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Experimental Study and Numerical Simulation Analysis of Geosynthetics Reinforced Bond Performance

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Abstract: The test of bond performance of civil composite reinforcement is usually carried out by consolidation drainage triaxial shear test, which involves three aspects: the stress, strength and volume change of cohesive soil. If we want to increase the volume stability of the high-pressure compaction soil, we need to increase the way of reinforcement, but through the way of reinforcement, the shear swelling body of the soil will be reduced, while the shear shrinkage body of the soil will not be reduced or increased. The test pieces used in the experiment are reinforced specimen and plain soil specimen. The biggest difference between them is the axial strain. When the axial strain is low, the reinforced specimen is lower than the strength of plain soil specimen, and the plain soil specimen is slowly higher than the reinforced specimen, which requires the axial strain to increase to a certain extent, which also has the phenomenon that the reinforcement delays the soil strength, which also depends on the number of reinforcement layers and tension of the reinforcement materials with the increase of modulus of elongation, the phenomenon of delay will be more obvious. The peak strength of the soil is controlled by changing the number of layers of reinforcement and the tensile modulus of reinforcement. It shows that with the increase of the number of layers of reinforcement, the peak strength of the soil is increased in a certain range, but once the peak value is exceeded, the peak strength of the soil will not be greatly changed by changing the number of layers of reinforcement, except through by changing the number of reinforcement layers, the residual strength of soil can be controlled by changing the reinforcement material of tensile modulus, so that the stress-strain characteristics of soil will be greatly changed.

Keywords: Geosynthetics; Bonding performance; Numerical simulation analysis

With the rapid development of science and technology, the quantity of national civil engineering has also made a qualitative leap. In order to enable civil engineering to be used for a long time, some reinforcement technologies are often used to strengthen the project. The reinforced soil of geosynthetics often uses backfill and reinforced materials. Among them, the interaction between reinforcement and soil for the strength and deformation characteristics of reinforced soil also occupies the main role.

1. Experimental Study of Geosynthetics Reinforced Bond Performance

1.1. Experimental Methods

The material selected in the experiment is red sandstone weathered soil with maroon yellow color. The

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reason for selecting this material is that it contains iron manganese oxide,[1] which makes this material have good compactness, compressibility and cohesiveness. On the other hand, this material contains muscovite and a small amount of fine sand with kaolin lumps. According to the previous practical operation, it can be known from the geotechnical test report that the number of particles of red sandstone weathered soil is more than half, and the particle size is controlled in the range of 2mm to 0.073mm. See **Table 1** and **Table 2** below for the specific morphological characteristics. From the tables, we can see from the classification characteristics that this soil is in the boundary between silt and silty clay. The powder content of the experimental materials in this experiment will increase with the passage of time, which will lead to the essential change of engineering. In the experiment, we mainly measure the physical characteristics of engineering experiments. The civil grid [2]used in the experiment is relatively easy to break the rubber film, and the mesh size of the civil grid is relatively large. The reliability of the experimental results of small size is relatively low. Therefore, the more flexible civil fabric[3] and geotextile are selected as reinforcement materials, and the mechanical properties are measured by tensile test.

Table 1. Particle Composition of Soil

Particle Size/mm	2~1	1~0.5	0.5~0.25	0.25~0.1
Particle Composition	8.5	9.2	14.1	25.7
Particle Size/mm	0.1~0.074	0.074~0.002	<0.002	
Particle Composition	16.7	23.7	2.1	

Table 2. Physical Property Index of Soil

Moisture Content/%	Density/g/cm^3	Specific Gravity of Soil Particles	Void Ratio	Saturation/%
27.9	1.84	2.71	0.88	86
Liquid Limit/%	Plastic Limit/%	Plasticity Index	Compression Coefficient under 100kPa~200kPa/(MPa)$^{-1}$	Compression Modulus
35.0	24.7	10.3	0.25	7.5

Table 3. Tensile Test Results of Reinforced Materials

	Thickness/mm	Tensile Strength/(KN/m)		Elongation/%		5% Elongation Tension/(KN/m)	
		Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Civil Fabric	2.3	22.2	22.8	25.6	28.7	10.3	7.8
Geotextile	0.8	5.76	6.42	75	81	< 0.4	< 0.4
		10% Elongation Tension/(KN/m)		Tensile Modulus/(KN/m)			
		Longitudinal	Transverse	Longitudinal	Transverse		
Civil Fabric		14.43	11.82	162.8	147.8		
Geotextile		< 0.4	< 0.4	6.9	7.3		

In the experiment, when the water in the void of unsaturated soil is stretched and the sample is on the permeable stone, the water absorption in the permeable stone will increase. In order to avoid this phenomenon in the experiment, we often bake the permeable stone on the electric furnace, so that the sample can be drained smoothly during consolidation. After many experiments, the consolidation drainage time of the specimen is usually set within 24 hours. The above drainage experiments of unsaturated soil are often carried out by measuring the volume of pore water discharged from the sample. The three-phase system of unsaturated soil is composed of soil particle skeleton, pore water and pore gas. In the experiment, we often measure the fluid volume in the compression chamber to determine the volume change of the sample. The experimental measurement method is to flush the pressurized gas into the measuring tube. The outer tube of the measuring tube is a transparent plexiglass tube and the inner tube is a glass burette. The change of air pressure is measured through the air pressure difference.

1.2. Experimental Results and Analysis

Figure 1 shows the volume change characteristics of reinforced soil under different degrees of compaction, in which positive values represent the state of compression and negative values represent the state of expansion.

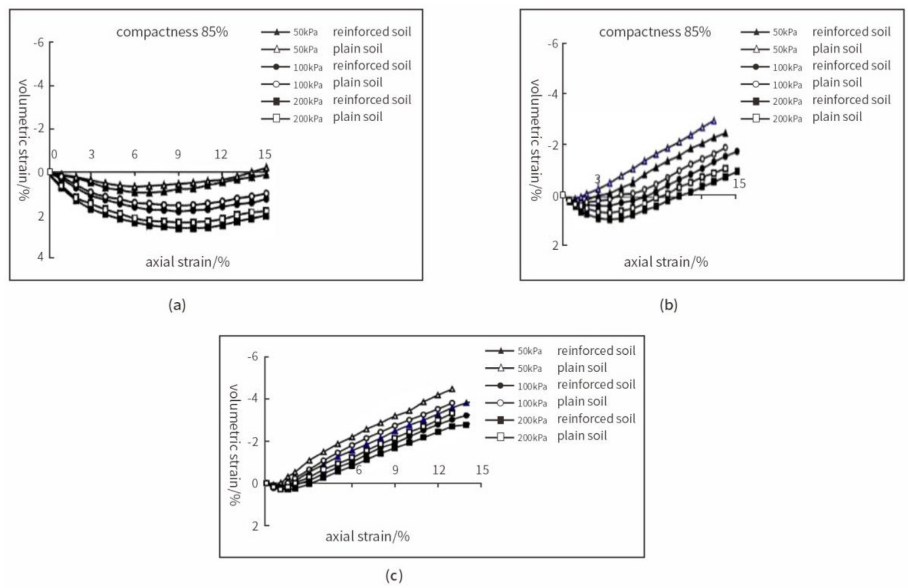

Figure 1. Volume Change Characteristics of Civil Fabric Reinforced Soil

a and b in **Figure 1** are when the compactness is 90%, the low confining pressure is under kPa, and the soil specimen is dilatancy. When the confining pressure is above 100kPa, the order of compression and dilatancy of soil specimen will be reversed. In addition to the influence of confining pressure, there is another reason, that is, the increase of axial strain will also change the volume change of soil. From the experiment, it is not difficult to find that the dilatancy can be restrained by reinforcement.

Table 4. Reduction Range of Axial Strain Reinforced Soil Compared with Plain Soil

Confining Pressure	50kPa	100kPa	200kPa
Compactness90%	19.08	17.45	15.38
Compactness95%	21.56	20.84	17.2

It can be seen from **Table 4** that when the degree of compaction is controlled at 95%, the plain soil with different confining pressures shows volume expansion. Through reinforcement, the experimental phenomenon is still shear expansion.[4] When the confining pressure is the same, the expansibility of reinforced specimens is still lower than that of plain soil specimens. From **Table 4**, we can know that when under different confining pressures, the dilatancy of soil will be different, and the resistance effect of reinforced soil to soil dilatancy will be different. When the confining pressure increases, the effect of reinforcement will be reduced. In addition to the above two reasons, different degrees of compaction will also affect the dilatancy. A large degree of compaction will increase the dilatancy. Reinforced soil can reduce the dilatancy of soil. Relatively speaking, the stability of reinforced soil is much better than that of other unreinforced soil. According to the relevant regulations of highway construction, the compactness[5] of backfill is required to reach more than 90%. Under this degree of compaction, the volume change of the soil used in the experiment will be close to the direction of dilatancy. After many experiments, we can know that the dilatancy of soil will be limited by reinforcement, and the stability of soil volume can be greatly improved by reinforcement.

2. Numerical Simulation Analysis of Geosynthetics Reinforced

2.1. Calculation model of Numerical Analysis

The soil element model used in the experiment is a viscoelastic plastic mixture, and the functional relationship of stress is nonlinear. The stress characteristics of the grid element model are that it can not be pressed, but can only be pulled, and the bending stiffness is also small, which is the same as the properties of membrane materials. Therefore, the membrane element is used to simulate the stress and strain characteristics of reinforcement materials. Another reason is that the tensile strength and modulus of geogrid are much better than other types of grids. When the strain force is small, the tensile curve presents a straight-line state. In order to make the tensile strength of civil grid in fill much smaller than the tensile strength, the constitutive relationship of grid element is regarded as linear elasticity.[6-8] For the contact problem of interface, there are many contact elements, such as thickness element, thickness free element and two node element.

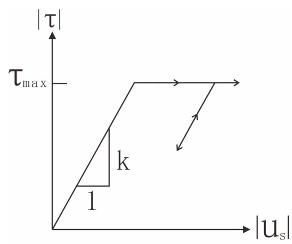

Figure 2. Relationship between Shear Stress and Relative Displacement

2.2. Numerical Calculation Analysis

Figure 3 shows the reinforced retaining wall of civil grid built in an area. The test sample is 6m high with no water seepage. The fill used is sandy soil. The density of the fill is 1.8 tons per cubic meter and the friction angle is φ = 30°, the face plate of the retaining wall is C20 concrete plate, the thickness of the face plate is 20cm, the total number of layers is 10, the distance between the civil grid is 0.6m, and the connection with the wall is very firm. The foundation adopts gravel soil foundation, the bearing pressure of the foundation is quite high, and the compressibility is relatively small.

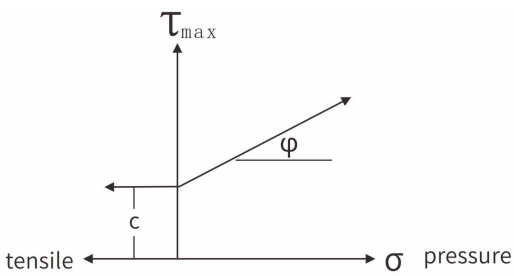

Figure 3 Interface Strength Criterion

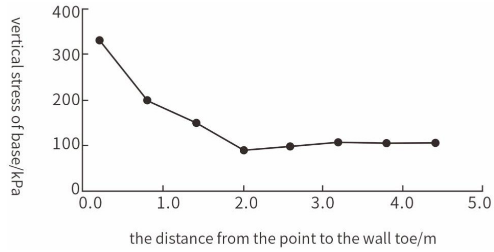

Figure 4 Vertical Stress Distribution of Basement

3. Conclusion

When the compactness of red sandstone weathered soil is different, the corresponding volume change characteristics will be different. When it is under high pressure, the soil is dilatancy, while when it is under low pressure, the soil is in shear shrinkage. The dilatancy can be restrained by reinforcement, but the shear shrinkage of soil will not change much. Reinforcement can enhance the stability of reinforced soil, but the improvement of soil stress characteristics will lag. In addition, in the process of consolidation, the reinforcement and soil will be compressed. If the reinforcement wants to recover through shear, it must be stretched. In order to enhance the peak and residual strength of soil, the two strengths can be improved to a certain extent by reinforcement. Compared with the previous, the image shows that the peak value does increase to a great extent. It can be seen from the curve of stress and strain that it changes the strain characteristics of soil. When plain soil and reinforced specimen are tested at the same time, the peak value of reinforced specimen is at the place of high strength strain. When the strain is in a certain large range, the peak value is still at a high place, and the place of shear peak value in the figure is relatively wide, which also makes the ductility of reinforced specimen relatively high. In order to obtain better peak strength, we can choose low tensile modulus and increase the reinforcement layer. Compared with the experimental materials with high tensile modulus, the peak strength is improved a lot. In addition to the peak strength increased a lot, the residual strength of soil also increased a lot. The strain characteristics of soil are changed by increasing the tensile modulus.

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