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Research Article

Study on the Shearing Strength of Agricultural Food Lightweight Soil by Triaxial Compression Test

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Abstract: In this study, samples of agricultural food lightweight soil were made to do the laboratory test to obtain the shearing strength parameters. Based on the triaxial compression test, the relation between stress and strain and the shearing strength parameters of the agricultural light-weight soil were studied. It shows that the relationship between the stress and strain of agricultural food lightweight soil has the features of nonlinear and hardening. The shearing strength parameters of this material were obtained in this study, besides, it is found that the cohesive force increases but the trend for the increment of internal friction angle is not obvious with the increment of cement content.

Keywords: Agricultural food lightweight soil, shearing strength parameter, stress and strain, triaxial test

INTRODUCTION

Agricultural light-weight soil is made by adding the waste foamed polystyrene, curing agent and water. The current research on its engineering properties of this material is not enough. Because the mechanics properties of this are very complicated, therefore, in order to make this technology to be widely used. Because the raw soil, food lightweight materials and curing agent are different, so the difference for the mechanics nature of this mixed soil is very big. Besides, this kind of material is different from the original agricultural and mud solidified soil, the current research on its engineering properties of this materials is not enough. Therefore, in order to make this technology widely used, it is necessary to do more work on the physical and mechanical indexes of this material. As a new type of geotechnical material, it is very important to study the mechanical properties of this food lightweight soil. Yajima and Mydin (2006) studied the Mechanical properties of food lightweight soil, Kikuchi *et al*. (2008) studied the absorption property evaluation of light weight soil, Wong and Leo (2006) proposed a model to describe the constitutive relation. Feng (2014) studied the relationship between deformation modulus and its intensity of this material. Zhu *et al*. (2007) and Liu *et al*. (2005) have achieved the tests about influencing factors on the physico-mechanical properties of the light-weight material. The shearing strength parameters (cohesive force c and internal friction angle φ) are the important indexes to describe the physical and mechanical properties of this material. Based on the shearing strength parameters, the soil pressure of retaining wall and slope stability can be computed, so it is very important to decide reasonable shearing strength parameters for this material. In this study, samples of agricultural food lightweight soil were made to do the laboratory test to obtain the shearing strength parameters. Based on the triaxial test, the characteristics for the stress and strain under loading condition were researched and the shearing strength parameters of agricultural food lightweight were obtained, which can provide good basis for engineering practice for this material (Chen *et al*., 2002).

MATERIALS AND METHODS

The paper made the Cu test in Henan university of technology. The shearing strength parameters are the important indexes for soil, they are generally decided by direct shearing test and triaxial compression test. Though the direct shear test operation is simple, but it can't control the stress condition in the process of test. The triaxial compression test can control the drainage consolidation condition well and do not require fixing the shear plane of samples, besides, the stress condition and the pore water pressure of the samples are clear during the test. Therefore, in this study, the triaxial compression test was chose to study the changing law of stress and strain characteristics and decide the shearing strength parameters.

Table 1: Mixing ratios for the food lightweight soil in this test

		Cement		EPS		Water	
Number	Quality of agricultural (g)	Percetage (%)	Quality (g)	Percetage (%)	Quality (g)	Percetage (%)	Quality (g)
1	466	10	46.6	2	9.32	70	327
2	466	15	70.1	3	13.98	70	327
3	400	20	80	4	16	70	280

According to the related soil test method, the triaxial compression test contains Un-consolidated and Un-drained (UU) test, Consolidation and Un-drained (CU) test and Consolidation Drained (CD) test. For the UU test, it can describe the situation when the soil is broken by rapid load. Because the food lightweight soil material is usually used as the filling material and will not withstand rapid destruction, so the un-drained test is not needed.

For the CD test, because the volume deformation is measure by pore water discharge, but the volume deformation of the food lightweight soil not only contain the pore water discharge but also the deformation of EPS. The deformation is the main deformation part, but the common triaxial compression test can not measure the deformation of EPS. Besides, for the shearing process of CD test, it is very hard to make the pore water press keep zero and the measured relationship between stress and strain is not decided. Therefore, in this study, the CD test was not selected. For the CU test, it can simulate the situation when the consolidated food lightweight soil is broken by slow loading, so it satisfy the operating requirements of food lightweight soil, therefore, in this study, the CU test was selected to study the shearing strength of food lightweight soil. According to the test requirements, the pore water pressure dissipation by 95% was chose as the consolidation criteria.

The production and maintenance of samples: Because the food lightweight soil is an artificial material, the mechanics properties change with different mixing ratios. Therefore, in order to obtain the classic shearing strengths parameters, in this study, three groups of mixing ratios were chose to do the CU test (shown in the following Table 1).

For the common soil samples, they are produced by hierarchical compaction, because the particles will produce bigger volume deformation when the agricultural food lightweight is compacted, therefore, the production of samples should not be compacted. The process for the production of samples is as follows:

Stfor mixing food lightweight soil: According to the mixing rations, the water should be added to the raw agricultural first, then the water content of raw soil should be adjusted. The B10 type mixer is used to do the mixing, about 3 min later, then particles should be added to the homogeneous slurry. At last, the cement should be added and the machinery forced mixing blends for 5 min to make the cement paste even. For the mud mixture, the mud is filled within the pore of particles and the particles should be wrapped in mud.

Maintenance of samples: The Maintenance should be operated in the standard curing box, the curing temperature is (20 plus or minus 2°C), the humidity is 100%, the demoulding should be operated after 24 h curing, the samples should be maintained to the designing age. For the maintained samples, the quality and volume of them should be measured, the triaxial compression test should be operated after extraction saturated (2 h) and immersion (24 h). Forming of food lightweight soil The mixing soil was added to the three disc mould (the inner diameter is 3.91 cm and the height is 8.0 cm). A layer of vaseline should be wiped on the cutting ring inside to facilitate ejection before the charging. In order to eliminate the air bubbles of samples and make the samples compacted. The paste should be made by quality control and the layered vibrated forming method. Besides, the paste should be added into the mold by three layers.

The relationship between stress and strain of agricultural light-weight soil: During this Cu test, though the samples has been extracted and soaked to make them saturated, the saturation is very difficult to achieve 80% above. Because the cement hydrates is closed and there are closed air bubbles in the particles of mixed soil, so it is difficult to make the samples fully saturated. For the CU test, the pore water pressure during the test should increase evenly to ensure it meet the actual pore water pressure. In this test, the shear strain rate control is 0.08 mm/min and three levels of confining pressure is 100, 200, 300 and 400 kPa, respectively. Samples of different mixing ratios were chose to do the triaxial compression test, test results for the relation between principal stress difference and axial strain under different confining pressure are shown in the following Fig. 1 to 3.

According to the test results, the initial linear degree and the tangent slope of stress strain curve are falling. When the stain is smaller and the confining pressure is higher, the initial elastic modulus and principal stress difference is smaller. When the When the stain is bigger and the confining pressure is higher, the hardening trend increases with the increment of principal stress difference. Based on the CU test results, though the confining pressure is different, the changing tend for the principal stress difference and confining pressure is the same. For the samples of different cement content and density, when the confining pressure is more than 100 kPa, the curve of strain and

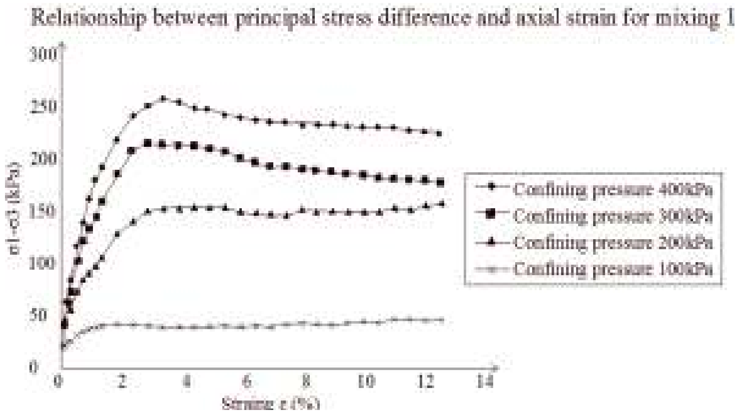

Fig. 1: Relation between principal stress difference and axial strain for mixing 1 (Cement percentage is 10%, content is 2%)

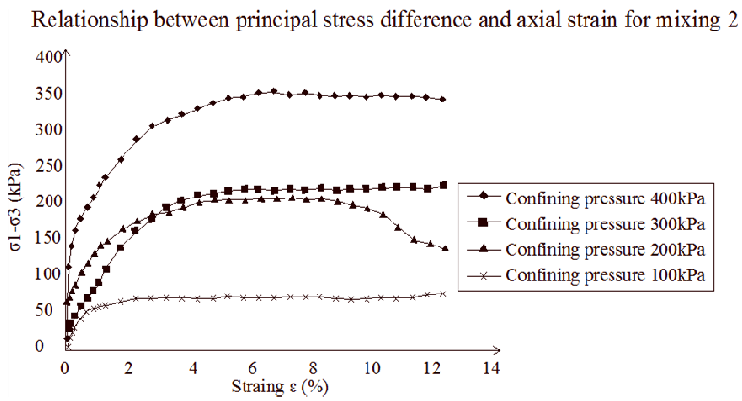

Fig. 2: Relation between principal stress difference and axial strain for mixing 2 (Cement percentage is 15%, content is 4%)

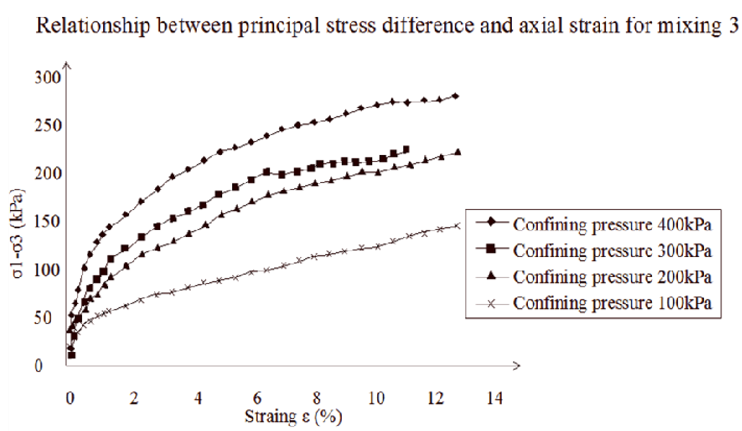

Fig. 3: Relation between principal stress difference and axial strain for mixing 3 (Cement percentage is 20%, content is 6%)

stress has the hardening characteristics. When the strain is bigger, the principal stress difference increasing with the increment of confining pressure and this tend above is obvious, so it can be assumed that the structure of the samples have been broken and enter the recompression dense phase under the effect of confining pressure, so it shows the tendency of intensity increment.

The representative test result for the relationship between stress and strain is shown in the following Fig. 4. The curve of stress and strain of agricultural food lightweight soil has the following features: First of all, Nonlinear characteristics. The initial phase for the relationship curve between the principal stress difference and axial strain is a straight line and the mixed soil is in the elastic state. When the stress reaches to the yield stress, the stress-strain relationship is nonlinear, it shows that food lightweight soil mixed haS plastic deformation. Therefore, the deformation relation shows that the mixing soil deformation has the nonlinear characteristics. Secondly, Hardening

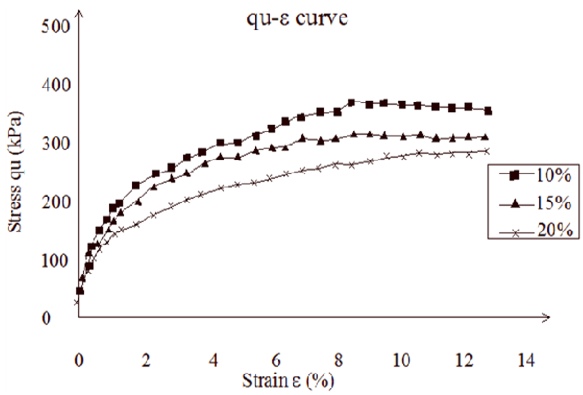

Fig. 4: Representative stress and strain of the samples

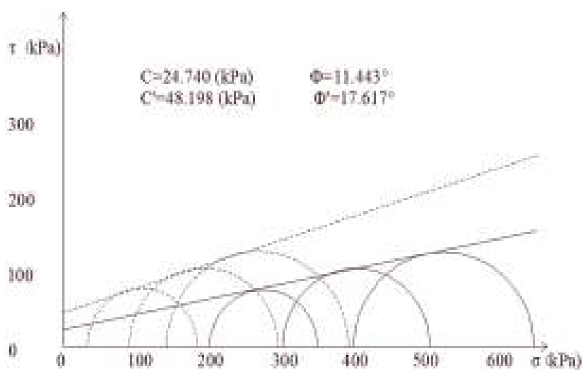

Fig. 5: Shearing strength envelope for samples of mixing 1

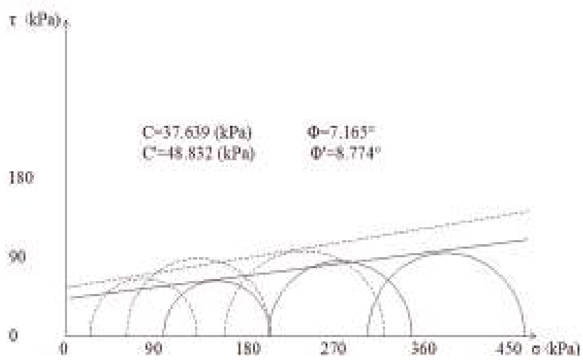

Fig. 6: Shearing strength envelope for samples of mixing 2

behavior. For the loading process, when the material deformation reach to the elastic-plastic phase, the stress increases with the increment of stress and the curve do not show obvious peak, the stress-strain relationship shows obvious hardening characteristics. Based on the analysis above, it shows that the total strain of agricultural food lightweight can be divided to the elastic strain increment and the plastic strain increment.

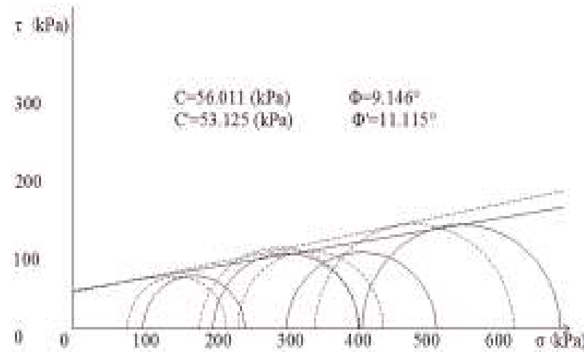

Fig. 7: Shearing strength envelope for samples of mixing 3

The shear failure forms of the samples is related with the mixing ratios. When the cement content is less than 10%, the samples are generally rupture and have obvious failure surface, it shows that the internal structure of the samples has already been damaged. When the cement content is higher (more than 20%), the deformation is mainly the plastic deformation and the samples are damaged in the form of drum-shaped. The damaged samples has obvious shear plane and a lot of fine cracks appeared on the surface of them. Based on the related theory of soil mechanics, the total stress is the sum of pore water pressure and effective stress. Based on the CU test, the shearing strength parameters of total stress (c, φ) and the shearing strength parameters of effective stress (c, φ) can be decided by the mohr circle and the shear strength envelope. The shearing strength envelopes of this test are shown in the following Fig. 5 to 7. According to the test results, all the envelopes can be fitted to a straight line and it satisfy the Mohr-Coulomb strength criterion. Then the shearing strength parameters obtained in this study are shown in the following Table 2.

RESULTS AND DISCUSSION

According to the test results, all the envelopes can be fitted to a straight line and it satisfy the Mohr-Coulomb strength criterion. The solid line is for the total stress Mohr circle and strength envelope and the dotted Mohr circle is for the effective stress and effective strength envelope. All the internal friction angle is positive value and the strength envelope is a rose line. It shows that φ is smaller than eφ and the c is smaller than c', which is similar to the common soil.

According to Table 2, for the shearing strength parameters of agricultural light-weight, with the increment of cement content, c and c' increases but the trend for the increment of φ and φ' is not obvious.

Table 2: Shearing strength parameters for the food lightweight soil

Number	Density ρ(g/cm^3)	Cement content (%)	Content (%)	C (kPa)	φ(°)	C'(kPa)	φ'(°)
1	0.986	10	2	24.7	11.4	48.2	17.6
2	0.883	15	4	37.6	7.2	48.8	8.8
3	0.848	20	6	56.0	9.1	53.1	11.1

CONCLUSION

Agricultural light-weight soil is made by adding the waste foamed polystyrene (EPS), curing agent and water. This artificial filling soil material can not only make the waste reused but also solve the traditional civil engineering problems such as large settlement, uneven settlement and poor stability (Deng *et al*., 2006). Therefore, this technology has great significance for the protection of ecological environment and cost reduction of the project. In this study, based on the triaxial test, the shearing strength of the agricultural light-weight soil were studied and the following conclusions were obtained:

- Though the confining pressure is different, the changing tend for the principal stress difference and confining pressure is the same. For the samples of different cement content, when the confining pressure is more than 100 kPa, the curve of strain and stress has the hardening characteristics
- The curve of stress and strain of agricultural food lightweight soil has features of nonlinear and hardening. The total strain of agricultural food lightweight can be divided to the elastic strain increment and plastic strain increment
- According to the test results, all the envelopes can be fitted to a straight line and it satisfy the Mohr-Coulomb strength criterion. For the shearing strength parameters of agricultural light-weight, with the increment of cement content, cohesive force increases but the trend for the increment of internal friction angle is not obvious.

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REFERENCES

Chen, Z.Y., J.X. Zhou and H.J. Wang, 2002. Soil Mechanics. Tsinghua University Press, Beijing, China.

Deng, F.H., H.H. Mo, Q.J. Zeng and X.J. Yang, 2006. Analysis of the dynamic response of a shield tunnel in soft soil under a Metro-Train vibrating load. J. China Univ., Mining Technol., 16(4): 509-513.

Feng, Y., 2014. Relationship of sludge mixed food lightweight soil deformation modulus and its intensity. EJGE, 19(3): 1861-1867.

Kikuchi, Y., T. Nagatome, H. Fukumoto and M. Higashijima, 2008. Absorption property evaluation of light weight soil with air foam under wet sand condition. J. Soc. Mater. Sci. Japan, 57(1): 56-59.

Liu, H.L., J.M. Dong, Y.D. Zhou, J.J. Wang and Y.F. Gao, 2005. Factors influencing on physico-mechanical properties of the light soil mixed polystyrene. Rock Soil Mech., 26(3): 445-449.

Wong, H. and C.J. Leo, 2006. A simple elastoplastic hardening constitutive model for EPS geofoam. Geotex. Geomembranes, 24(5): 299-310.

Yajima, J. and S.H. Mydin, 2006. Mechanical properties of the unsaturated foam composite light-weight soil. Proceeding of Unsaturated Soils, pp: 1639-1650.

Zhu, W., M.D. Li and J. Tang, 2007. Influencing factors on shear strength of dredged sediment and beads-mixed food lightweight soil. Highway, 2: 7-10.