Experimental Study and Numerical Simulation Analysis of Geosynthetics Reinforced Bond Performance

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Abstract In the laboratory, 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. From the experimental results, it is not difficult to find that if researcher want to increase the volume stability of the high-pressure compaction soil, researcher 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. In the experiment, the peak strength of the soil is controlled by changing the number of layers of reinforcement and the tensile modulus of reinforcement. The experiment 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 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.

1. Introduction
With the rapid development of science and technology, there is a qualitative leap in the number of national civil engineering, in order to enable civil engineering to be used for a long time, often through some reinforcement technology to reinforce the project, geosynthetics reinforced soil is often used in backfill and reinforced materials for the complex, in which reinforced materials and soil for the strength and deformation characteristics of reinforced soil, geosynthetics. The interaction between them also occupies the main role.

2. Experimental study on bond behavior of geosynthetics reinforcement

2.1. Test Method
The material chosen in the experiment is red sandstone weathering soil which appears brown red yellow. The reason for choosing this material is that it contains iron and manganese oxides[1], which
makes this material have good compactness, compressibility and cohesiveness, and on the other hand, it contains muscovite and a small amount of fine sand, with kaolin lumps. According to the actual operation in the past, Hunan Changsha highway on both sides of the geotechnical experimental report can know, red sandstone weathering soil particles of the particle number is more than half, particle size is controlled in 2 mm to 0.073 mm range, the specific morphological characteristics see the following table 1 and table 2, from the table researcher can this soil is in the boundary between silt and silty clay. In this experiment, the content of the powder of the experimental materials will increase with the passage of time, which will lead to changes in the nature of the project, in the experiment, I mainly measure the physical characteristics of the engineering experiment, the civil grid used in the experiment is relatively easy to break the rubber membrane, and the size of the mesh of the civil grid is relatively large. The reliability of the experimental results of the small size is relatively low. Therefore, the more flexible civil fabric and geotextile are selected as reinforcement materials, and the tensile test is used to measure the mechanical properties.

| 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

| WATER CONTENT/% | P / (G/CM³) | SPECIFIC GRAVITY OF SOIL PARTICLES | VOID RATIO | SATURATION/% |
|-----------------|-------------|-----------------------------------|------------|--------------|
| 27.9            | 1.84        | 2.71                              | 0.88       | 86           |
| LIQUID LIMIT/%  | Plastic limit/% | Plasticity index | 100kPa~200kPa Compression coefficient/ (MPa)⁻¹ | Modulus of compressibility MPa |
| 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 PULL / (KN/M) |
|-------------|--------------------------|--------------|-----------------------------|
| GEOTEX TILE | Portrait Transverse | Portrait Transverse | Portrait Transverse |
| 2.3         | 22.2                     | 22.8         | 25.6                        | 28.7 | 10.3 | 7.8 |
| GEOTEX TILE | 0.8                      | 5.76         | 6.42                        | 75   | 81   | <0.4 | <0.4 |
| GEOTEX TILE | 10%Elongation pull/ (kN/m) Portrait Transverse | Tensile modulus/ (kN/m) Portrait Transverse |
| GEOTEX TILE | 14.43                    | 11.82        | 162.8                       | 147.8 |
| GEOTEX TILE | <0.4                     | <0.4         | 6.9                         | 7.3 |

In the experiment, when the water in the pore of unsaturated soil is stretched, and the sample is on the permeable stone, the amount of water absorbed by the permeable stone will also increase, in order
to avoid this phenomenon, researcher often bake the pervious stone on the electric stove, so that the sample can drain smoothly when it is consolidated. After many experiments, the consolidation and drainage time of the specimens is usually set within 24 hours. The drainage experiments of unsaturated soils are often carried out by measuring the volume of water drained from the pores of the sample. The three-phase system of unsaturated soil is composed of soil particle skeleton, pore water and pore air. In the experiment, we often measure the volume of fluid in the pressure chamber to determine the volume change of the sample. The method of experimental measurement is to pour the pressurized gas into the measuring tube, the outer tube of which is a transparent plexiglass tube, the inner tube is a glass burette, and the change of air pressure is measured by air pressure difference.

2.2. Test results and analysis
Figure 1 shows the characteristics of the volumetric deformation of a reinforced soil mass at different degrees of compaction, wherein a positive value indicates a state of compression and a negative value indicates a state of expansion.

![Figure 1. Volume change characteristics of civil fabric reinforced soil](image)

In Figure 1, when the degree of compaction is 90%, the low confining pressure is under kPa, and the soil specimen is dilatant, 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 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 the way of reinforcement.

| EXPERIMENTAL PRESSURE | 50KPA    | 100KPA   | 200KPA   |
|-----------------------|----------|----------|----------|
| DEGREE OF COMPACTION 90% | 19.08    | 17.45    | 15.38    |
| DEGREE OF COMPACTION 95% | 21.56    | 20.84    | 17.2     |
From the table, when the degree of compaction is controlled at 95%, the volume expansion of the plain soil under different confining pressures, by the way of reinforcement, the experimental phenomenon is still shear dilatancy\cite{4}, when it is the same confining pressure, the expansion of reinforced specimens is still lower than the plain soil specimens. From Table 4, we can see that the dilatancy of soil will change when it is under different confining pressures. Different, if the soil is reinforced for the soil dilatancy resistance effect will be different, when the confining pressure increases, the reinforcement effect will be reduced, in addition to the above two reasons will affect the dilatancy, different degrees of compaction will also have an impact, the degree of compaction will make the dilatancy will also increase. Reinforced soil can make the soil dilatancy is reduced, the relative stability of reinforced soil is much better than other unreinforced. According to the relevant highway construction specifications for the degree of compaction of backfill soil\cite{5} requirements is to achieve 90% of the standard, when it is in the degree of compaction, the soil used in the experiment will be at the volume of dilatancy to the direction of close, after many experiments, we can know that the way for reinforcement of soil dilatancy will be limited, And the stability of the volume of the soil can be greatly improved by means of reinforcement.

3. Numerical Simulation Analysis of Geosynthetics Reinforcement

3.1. Computational model for numerical analysis

The soil element model used in the experiment is a mixture of viscoelastic-plastic soil, and the function of stress is nonlinear. The characteristic of grid element model is that it can only be pulled but not compressed, and its bending stiffness is small, which is the same as the membrane material. So the membrane element is used to simulate the stress and strain characteristics of the reinforcement. Another reason is that the tensile strength and modulus of geogrids are much better than those of other types of geogrids. When the strain is small, the tensile curve is a straight line. In order to make the tensile force of the grille in the fill much smaller than the tensile strength, the constitutive relationship of the grille element is regarded as linear elasticity\cite{6-8}. For the contact problem, there are many contact elements, such as the element with thickness, the element without thickness and the two-node element.

3.2. Numerical Calculation Analysis

Figure 3 is a reinforced retaining wall for the construction of an earthwork grid in a certain area. The test sample is a wall with a height of 6m, and there is no water seepage. The backfill used is sandy soil, the density of which is 1.8 tons per cubic meter, and the friction angle is $\phi=30^\circ$. The panel of the retaining wall is a C20 concrete slab, the thickness of the panel is 20cm, and the total number of layers is 10. The distance between the civil and wooden grilles is 0.6m, which connects with the wall surface very firmly. The foundation of the gravel soil foundation, the foundation under the load pressure is very high, compressibility is relatively small.
4. Conclusion

When the degree of compaction of red sandstone weathered soil is different, the corresponding volumetric deformation characteristics will be different. When the soil is in high pressure, it is dilatancy, and when in low pressure, it is in a state of shearing shrinkage. By adding reinforcement, it can inhibit the dilatancy of the soil, and the shearing shrinkage of the soil will not change much, by adding reinforcement can make the reinforced soil stability. However, the improvement of soil stress characteristics is lagging behind by the way of reinforcement. There is the process of consolidation, reinforcement and soil will have the phenomenon of compression, through shear, if the reinforcement is restored through tension. In order to enhance the peak and residual strength of the soil, the way of reinforcement can make the two strengths have a certain degree of improvement, compared with the previous, the image shows that the peak is indeed a large degree of increase, through the curve of stress and strain can be seen to change the strain characteristics of the soil. When the soil and the reinforced specimen are tested at the same time, the peak value of the reinforced specimen is at the place where the strength is large, and when the strain is in a certain range, the peak value is still in the high place, and the place of the peak value in the figure is relatively wide, which also makes the ductility of the reinforced specimen is relatively high. In order to obtain a better peak strength, researcher 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 the soil is also improved a lot. The researchers change the strain characteristics of soil by increasing the tensile modulus.

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