Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 3, No. 2, 2022

Study on Mechanical Properties of the Compound Soil of Feldspathic Sandstone and Sand Based on Micro – level

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Abstract: It is of great practical significance to study the mechanical properties of composite materials of arsenic and sandstone to control the ecological environment in soft sandstone area. In order to understand the material and structural characteristics of composite materials under different compound proportions, the microstructure and the composition of the material elements were analyzed by the microscopic test and the test of mercury injection from the microscopic level. The dynamic three axis instrument was used to carry out the mechanical test under the different mixing ratio. The results showed that the main mineral components of feldspathic sandstone are quartz, albite, montmorillonite and calcite. The structure has the strength in the anhydrous state. When the water is saturated, the structure collapses, the cohesive force decreases rapidly, and it has the collapsibility; Due to the complexity of the structure and the optimization of the gradation, the permeability is greatly reduced; the macroscopic mechanics exhibits strain hardening and nonlinear characteristics.

Keywords: Feldspathic sandstone, Mixed soil, Micro structure, Mechanical properties.

1. Introduction

Arsenic sandstone and sand are the main causes of soil erosion and desertification in Maowusu sandy land. Aeolian sand has loose structure, no cohesion, high porosity between grains, difficult formation and poor shear resistance; The arsenic sandstone is dense in texture, rich in silt particles, poor in cementation between particles, low in diagenesis, low in structural strength, poor in engineering performance, and loose as mud when encountering water, vulnerable to weathering and erosion. Therefore, the control of arsenic sandstone is an important step to prevent water and soil loss.

In recent years, different scholars have made relatively mature research on the lithology, erosion, mechanical properties and physical and chemical properties of arsenic sandstone, such as its mixed soil with sand[1-4].

In this paper, starting from the micro level, through the composition analysis of the basic constituent minerals of arsenic sandstone, observation of the microstructure of the composite soil, understanding of the changes in the internal structure of the material after the combination of arsenic sandstone and sand, and according to the triaxial test to measure its macro mechanical properties, the internal causes of the macro characteristics of the composite soil are finally obtained.

2. Basic Physical Properties of Arsenic Sandstone

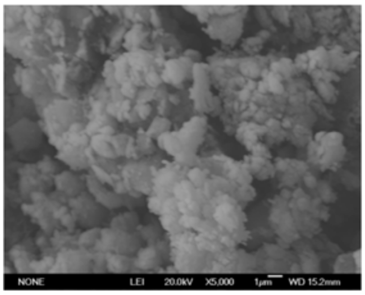
The physical and chemical properties of arsenic sandstone are mainly affected by its mineral composition and structure. Quartz and feldspar are relatively stable in chemical properties and are not prone to hydration reaction. However, montmorillonite and calcite are easy to be dissolved under the action of water due to their own microstructure characteristics, resulting in two phenomena: latent erosion and mechanical collapse. At the same time, the content of hydrophilic dolomite, K-feldspar and kaolinite is relatively small. The special mineral composition of arsenic sandstone determines its macro performance under the action of water, that is, it is not easy to be compressed, and the structure has a certain strength in the anhydrous state. When it is saturated with water, the structure collapses, the cohesion decreases rapidly, and it has a certain collapsibility.

In order to understand the physical characteristics of arsenic sandstone, mercury intrusion test was used to measure the specific surface area and total pore volume of arsenic sandstone and composite soil structure.

By comparing various physical indexes of arsenic sandstone and composite soil, it can be found that the total porosity of arsenic sandstone is greater than that of composite soil. Through further analysis, it can be concluded that due to its mineral composition and structural characteristics, the arsenic sandstone material has large inter particle pores, and its macro physical properties are characterized by its high permeability. Under the anhydrous state, its particles and particles are obviously cemented, and the load is mainly borne by its soil particle skeleton. The phenomenon of water and fertilizer leakage is obvious. After the arsenic sandstone is mixed with a certain amount of sand to become composite soil, due to the complementarity of its structure and the optimization of its grading, the total pores of the composite soil are reduced. At the same time, small particles are filled into the gaps of large particles, which increases the viscosity of water in the composite soil, greatly reduces the permeability, and plays a role in water and fertilizer conservation.

From the comparison between the bulk density and apparent density of arsenic sandstone and composite soil, it is found that the bulk density and apparent density of arsenic sandstone are both greater than the surface density of composite soil, indicating that although the total porosity of arsenic sandstone is greater than that of composite soil, the actual unit weight of arsenic sandstone is greater than that of composite soil, that is, arsenic sandstone is relatively dense, the mass per unit volume is greater than that of composite soil, and the clay content is greater than that of composite soil, which explains the internal reasons for the macro performance of arsenic sandstone.

The total porosity of arsenic sandstone is larger than that of composite soil, but its porosity is far less than that of composite soil, which further verifies that arsenic sandstone has many large pores, compact texture and strong water permeability; However, the composite soil has many micro pores, loose texture and weak water permeability.



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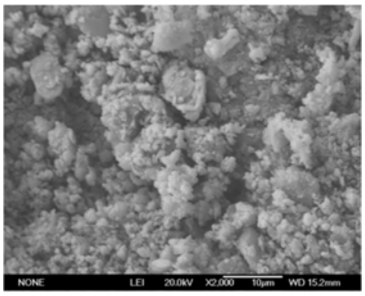

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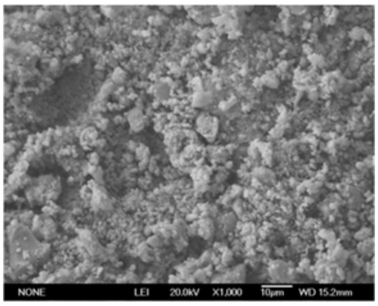

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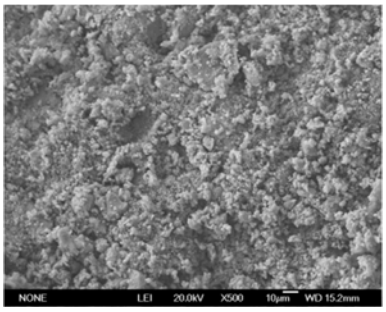

500x

Figure 1. Microstructure of composite soil under different magnification times

By comparing the microstructure maps of the composite soil under different magnification (Fig. 1), it is found that the microscopic particles and pores in the 500x and 1000x images are too small for data extraction and analysis, while the 5000x display range is small, which is difficult to reflect the overall layout of the microstructure. Therefore, the scanning electron microscope image of the composite soil microstructure with a magnification of 2000x is selected for analysis.

It can be seen from the figure that the particles in the composite soil are composed of single silt particles and aggregates composed of fine particles of clay. The particles are mainly in face to face contact. The aggregates in the soil are significantly increased, and the particle sizes are uneven. It can be clearly seen that there are pores of different sizes, and these pores are not interconnected. The surface of arsenic sandstone particles is rough, with strong friction and bite force between them. However, the particle size is relatively single, the content of fine particles is low, and the pores between particles cannot be filled, resulting in water easily passing through the soil.

Therefore, after the arsenic sandstone and sand are mixed, the particles are reconstructed. The clay particles with smaller particle size in the arsenic sandstone are filled into the pores between the sand particles with larger particle size, increasing the overall unit weight of the composite soil, increasing the specific surface area per unit volume, enhancing the water holding capacity of the soil mass, lengthening and thinning the path of free water flowing in the soil mass pores, and increasing the viscosity of the fluid, thus reducing the permeability of the soil mass, After the arsenic sandstone and sand are mixed, the mechanical properties have changed to some extent.

3. Study on Mechanical Properties of Composite Soil

In order to understand the mechanical properties of the composite soil and explore its internal relationship with the microstructure, the mechanical analysis of the composite soil with different mixing ratios was carried out under the water content. The samples were taken from Xiaojihan Township, Yulin, and the sand was taken from the local aeolian sand in Yulin. According to the preparation method of remolded soil, arsenic sandstone and sand are mixed to prepare a cylinder soil sample with a height of 80mm and a diameter of 40mm. GDS dynamic triaxial loading equipment was used for the test.

The test condition is consolidated undrained test, and the mixture ratio of composite soil (sand: arsenic sandstone) is 0: 1, 1: 5, 1: 4, 1: 3, 1: 2 respectively; The loading confining pressure is set to 50kPa, 100kPa, 200kPa; The water content of the mixed soil is 14%; The dry density is 1.6g/cm3. It can be seen from the stress-strain curve of arsenic sandstone in Fig. 2 that the mechanical properties of arsenic sandstone show strain hardening, so the control condition for failure of the specimen is that the strain reaches 15%.

Because soil is composed of fragmented solid particles, the macroscopic deformation of soil is mainly caused by the change of position between particles rather than the deformation of particles themselves. In Figure 2, the strain increment caused by the same stress increment is different under different stress levels, which shows the nonlinearity of arsenic sandstone and sand composite soil. It can also be seen in the figure that the stress of arsenic sandstone increases with the increase of strain, but the increase rate is slower and slower, and finally approaches an asymptote. According to the analysis of the stress strain curve of composite soil in Figure 3, the trend is basically the same as that of arsenic sandstone.

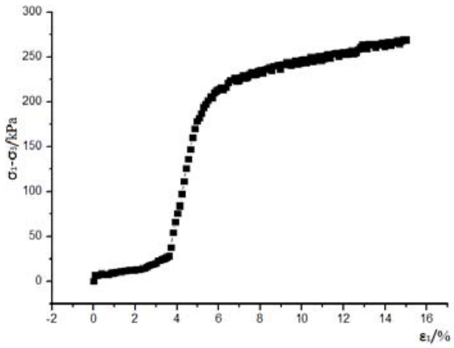

Figure 2. The stress-strain curve of feldspathic sandstone

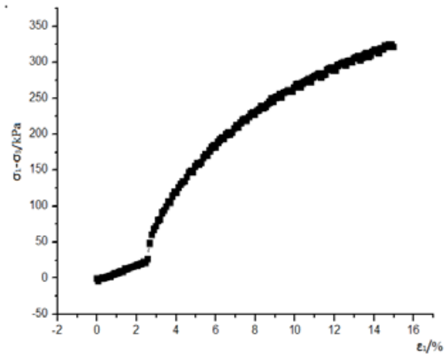

Figure 3. The stress-strain curve of compound soil

Table 1. Soil mechanics parameters under different mixing ratios of feldspathic sandstone and sand

mix proportion	0:1	1:5	1:4	1:3	1:2
Cohesion (kPa)	17.5	18	18	15	13
internal friction angle (°)	33	29	26	24	22

It can be seen from Table 1 that the mechanical parameters of the composite soil vary greatly under different mixing ratios. With the decrease of arsenic sandstone content and the increase of sand content in the composite soil, the change of cohesive force is not obvious when the mixing ratio is small, but with the increase of sand content, the cohesive force of the composite soil decreases gradually, and then basically presents a linear relationship; The internal friction angle of the composite soil decreases with the increase of the composite proportion, which is basically a linear relationship.

4. Conclusion

a. The total porosity of arsenic sandstone is larger than that of composite soil, and its porosity is smaller than that of composite soil; The bulk density and apparent density of arsenic sandstone are greater than the surface density of composite soil.

b. The particles in the composite soil are composed of single powder particles and aggregates composed of fine particles of clay. The particles are mainly in surface to surface contact. The pore sizes in the composite soil are different and not connected with each other; The surface of arsenic sandstone particles is rough, with strong friction and bite force between them, but the particle size is relatively single.

c. The mechanical properties of arsenic sandstone show strain hardening phenomenon, and the strain increment caused by the same stress increment under different stress levels shows the nonlinearity of arsenic sandstone and sand composite soil.

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