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## Study on the shear resistance of basalt fiber to mantle

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# Study on the shear resistance of basalt fiber to mantle

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**Abstract:** Xia-shu soil, which is a kind of wind-dust sedimentary soil in China, mainly distributed in the middle and lower reaches of the Yangtze River in China. Zhenjiang is a city with frequent landslide hazards. In order to improve the stability of the Xia-shu soil slope of Zhenjiang area, the idea of using basalt fiber to improve the Xia-shu soil is proposed to enhance the shear performance of the Xia-shu soil. In the test scheme, 0.1%~0.6% basalt fiber was blended into the Xia-shu soil, and the modified Xia-shu soil was subjected to direct shear test to obtain the shear strength of the Xia-shu soil, and then the cohesive force of the Xia-shu soil was obtained. Furthermore, the relationship between the cohesive force  $c$  and the internal friction angle  $\phi$  of the Xia-shu soil and the basalt fiber content is obtained. The results show that with the increase of basalt fiber content in the Xia-shu soil, the cohesive force  $c$  of the Xia-shu soil is obviously improved, and the internal friction angle remains basically unchanged.

## 1. Introduction

The thickness of the Xia-shu soil slope reaches several meters to even tens of meters. Under natural conditions, the Xia-shu soil has high shear strength and good stability. However, the Xia-shu soil is susceptible to climate change, resulting in a decrease in the shear strength of the soil and poor slope stability<sup>[2]</sup>. The existing improvement method basically strengthens and sets the retaining wall on the surface of the Xia-shu soil slope, and does not fundamentally solve the related problems. Basalt fiber is a new type of inorganic environmentally-friendly green high-performance fiber material with excellent performance of high strength, corrosion resistance and high temperature resistance. Incorporation into the clods has a good effect on the integrity, tensile properties and shear resistance of the clods<sup>[3]</sup>.

There are a lot of micro-slits inside the Xia-shu soil. Due to the existence of these gaps, rainwater will enter these micro-slits, which will result in greatly reduced mechanical properties of the Xia-shu soil, especially the shear strength of the Xia-shu soil. The shear resistance of bauxite reinforced by basalt fiber is to incorporate discontinuous basalt fiber into the Xia-shu soil to form a new type of clay material. Basalt fiber is a typical silicate fiber with natural compatibility, compatible with inorganic binders, and moisture absorption rate of less than 1%, ensuring its stability and environmental coordination during use. The cohesive force and friction between basalt fiber and Xia-shu soil and the excellent mechanical properties of basalt fiber itself are the fundamental reasons for the improvement of basalt fiber.

For the above reasons, the idea of using basalt fiber to improve the shear resistance of the Xia-shu soil has emerged.



## 2. Experimental instruments、 sample preparation、 experimental protocol

### 2.1. Experimental instruments

The experimental instrument used a strain-controlled direct shear (Fig. 1).



Fig. 1 Strain control straight shear

The instrument is suitable for determining the shear strength parameters  $c$  and  $\phi$  of fine-grained soil. The relevant parameters of the instrument include the test piece area:  $30\text{cm}^2 \times 2\text{cm}$ , rod ratio: 1:20, vertical graded loading: 50, 100, 200, 300, 400kPa, shear rate: 0.001-2.4mm/min. The basic principle of the experiment is to apply different shearing forces to the test piece and then apply shearing force to the test piece until the damage is applied, and directly measure the shear strength on the sheared surface.

### 2.2. Sample preparation

The Xia-shu soil is taken from the slope of a slope of Nanxu Avenue in Zhenjiang City (Fig. 2). Before the preparation of the sample, the original soil sample was taken for moisture content measurement, and the natural moisture content was measured to be 4.47%.



Fig. 2 Mining site

First, the Xia-shu soil is manually crushed, and the particle size of the crushed soil can be passed through a square hole sieve having a diameter of 2 mm, and stored in a dry crisper for use. Secondly, the proper amount of pure water is added to the Xia-shu soil, so that the moisture content of the loess soil reaches 15%, and the loess soil is in a good shear state <sup>[4]</sup>. According to the design scheme, the Xia-shu soil and basalt fiber are weighed, and in order to ensure the uniformity of the sample, the basalt fiber with a length of 2 cm is uniformly used. Finally, the prepared soil sample is compacted in a ring cutter.

### 2.3. Experimental protocol

In order to study the change of shear capacity of the Xia-shu soil under different basalt fiber content, the basalt fiber content in the designed loam is 0%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%; The Xia-shu soil of different basalts fiber content was subjected to rapid shear test at vertical stresses of 50kpa, 100kpa, 200kpa, 300kpa and 400kpa. Record the relevant data, draw a chart, and get the Coulomb shear strength formula:

$$\tau_f = c + \sigma \tan \phi.$$

In the formula  $\tau_f$  is the shear strength;  $\sigma$  is the normal pressure on the shear failure surface;  $\varphi$  is the internal friction angle of the sand.

### 3. Shear strength of Xia-shu soil with different basalt fiber content

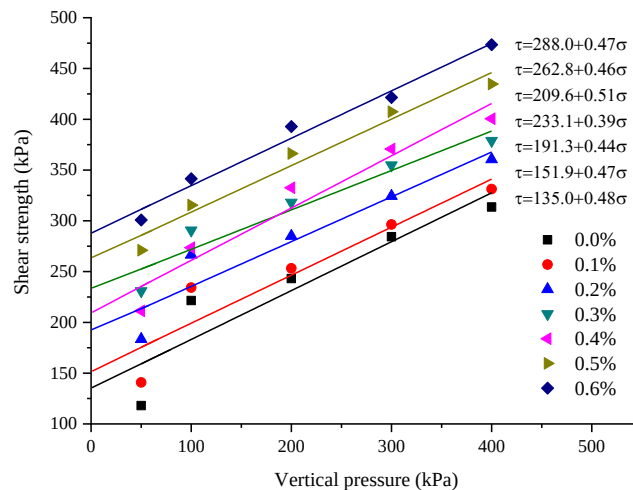


Fig. 3 Barium strength map of different basalt fiber content

In the process of changing the basalt fiber content from 0% to 0.6%, the shear strength of the Xia-shu soil has been in a growing process. When the vertical pressure is 50Mpa, the shear capacity of the lower abundance increases with the increase of the basalt fiber content, but the growth rate is large and uneven. When the vertical pressure is 100Mpa, 200Mpa, 300Mpa, the shear resistance of Xia-shu soil has not changed with the increase of basalt fiber content, but the degree of growth has slightly slowed down, and the growth rate has become more uniform. When the vertical pressure is 400Mpa and the basalt fiber content of the Xia-shu soil is small, the shear strength of the Xia-shu soil increases little, but when the basalt fiber content reaches 0.3%, the shear strength of the Xia-shu soil increases significantly.

### 4. Experimental data chart analysis

#### 4.1. Analysis of relationship between basalt fiber content and cohesive force $c$ of mandible

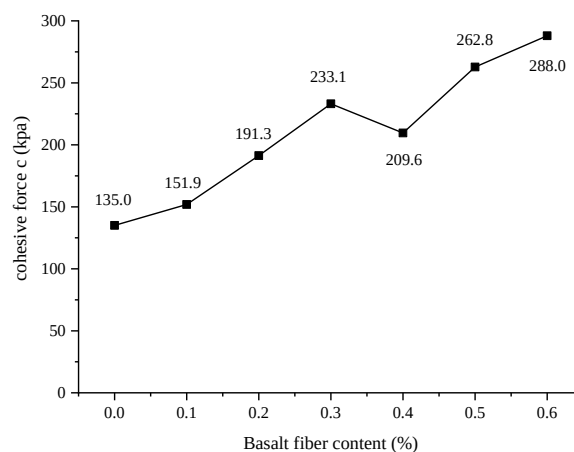


Fig. 4 Relationship between basalt fiber content and cohesive force of mantle

It can be seen from Fig. 4 that with the increase of basalt fiber content, the cohesive force of the Xia-shu soil is generally increasing, and there is a tendency to continue to grow. When the basalt fiber content is between 0% and 0.3%, the cohesive force of the Xia-shu soil increases rapidly, but when the basalt fiber content is between 0.3% and 0.6%, the growth rate is slower. The Xia-shu soil is expansive soil, when sheared, due to the frictional resistance between the basalt fiber and the mantle, the basalt fiber can still withstand partial stress after the test piece is sheared and deformed [5]. When the basalt fiber content is 0.4%, the cohesive force of the Xia-shu soil decreases. By observing the test piece with the basalt content of 0.4%, it is found that there are few basalt fibers on the shear plane of the test piece due to the basalt fiber. The shape in the Xia-shu soil and the shear stress of the lower bauxite are inconsistent, which leads to the material advantage of the basalt fiber itself when the test piece is sheared. Therefore, this point should be the accidental error of the experiment, so it can be ignored.

#### 4.2. Analysis of the relationship between the content of basalt fiber and the internal friction angle $\phi$ of the lower soil

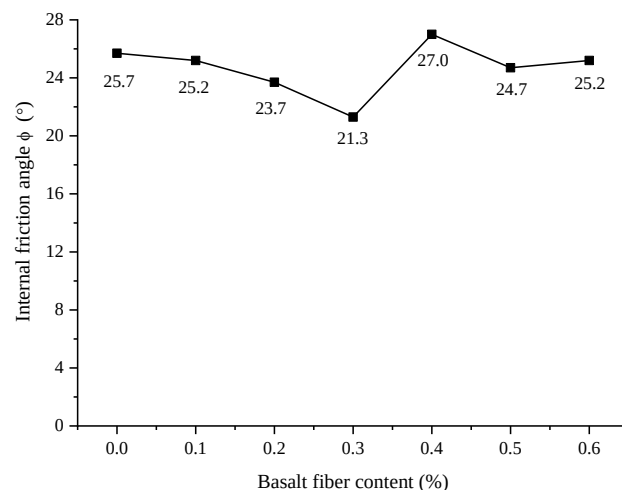


Fig. 5 Relationship between the content of basalt fiber and the internal friction angle  $\phi$  of the lower loess

It can be seen from Fig. 5 that as the basalt fiber content increases, the internal friction angle  $\phi$  of the Xia-shu soil is substantially unchanged. When the initial basalt fiber content is very small, the variation of the curve  $\phi$  is slightly decreased first. When the basalt fiber content increases continuously, the curve rises steadily, but the increase is small, which can be almost negligible. Through the improved basalt fiber, the principle of enhancing the shear resistance is the frictional resistance between the basalt fiber and the soil, and does not change the physical properties of the rammed earth mass itself. Basalt fiber is similar to a small grid. It is divided into several units inside the soil, which limits the deformation of the soil and enhances the shear resistance of the lower soil.

## 5. Conclusion

In the direct shearing experiment, the shearing instrument has the advantages of simple structure and convenient operation, and is capable of quickly measuring the shear strength of the test block, but is limited to factors such as drainage conditions, concentrated stress, and small shear fracture area. The effect is that the shearing result is deviated from the actual. However, as long as the specification is implemented, relatively correct data can be obtained in a short period of time, so a direct cut scheme is still preferable.

In the data obtained after shearing all the test pieces, it can be seen that when the basalt fiber blending amount reaches 0.6%, the shear strength value of the Xia-shu soil test block can be doubled

when it is not incorporated. Due to the limited scope of the study, the test block used in the experiment was 0.1%~0.6%, and the relationship between the complete basalt fiber content and the shear strength of the Xia-shu soil could not be obtained. According to the current research, as the basalt fiber continues to increase, the shear strength of the Xia-shu soil will continue to increase, and the shear capacity of the Xia-shu soil will be maximized at a later dosage. Based on our research, it is recommended to incorporate basalt fiber from 0.5% to 0.8% in the lower loam to improve the shear resistance of the loess.

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