Analysis on Foamed Cement Banking Mechanical Property Affected by Age

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Abstract

In order to study the shear strength of foamed cement banking at the different age, the mechanical properties of foamed cement banking were studied in this paper. The following conclusions are drawn through a large number of triaxial test with UU. At the same age, the curve shape with the increase of confining pressure is from softening to hardening. At the same confining pressure, with the increase of the age, the peak of the failure increases gradually, and the curve shape is from hardening to softening. The residual strength of the specimen after failure is not much volatility.When the unit weight is determined, with the increase of the age,the cohesion force and the internal friction angle are increased. It provides theoretical basis for practical engineering application and structure design.

Keywords

Foamed Cement Banking; Triaxial Test; Age; Shear Strength; Stress Strain Curves.

1. Introduction

With the rapid development of China's economy, the highway construction has been developed vigorously. But it found that some of the technical problem was not solved, such as highway bridgehead vehicle jump, the slope stability of road. With the development of new materials and related technology, the foamed cement banking technology has obtained development and application in domestic. It adds curing agent, water and foamer to the soil according to the certain proportion, and forms a new type of fill after fully mixing and stirring.

The foamed cement banking has launched research and application at home and abroad. Canlin Zhang studied the influence of different soil content on the fluidity and compressive strength of the foamed cement banking [1]. Yuli Cui,Kwang-Suek Oh studied the effect of temperature on the performance of foamed concrete [2, 3]. Wang Liyan analysed the stress and strain characteristics, the failure mode and the shear strength of the mixed soil in the different amount of slag and the age [4]. Yoon Gil-Lim, Jinmei Dong studied the stress and strain characteristics of the polystyrene light soil [5, 6]. Zhaoyu Wang et al. analysed different rubber content and consolidation pressure on the influence of the stress-strain relationship and the stress mechanism of lightweight soil [7].

As a new type of geotechnical materials,the triaxial test of the foamed cement banking is beneficial to understand the mechanical response of the soil under the complex stress state. The paper studied the stress-strain characteristics and the deformation , failure mechanism by means of triaxial test in different age.

2. Triaxial Test

2.1 Test Materials

Cement hardener: PO42.5 ordinary Portland cement; Foaming agent: KC-30 cement foaming agent; Raw soil: over wet soil from ya 'an area, the screening test shows that the soil category is the silty soil, the particle size distribution is shown in figure 1 and the physical and mechanical parameters are shown in table 1; Water:tap water.

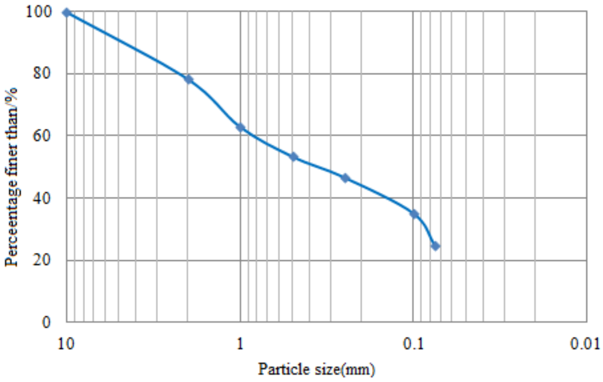


Fig.1 Grade curves of different coarse-grain contents

Table 1. The physical and mechanical parameters

sample	plastic index	CBR2.5 /%	swell capacity /%	frictional angle / °	cohesion /kPa	dry density /g•cm-3
silty soil	15.6	0.76	4.31	13.3	7.0	1.31

2.2 Protocol

The ratio of the silty soil to the weight of the mixture (the sum of the weight of silty soil and cement) is called the silt content. The proportion of silty soil and cement is 1:1, which the content of silty is 50%.Water content is the ratio of the water to the mixture, which is 50%. Foamer content is the ratio of the weight of the foamer to the mixture, which is 2%, 3%.The change rule of the shear strength is studied under different age, and the test scheme is shown in Table 2. After a lot of experiments, when the foamer content is constant, the same age, the change of the sample density is not obvious. According to the measuring accuracy of the test equipment,three sets of confining pressure are set up, which is 0.1MPa, 0.2MPa, 0.4MPa. The strain rate of the selected UU test was 0.8mm/min. During the experiment, the axial pressure applied on the sample, it records data when the height of each sample is reduced by 0.2% (0.16mm) until the reading is stable, a sharp decline or vertical strain reached the height of samples 20%.

Table 2. Protocol

number	silt content /%	water content /%	foamer content /%
A1	50	50	2
A2	50	50	3

2.3 Sample Preparation and Maintenance

According to the experimental design formula, the raw materials are taken from each experiment, and cement and silty soil (dry to constant weight and sieve particle size less than 5mm) is added to the cement mortar mixer for mixing.Then the foamer diluted by water through air compressor to form bubbles is added into the mixture, and the foaming mixture is added into mould (diameter 39.1mm, height 80mm cylinder), after stripping, film sealing,curing at room temperature to 3d, 14d, 28d age for performance testing.

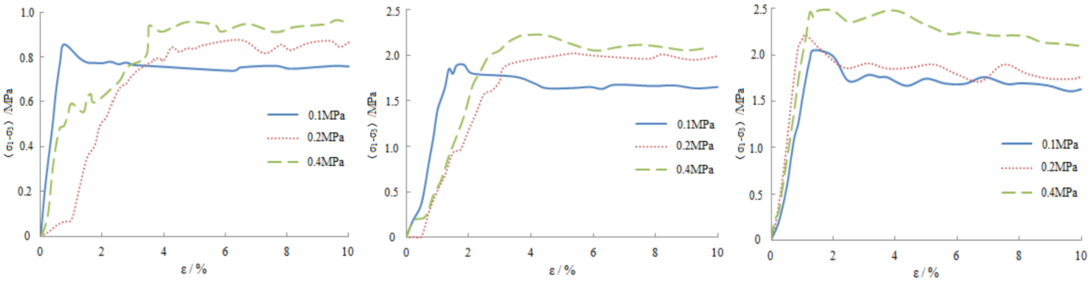
2.4 Performance Test Method

Triaxial test is a perfect test method for determining the shear strength of soil.Triaxial test is based on Moore-coulomb strength theory and the shear strength test of three axial compression is designed. 3~4 cylindrical specimens are usually used to measure the shear strength of soil under different confining pressures, and the shear strength parameters of the soil are determined by using Mohr-coulomb failure criteria. In this paper, the experiment was made by using the unconsolidated and undrained triaxial shear (UU) test.

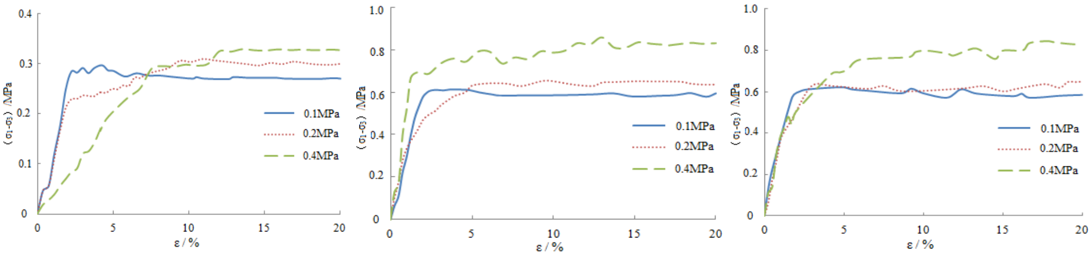
3. Unconsolidated and Undrained Triaxial Shear Test and Result Analysis

3.1 The Stress-strain Characteristics of Foamed Cement Banking

The stress-strain curves of specimens under different age are drawn, as shown in Figure 2.



a. stress-strain curves（A1,3d）b. stress-strain curves（A1,14d）c. stress-strain curves（A1,28d）



a. stress-strain curves（A2,3d）b. stress-strain curves（A2,14d）c. stress-strain curves（A2,28d）

Fig. 2 stress-strain curves of specimens under different age

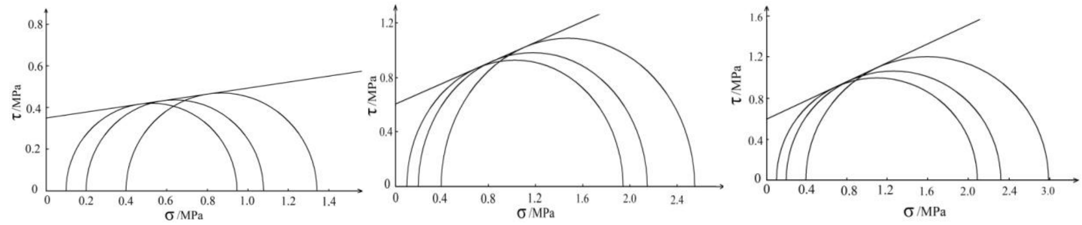
From figure 2 (a~c): stress-strain curves are nonlinear. At the same age, the curve shape with the increase of confining pressure is from softening to hardening, and the strength increases continuously. At the same confining pressure, with the increase of the age, the peak of the failure increases gradually, and the curve shape is from hardening to softening. But when the age reached 14d, the strength increased slowly, and the residual strength of the specimen after failure is not much volatility.

At the same age, with the increase of confining pressure, the change of the curve in the elastic stage is not obvious, which the change of the initial elastic modulus change little. The peak shear strength increases with the increase of confining pressure. Because when the confining pressure increases, the relative density of the sample increases, the occlusal and shear deformation ability of the particles are enhanced, so that the larger the stress is, the higher the shear strength is. The foamed cement banking is composed of soil particles, cement and foamer, and its mechanical properties are determined by the cohesion (cementing force) and the friction bite force between the soil particles and cement. Under the same confining pressure, with the increase of the age, the aggregate reaction is more adequate, so the cohesive force and the friction force increase between the particles. The macroscopic expression is that its elastic properties are strengthened, and the ability to resist shear deformation is enhanced.

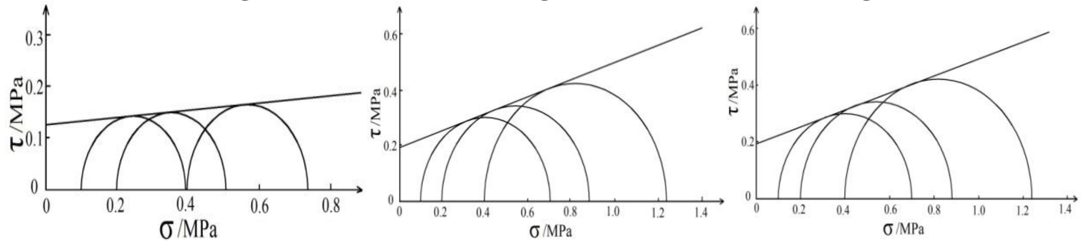
The deformation and failure of the foamed cement banking is mainly determined by its internal skeleton structure and the elastic deformation of the cement soil. The foamed cement banking occurred the plastic failure after the elastic-plastic deformation, it is completely elastic-plastic deformation, the stress-strain curve is almost a straight line at plastic deformation stage, and the samples occur simple compaction deformation, resulting in destruction of soil. The deformation and failure mechanism of samples is under the extrusion of major principal stress, the samples have large axial deformation and cause lateral deformation at the same time. So the transverse tension effect in a neutral surface of soil samples is generated so that form vertical or larger longitudinal angle fracture,which ultimately leads to soil destruction.

3.2 The Shear Strength Analysis of Foamed Cement Banking

According to the stress-strain curve, the principal stress difference is selected as the failure point. If there is no peak, the dense point of the stress path or the principal stress difference（σ1-σ3）according to a certain axial strain (generally ε=15%, according to the actual situation after the proof) is as the value of the failure intensity. On the plane drawing Mohr stress circle, the common tangent of stress circle is drawn under different confining pressure.The common tangent is the shear strength envelope as the Mohr failure stress circle.



a. A1 age 3d b. A1 age 14d c. A1 age 28d



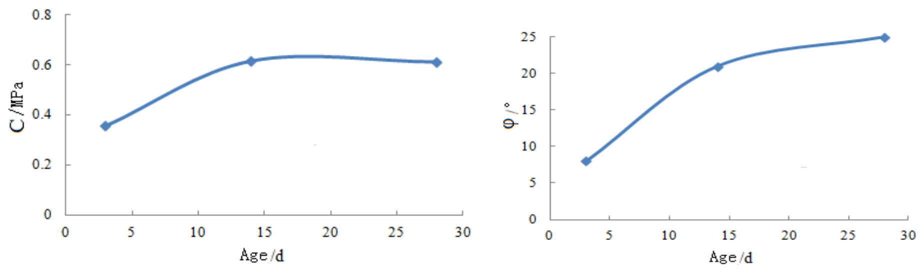
a. A2 age 3d b. A2 age 14d c. A2 age 28d

Fig. 3 Stress circle and strength envelope in different age

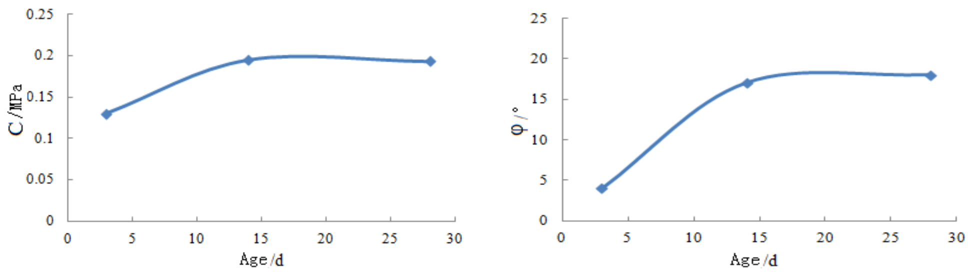
From figure 3 (a~c): The trend of Mohr's circle common tangent is increased with the increase of stress. So foamed cement banking is accorded with Mohr-Culomb failure criterion, and the linear regression can be used by $\tau=\sigma\tan\varphi+c$. By fitting the test results in different age, the shear strength envelope of the three different age was obtained. The angle of envelope is internal friction angle (φ) and the intercept on the vertical axis is cohesion (c). The shear strength index of foamed cement banking was obtained after calculating (see table 3).

Table 3. The relationship between age and shear strength indexes

number	unit weight /g•cm$_{-3}$	age/d	cohesion / MPa	internal friction angle / °
	10.4	3	0.356	8
A1	9.6	14	0.613	21
	9.5	28	0.617	24
	8.2	3	0.130	4
A2	7.4	14	0.193	17
	7.2	28	0.195	17



a. A1 relation curve charts b. A1 relation curve charts



a. A2 relation curve charts b. A2 relation curve charts

Fig. 4 the relation curve charts between age and shear strength indexes (c, φ)

The experimental data coming from table 3 are plotted the relation curve charts (between age and shear strength indexes) shown in Figure 4. From figure 4: When the unit weight is determined, with the increase of the age, the cohesion force and the internal friction angle are increased. But after the age reached 14d, the friction angle and internal friction angle increase slowly.

4. Conclusion

In order to study the shear strength of foamed cement banking at the different age,the mechanical properties were studied in this paper.The following conclusions are drawn through a large number of triaxial test with UU.

(1) At the same age, the curve shape with the increase of confining pressure is from softening to hardening, and the strength increases continuously. At the same confining pressure, with the increase of the age, the peak of the failure increases gradually, and the curve shape is from hardening to softening. But when the age reached 14d, the strength increased slowly, and the residual strength of the specimen after failure is not much volatility.

(2) The deformation and failure of the foamed cement banking is mainly determined by its internal skeleton structure and the elastic deformation of the cement soil.The foamed cement banking occurred the plastic failure after the elastic-plastic deformation, it is completely elastic-plastic deformation,the stress-strain curve is almost a straight line at plastic deformation stage.

(3) When the unit weight is determined, with the increase of the age, the cohesion force and the internal friction angle are increased. But after the age reached 14d, the friction angle and internal friction angle increase slowly.

Acknowledgements

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