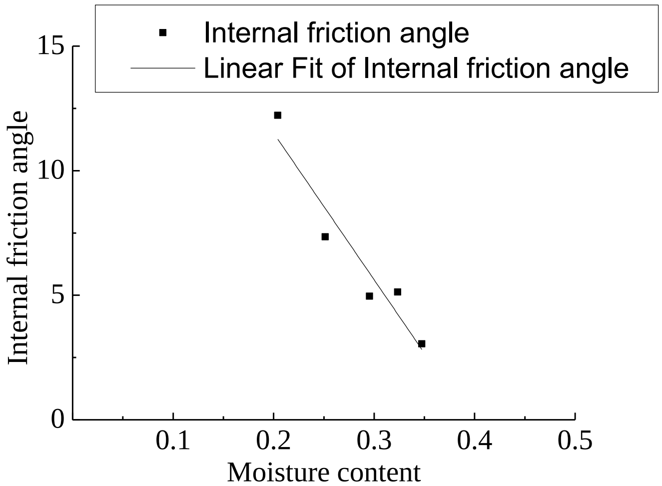

Figure 12 Relationship curve of moisture content and internal friction angle

3. Conclusion

Through the direct shear test of the red layer soft rock and by analyzing the experimental data, the following conclusions can be obtained:

In this area, the cohesive strength of the red layer soft rock decreases with the increase of moisture content, and the decreasing function can be expressed as: $y_1 = -204.5628x_1 + 74.8916$; which y_1 indicates the cohesion c (kPa); x_1 indicates the moisture content(%).And it can be concluded that when the moisture content is close to zero, the cohesive force is about 75kPa.

In this area, the internal friction angle of red layer soft rock decreases with the increase of moisture content, and the decreasing function can be expressed as: $y_2 = -58.875x_2 + 23.283$;which y_2 indicates the internal friction angle φ (degree); x_2 indicates the moisture content(%).When the moisture content is close to zero, the internal friction angle is about 23.3 degrees.

The stability of red soil slope is very sensitive to the change of moisture content, the cohesion and internal friction angle are increased with the decrease of the moisture content in the red layer soft rock, as well as the shear strength of the red layer soft rock. Conversely, when the moisture content increases, because of the mineral composition of the red soil layer generally contains more hydrophilic clay mineral, so the small change of the soil moisture content may decrease the shear strength of the soil. we should pay attention to the stability of slope in red bed area during rainfall and ought to do protective measures.

Because of the red layer soft rock out of the parent, and the actual engineering environment is different, sampling and transporting as well as some inevitably errors during the test operation , the results obtained will be some deviation. In addition to the moisture content, the factors that affect the stability of the soft rock in the red beds are very complicated, in practical engineering, we should do the appropriate prevention and control measures according to the actual situation.

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