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Study on Strength and Deformation Characteristics of Rock Soil Mixture and Soil Stone Interaction

Siyi Wang[a], Guoliang Wang*[b]

[a]Xi'an Si Yuan University, Xi'an 710038, China
[b]Hualu Engineering & Technology CO., LTD., Xi'an 710065, China
wangguoliang@126.com

The earth rock mixture is widely distributed in nature, which is different from the general soil. The mixture is composed of high strength breccia and weak grained soil with weak strength. The whole stability of the geological body is poor, and the structure is complex, often leading to landslides, mudslides and other natural disasters. In this paper, the block type is gravel; the soil is sand containing low liquid limit clay; and the stone content is 50%. The strength and deformation characteristics of rock and soil mixture under 4 different gravel sizes are studied by three axis tests in the laboratory. The test results show that: 1). Different gravel size under different confining pressure of soil rock mixture stress-strain curve is the hardening curve. With the increase of gravel size decreases, the peak intensity of the sample is especially under high confining pressure; 2). The volume strain of different size gravel soil stone mixture under pressure the range increases with the increase of axial strain in the shear process until the damage, which has been in the shear specimen; 3) Soil and gravel mixture of the internal friction angle and fractal dimension of gravel is changed with the approximate parabolic function relationship. The results of the experimental analysis will provide a theoretical basis for further study of such special geological bodies as earth rock mixture.

1. Introduction

China is a country with extremely complex geological conditions, and geological disasters occur frequently in our country. Not only the number and type of all, including landslides, debris flow, collapse and other disasters are particularly prominent (Xiang and Jiang, 2011). At present, with the development of various large-scale construction projects, the stability of many engineering geological bodies, which include slopes, dangerous road rocks, and foundations, is closely related to the mechanical properties of extensively distributed soil-rock mixtures. Typical cases include the famous Huangdi stone landslide, the new beach landslide, and oil landslide; Panxi area has always been a high incidence of landslide disasters, and there are more than the landslide type landslide mixture landslides,such as the original barren river in Hubei Province to the county beach town of the Yangtze River on the left bank of the beach ancient landslides, the landslide slip belt soil mainly purple, gray and gray and white clay, silty clay folder broken stone than the Sichuan Province Wangjiaping landslide (Zhang et al., 2014). According to the results of drilling and trenching, the slippery soil is composed of Quaternary deposits, which are mainly crushed stone, crushed soils and silty soils with collapse. It is not only possible to deepen the understanding of soil mechanics on this special geological body, but also for a large number of slopes and other earth and rock mixed in the construction of our country. It is also possible to study the mechanical properties and deformation and failure mechanism of the soil and stone mixture (Zhu et al., 2017). The stability of the engineering environment analysis, deformation basket prediction and prevention, and control, has a high application value (Wang et al., 2016). As shown in Figure 1, the examples of strength and deformation characteristics of rock soil mixture and soil stone interaction are shown in details.

The earth-rock mixture is a special engineering geological material with a physical property between the homogeneous soil and the broken rock. It is made up of gravel or stone as aggregate and clay or sand as a filler (Xu et al., 2015). Unlike the general soil, it is a heterogeneous system. The composition of the soil and stone mixture under the external load of mechanical properties is very different, while there is a complex

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interaction between the earth and stone. Therefore, the mechanical properties of this kind of geomaterials such as failure mode, stress transfer and so on are different from homogeneous materials, and it has a large extent related to the internal structure of soil and rock mixture, such as particle size composition, stone distribution and so on (Cao et al., 2016). In view of this, we should attach importance to and strengthen the internal structure of soil and stone and other aspects of research. According to the relationship between the amount of soil and stone, Oil Xinhua will be divided into three categories: rock, soil and stone mixture. Rocks contain only stones, and earth and rock mixture contains both stone and soil, soil only contains soil. Earth and stone mixture of soil and gravel are that the particle size is greater than the painting into a stone, and less than called soil. Sub-class classification is based on the amount of stone, which will be divided into three types of soil and stone mixture: soil stone, mixed soil and stone soil (Zhao et al., 2007).

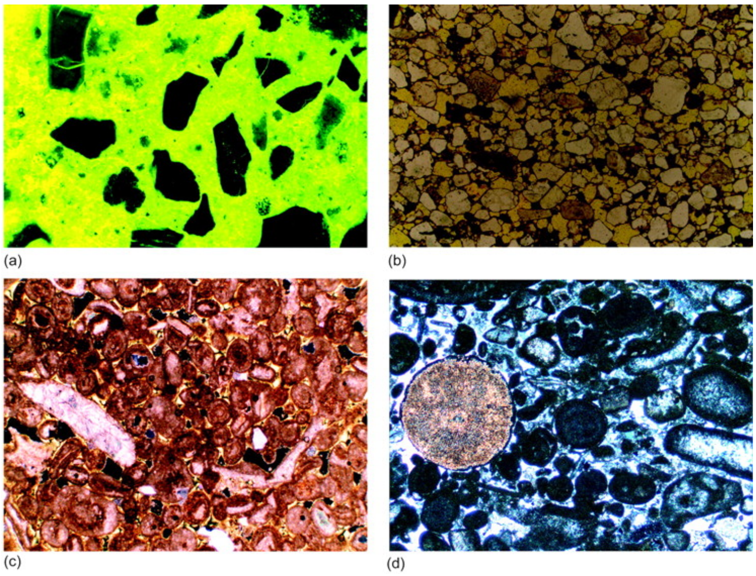

Figure 1: The Examples of Strength and Deformation Characteristics of Rock Soil Mixture and Soil Stone Interaction

Domestic and foreign research data show that the stone is suspended in the soil composed of the medium in the state when the amount of stone is insufficient. The spacing between the larger blocks is difficult to interact with the existence of stone on its macro. The effect of deformation characteristics is almost negligible. At this time, the strength of the soil-rock mixture depends on the soil. With the increasing of the stone content, the distance between the stone blocks is shrinking and the interaction takes place, which affects the deformation of the rock and soil. Depending on the result of the interaction between soil and stone, the stone blocks are in close contact with the skeleton of the whole rock and soil, and the soil is filled in the gap when the amount of stone increases to over (Sun et al., 2014). At this time, because of the tight arrangement of stone, it rarely appears in the soil, which is fully filled with the phenomenon and the vast majority of the soil part of the body is filled with the skeleton. At this time, the macroscopic mechanical strength of rock and soil mainly depends on the bite force and friction between the stone, and the strength of the stone will not change with the basic changes (Xu et al., 2006).

In the early research and engineering practice, the soil and stone mixture is directly classified as a kind of soil, and is also the default for homogeneous continuous material in its calculation. After that, the concept of soil-rock mixture was proposed and gradually recognized by the engineering community. In recent decades, domestic and foreign scholars have made a lot of fruitful and enterprising progress in the study of soil and rock mixture. The main methods include indoor experiment, large-scale experiment, and numerical simulation.

Earth and rock mixture is a kind of complex geological body, because the internal not only contains large diameter, high strength of the stone, but also affects the physical and mechanical properties of the factors are technical and test methods. It is difficult to accurately obtain the physical and mechanical parameters of the soil and stone mixture. Therefore, it is easy to cause waste of funds in the corresponding project construction, or even the unreasonable parameter selection will lead to the failure of construction. The indoor test can control the boundary condition and the force condition accurately, so the indoor research is of great significance to the study of the stone and soil mixture.

The current research rarely involves the influence of water on the mechanical properties of the soil-rock mixture and its affinity. In fact, most of the genesis of soil and rock is related to water, and the geology is mostly distributed in rivers and lakes (Xu et al., 2015). Therefore, the influence of water on the soil and rock mixture and the interaction should be one of the future research directions. The research data show that: on the one hand, the softening of water on the solid will be amplified due to the presence of stone; on the other hand, the contact between soil and stone does not form a lot of potential cracks, which is conducive to the phenomenon of candle and instability of other Earth and rock mixture structure (Xu et al., 2008). At the same time, the pressure on the soil and rock mixture deformation and damage behavior will have a direct or indirect impact. The soil and rock mixture located in the bank area has not been systematically developed due to the rise of the water level, the change of the load of the infiltration process, and the loading and unloading of the soil and rock mixture. The damage of the soil-rock mixture slope is the result of the interaction between the internal seepage field and the stress field under the influence of the natural factors such as rainfall infiltration. However, most of the current researches are to separate the seepage and stress analysis. Although this method is simple, it cannot objectively and truly reflect the interaction between the seepage field and the stress field, especially when the earth-rock mixture is in a saturated state (Ling et al., 2016).

In summary, the study of the strength of the soil and stone mixture is mainly to consider the impact of stone, confining pressure, loading method and other macro factors, which is the specimen within the stone when the shear displacement and attitude changes. The interaction mechanism between soil and rock during the experiment has not been reported yet. Thus, the influence of different stone content and different stone, which forms on the strength and deformation of soil and rock mass, is studied in this paper. The interaction between soil and rock is analysed, which provides the basis for reasonably determining the parameters of soil and rock mixture (Qi et al., 2016).

2. Experiments

2.1 Test material

The soil type is gravel, and the stone content is 50%. The soil is sandy with low liquid limit clay; the liquid limit is 29.2%; the plastic limit is 17.2%; the plasticity index is 12; the soil material is specific. The rating is shown in Table 1.

Table 1: Gradation of Soil

Particle diameter (mm)	Percentage (%)
1-0.5	1.1
0.5-0.25	2.6
0.25-0.075	28.1
<0.075	68.2

The grape size is 16-20 (class 1), 10-16mm (class 2), 5-10mm (class 3) and three sizes of mixed (16-20mm 20%, 10-16mm 20 %, 5-10mm 10%) (Gradation 4). The strength characteristics of soil and gravel mixture under different stone sizes are studied. The particle size distribution of each soil and gravel mixture is shown in Table 2.

Table 2: Gradation of Soil-rock Mixture

Particle diameter(mm)	Class1 (%)	Class2 (%)	Class3 (%)	Class4 (%)
20-16	50	-	-	20.0
16-10	-	50.0	-	20.0
10-5	-	-	50.0	10.0
1-0.5	0.6	0.4	0.6	0.6
0.5-0.25	1.3	1.3	1.3	1.3
0.25-0.075	14.2	14.3	14.2	14.2
<0.075	34.0	35.3	34.5	34.5

From the particle size distribution curve in Fig. 2, it can be seen that the fracturing dimension of the earth-rock mixture used in the experiment can be used to reflect the graduation. The fractal characteristics of the soil-rock mixture are usually used. As for the particle size, the number of particles is more difficult to obtain directly according to the test, while most of the studies use particle mass - particle size distribution of fractal model.

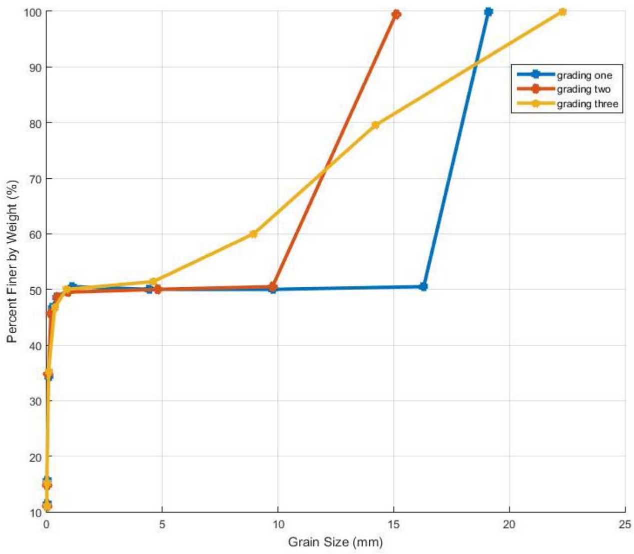

Figure 2: Gradation Curves of Soil-rock Mixture

$$\frac{M(r<R)}{M_T}=\left(\frac{R}{R_L}\right)^{3-D} \tag{1}$$

F is the pore radius; R is the particle size; M (r <R) is the particle mass of the particle size less than R; M is the total mass of the particles; R_L is the largest particle size.

$$\lg\left[M(r<R)/M_T\right]=(3-D)\lg(R/R_L) \tag{2}$$

The difference between the particle size distribution of the soil and the mixture of the gravel and the gravel is very large. The particle size distribution curve of the soil and the gravel mixture can be seen as having multiple fractal similarities (Qi C, 2016). Since the fine particles are consistent with the low liquid limit clay, the fractal dimension of coarse particles can be used to represent the soil and stone mixture under different gravel size. Through the calculation, we can obtain the fractal dimension of coarse particles in the four different gravel sizes, D1 = 2.2, D2 = 2.43, D3 = 2.56, D4 = 2.52.

2.2 Experimental method and results

In Figure 3, it shows the (σ1-σ3) -εa curves of the samples under different gravel size at confining pressure of 200, 400 and 800 kPa, respectively. We can get the following results:
1) The relationship between the (σ1-σ3) -εa curve of the soil and the gravel mixture under the same confining pressure has no obvious peak intensity as the hardening curve.
2) Under the same confining pressure, the hardening phenomenon of the (σ1-σ3) -εa curve gradually increases with the increase of the size of the gravel, especially at high confining pressure.
3) The (σ1-σ3) -εa curves of the samples under different gravel sizes and the same confining pressure have the local fluctuation.
(4) The same peak pressure of different specimens under different grape size increases with the decrease of the gravel size, especially at high confining pressure.

In Figure 4, it shows the volume strain - axial strain (δ_1-δ_2) of the samples under different grape size at confining pressure of 200, 400,800 kPa. We can obtain the following results:
(1) The volume strain of the soil and the gravel mixture increases with the axial strain, and the specimen is in the sheer state until the destruction of the specimen.
(2) Under the low confining pressure (200 kPa), the order of the corresponding strain in the axial strain is 5-10 mm, 16-20 mm, 10-16 mm and mixed size with the increase of axial strain.
(3) Under the high confining pressure (800 kPa), the order of the corresponding axial strain is 5-10 mm, mixed size, 10-16 mm and 16-20 mm with the increase of axial strain.

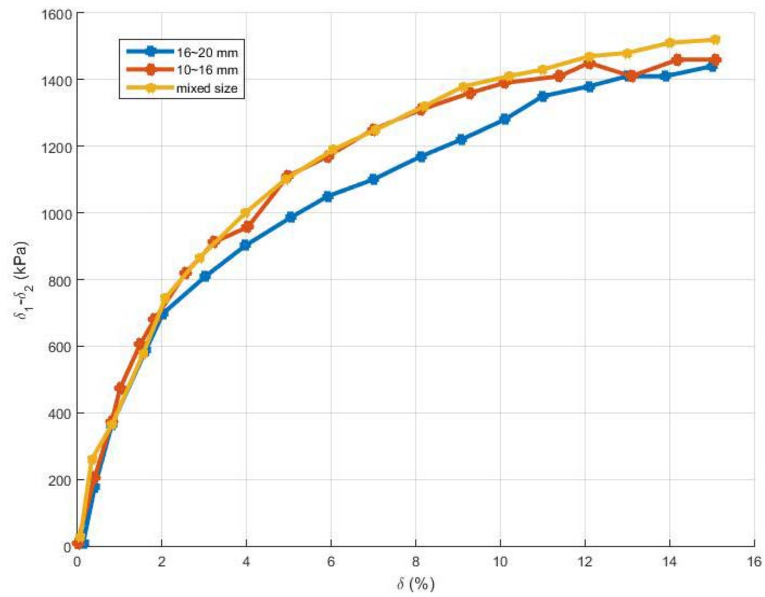

Figure 3: (δ_1-δ_3)-δ_a Curves of the Soil-rock Mixture in the Same Confining Pressure

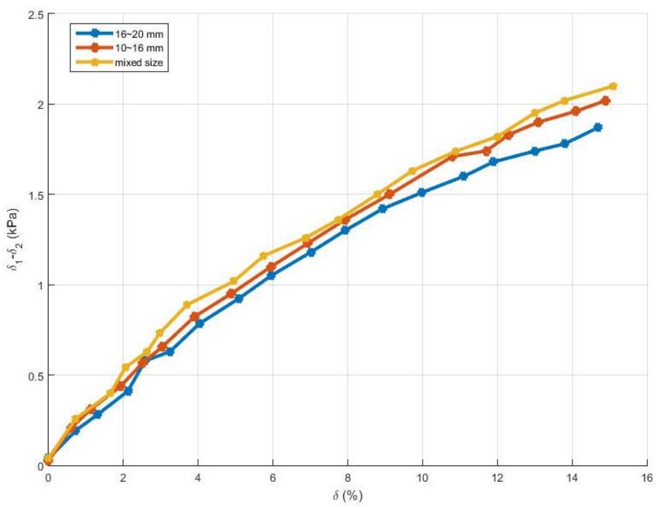

Figure 4: (δ_1-δ_2*) Curves of Soil-rock Mixture in the Same Confining Pressure*

3. Conclusion

In this paper, the strength and deformation characteristics of rock and soil mixture under 4 different gravel sizes are studied by three axis tests in the laboratory.

The test results show that:

1). Different gravel size under different confining pressure of soil rock mixture stress-strain curve is the hardening curve. With the increase of gravel size decreases, the peak intensity of the sample is especially under high confining pressure;

2). As the axial strain increases during shearing, the volume strain of the rock soil mixture with different size increases over the pressure range until it is damaged by the sheared specimen;

3) Soil and gravel mixture of the internal friction angle and fractal dimension of gravel is changed with the approximate parabolic function relationship.

The results of the experimental analysis will provide a theoretical basis for further study of such special geological bodies as earth rock mixture.

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