# Experimental Study on the Influencing Factors of the Shear Strength Parameters of Red Mudstone

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## Abstract

**In order to explore what kind of influence the moisture content and particle diameter have on the shear strength of red mudstone. In this paper, we have an indoor unconsolidated undrained quick shear test on the red mudstone under different condition, and then, have a statistical analysis on the data obtained from the test. Through this test, we find that the moisture content has a linear effect on the shear strength and the influence of the particle diameter is optimal, which provides a reference for the practical stability analysis of projects.**

## Keywords

**Red mudstone, direct shear test, influencing factors.**

## 1. Introduction

The shear strength is a very important ability of rock mass, and it is the main mechanics index for the evaluation of the stability and the bearing capacity of the architectural foundation. In engineering practice, this kind of mechanical parameter is needed during the design of subgrade, side slope, building foundation and so on. As a kind of extreme soft rock, Red mudstone is sensitive to water, when encountering water or exposed in the air, it is easily weathered to damage. At present, red mudstone is widely used as bearing layer in various buildings and structures, so it is necessary for us to have a research on the shear strength of red mudstone.

There are many factors that affect the shear strength of soil, except for its external condition, its internal condition is the main factor that affect the shear strength of the soil. In order to explore how much influence the moisture content and particle diameter have on the shear strength of red bed mudstone, a unconsolidated undrained quick sheer test on the red bed mudstone with different particle diameters is done under different moisture content.Through the analysis of the test data, we find that the effect of the moisture content and particle diameter on the compressive strength of red mudstone have an important meaning for the guidance of the engineering design and construction.

## 2. test principles and procedures

### 2.1 Test principles

Direct shear test is a common method to measure the shear strength of soil, and its theoretical basis is the strength theory of Coulomb. Through applying different normal pressure and shear stress respectively on the predetermined shear plane to shear samples, we can measure the value of the shear stress and the shear strength directly. Then, to determine the shear strength parameters, C and φ of the soil according to the Coulomb's law. There are two formulas according to the types of rock:

Sand $$\tau_f = \sigma \cdot \tan\emptyset \quad (1)$$

Cohesive soil $$\tau_f = \sigma \cdot \tan\emptyset + c \quad (2)$$

Form in:

$\tau_f$—The shear strength of soil(kPa);

σ—The normal stress on the sliding plane of the shear（kPa）;

c—The cohesion of soil(kPa）;

Ø—The internal friction angle of soil(°).

Red mudstone, which belongs to cohesive soil, is an extreme soft rock.so we should use formula (2).

## 2.2 Test Procedure

### 2.2.1 Sample Preparation

The specimen of the experiment is from a foundation pit in Sichuan, and belongs to strong weathered red soft stone, the main ingredients of it are siltstone, fine sandstone, medium sandstone, coarse sandstone, and sandy mudstone. First, pack the red rock block in a plastic wrap to the laboratory to carry out the following operations:

Figure.1 The samples of red mudstone

After soil samples are sent back to the laboratory, crush the rocks with a hammer, In order to see clearly how the particle diameter affect the shear strength of red mudstone, it is better to use Soil analysis sieves with apertures respectively less than 0.63 mm, 0.65 mm to 1.25 mm and 1.25 mm to 2.5 mm to screen the crushed red mudstone, and then mark the samples.For samples with different particle diameters, using the alcohol lamp burning method to mix them with water so that the rates of their water content are 15%, 20%, 23%, 25% respectively.

### 2.2.2 Fast Shear Test

Specimen Preparation: use standard ring knife to sample the ready-made specimens;

Instrument Installation: install stopwatch at the center of the pressuring frame.

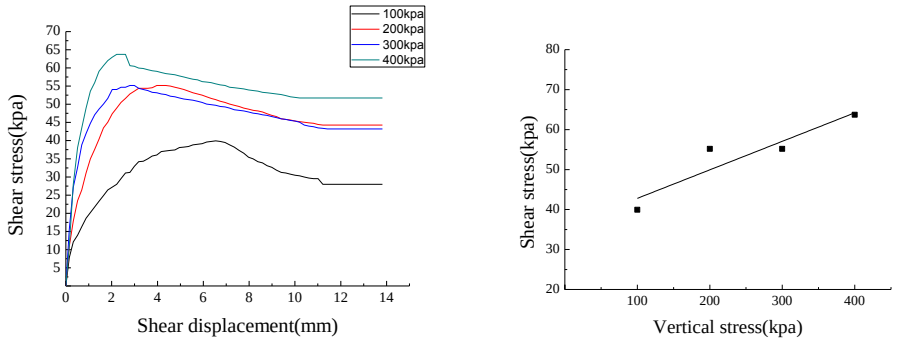
The installation and Shear of the Samples: after sampling, put the samples into strain controlled direct shear apparatus quickly, each samples are respectively under the pressure 100KP, 200kp, 300kp and 400kp.Then, apply horizontal shear stress on the shear plane so that the value of the shear stress and the shear displacement can be got when the samples are broken , and then determine the soil shear strength parameters $\varphi$ and $c$ according to the shearing law.

Data Statistics: Analyze the statistics, and then, according to the relation curves of shear stress and shear displacement, shear strength and the vertical stress, inner friction angle $c$ and cohesion $\varphi$ of the different particle diameters under the state of different water content can be obtained.

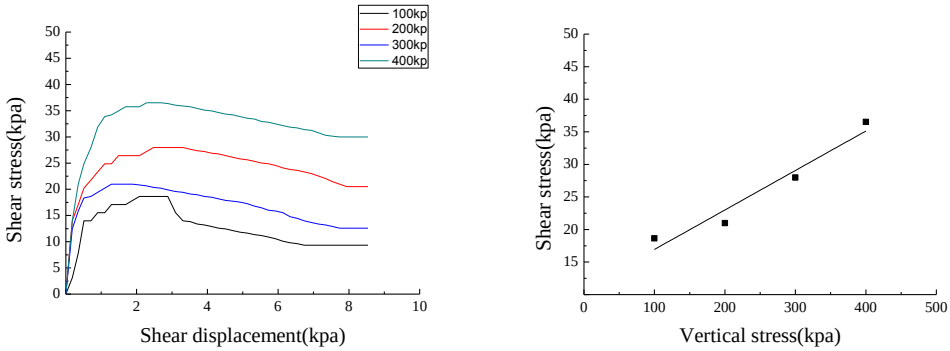
Figure.2 test procedure

### 2.3 Data Statistics

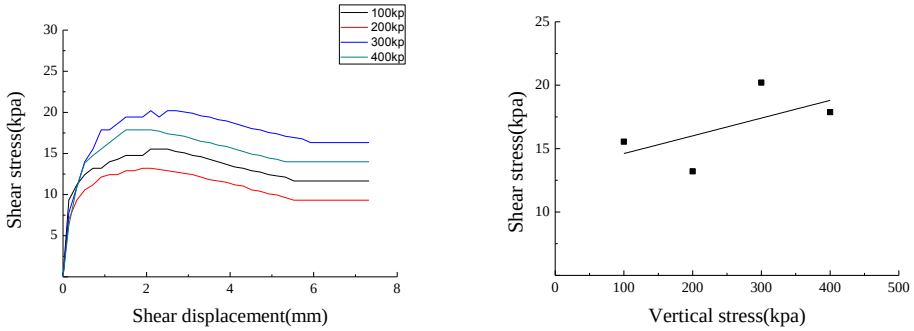
Analyze the statistics, meanwhile, according to the relation curves of shear stress and shear displacement, shear strength and the vertical stress, inner friction angle and cohesion of the different particle diameters under the state of different water content can be obtained. Here take the sample with its particle diameter less than 0.63mm as an example, we can get the figure 3:



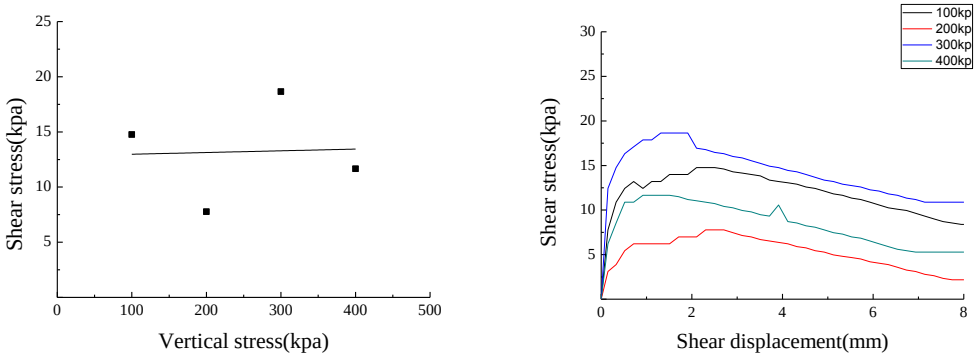

(a) water content15%




(b) water content20%




(c) water content23%




(d) water content25%

Fig. 3 samples with particle diameter less than 0.63mm

According to figure 3, we can get that when red mudstones with particle diameter less than 0.63mm and the moisture content is15%, the cohesion is 35.61kpa and the internal friction angle is 4.06. Similarly, when the moisture contents are 20%, 23% and 25%, their cohesions are 10.88kpa, 13.21kpa, 12.82kpa, ,and internal friction angles are 3.43, 0.8, 0.1. From the figure we can also clearly see the moisture content has a great influence on the red mudstone, and the samples with their particle diameter less than 0.65mm have no shear strength when the moisture content is more than 23%.That is to say, under this circumstance, the red mudstones are destructed.

According to the above method, we can get the cohesion and the internal friction angle of the samples with its particle diameter are between 0.63mm ~ 1.25mm and 2.5mm ~ 1.25mm,and then fill the following Table 1 with data we have got.

Table 1 shear strength indexes of samples under different conditions

| Particle size (mm) | moisture content (%) | cohesion c(kPa) | internal friction angle(°) |
|---|---|---|---|
| <0.63 | 15 | 35.61 | 4.06 |
| | 20 | 10.88 | 3.43 |
| | 23 | 13.21 | 0.8 |
| | 25 | 12.82 | 0.1 |
| 0.63to1.25 | 15 | 37.30 | 12.22 |
| | 20 | 19.04 | 7.34 |
| | 23 | 11.19 | 4.96 |
| | 25 | 8.68 | 5.13 |
| 1.25 to 2.5 | 15 | 34.58 | 8.64 |
| | 20 | 20.2 | 3.89 |
| | 23 | 9.32 | 2.52 |
| | 25 | 4.66 | 3.32 |

From table 1, we can find that red mudstone can be easy to be destructed when encountering water. Generally, the cohesion and the internal friction angle of red mudstone would decrease as the increa se of the moisture content ;the particle diameter of red mudstone also has certain effect on the resist ance strength index ,when moisture content is the same, samples with different particle diameter wo uld have different values of cohesion and internal friction angle ; the smaller the particle diameter i s , the greater influence the water content will have on the friction angle, while it is opposite for co hesion.

Through the statistics and analysis of the test data, we can find that the water content and particle diameter have a large impact on the shear strength of red mudstone, and the moisture content has a linear effect on the shear strength index of red mudstone. At the same time,we can also see that the effect of particle diameter on the shear strength of red mudstone is optimal. That is;no matter how much the moisture content is, the shear strength index is the biggest when the particle diameter is between 0.63mm ~ 1.25 mm.

In summary, in the engineering practice, to improve the shear strength of red mudstone, in addition to considering the change of water content, the diameter of the red mudstone particles should be considered as an important factor.

## 3. Conclusion

Through carrying out indoor direct shear test on red mudstone samples of different states, counting and analysing the test data, the following conclusions are obtained:

water content and particle diameter have an large impact on the shear strength of red mudstone, the moisture content has a linear effect on the shear strength and the influence of the particle diameter on the hear strength index is optimal.

In red mudstone area, the effects of moisture content and particle diameter on the shear strength of the rock mass need to be considered when we carry on engineering design,and during the construction,

except for controling the changes of the water, we also need to reduce the outside disturbances to the soil.

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