Evaluation of Mechanical Behaviour of Sandstone and Andesibasalt Rockfill Materials Using Triaxial & Direct Shear Tests

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Abstract

The mechanical behaviour of rockfill materials and aggregates depends not only on particle size and compaction, but also on their strength and lithological properties. In this research two types of large triaxial and direct shear tests are performed on rockfill materials. This Paper compares the stress-strain behaviour of sandstone and andesibasalt materials in triaxial compression tests (300×600mm) and direct shear tests (300×300mm). The study evaluates Two kinds of aggregates with different lithological properties and the result reveald that how the same particle sizes aggregates behaved differently due to different lithology and test procedures. This research showed that shear strength of hard and strong rockfill mass (andesibasalt) is more and the deformability is less, compared to weak rockfill materials (sandstone), and this variation increases with increasing confining stress and surcharge.

Introduction

Investigation of rockfill materials is one of the most important subjects in performing an optimum design of the rockfill structures without understanding the behaviour of these materials. A number of investigations and studies has been carried out to express the behaviour of rockfill material in rockfill dams [1],[2],[3],[4],[5],[6], the type and scale of laboratory testing on behaviour of rockfill materials and classification of the rockfill materials, [7], [8], [9], [11], [12], [13], [14], [15].This paper compares the stress

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strain behaviour of sets of triaxial and direct shear test results, carried out on rockfill samples of sandstone and andesibasalt. These samples wer taken from resource materials of Sabalan and Vanyar dams in northwest of Iran. Andesibasalt samples are stronger than sandstone samples. In these research three types of test, consist of unconfined compressive, triaxial and direct shear tests were performed on remolded samples of materials.

The investigation is performed based on the results obtained from large diameter triaxial and large shear box tests on the shell materials of two rockfill dams under construction in Iran.

Details of Tests

A series of samples were taken from Vaniar dam (sandstone) and Sabalan dam (andesibasalt) in northwest of Iran. Sandstone samples are weaker than andesibasalt samples. The unconfined compressive strength of sandstone samples is 80 Mpa. And less than andesibasalt samples (120 Mpa). The grain size distribution Curves of rockfill samples used for direct shear and triaxial tests are shown in figure1. In the present study, remolded density and moisture content were prepared (Table 1). The loading rate was 0.5-mm/min using displacement control method.

The large universal triaxial apparatus is one of the advanced and sophisticated units of material testing in the world that installed in Building & Housing Research Center. It has the capability of performing static and dynamic tests on soil and rockfill samples with diameter of 200 to 300 mm and rocks of 50 mm, as shown in figure 2.

In this research direct shear box and drain triaxial compression tests were carried out on seven samples at saturation condition. The samples in triaxial tests measured 300-mm diameter by 600mm height in the condition of consolidated drained. The samples in direct shear box tests measured 300mm × 300mm × 150 mm in the same conditions with triaxial tests. The used triaxial apparatus in this study are shown in figure 2.

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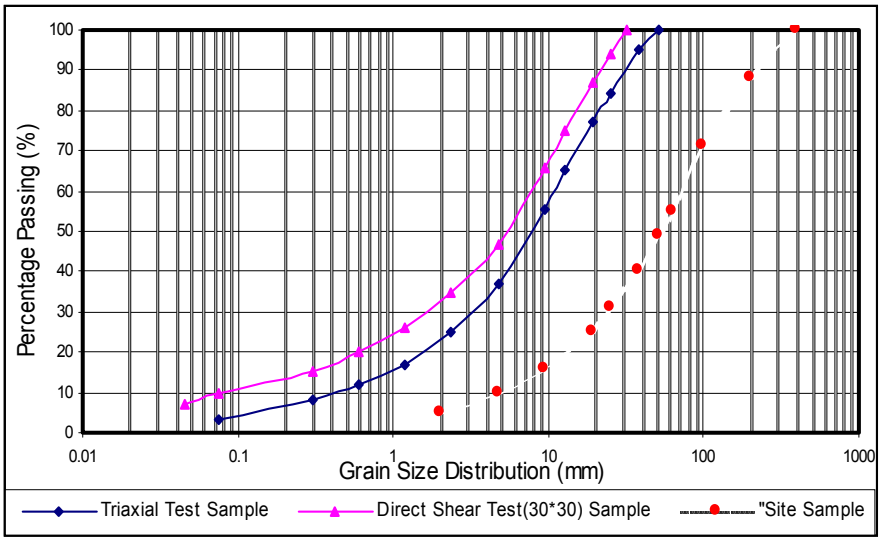


Fig 1. Grain size distribution curve of samples in direct shear and triaxial tests

Table 1. Characteristics of rockfill samples in triaxial and direct shear tests

Sample	Unconfined comp. Strength (Mpa)	No. Sample	Dry density(gr./cm^3)	Moisture content (%)
Sandstone	80	4	2.18	5.9
Andesibasalt	120	3	2.23	5.1



Fig 2. Large triaxial apparatus

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Drained Triaxial Compression Test

In this research, large static triaxial tests were carried out on two types of rockfill materials. The results were analyzed in order to examine the stress-strain behaviour of rock materials. Unconfined compressive strength of sandstone samples is less than andesibasalt samples. The stress-strain and volumetric strain curves of these samples are shown in figure 3.

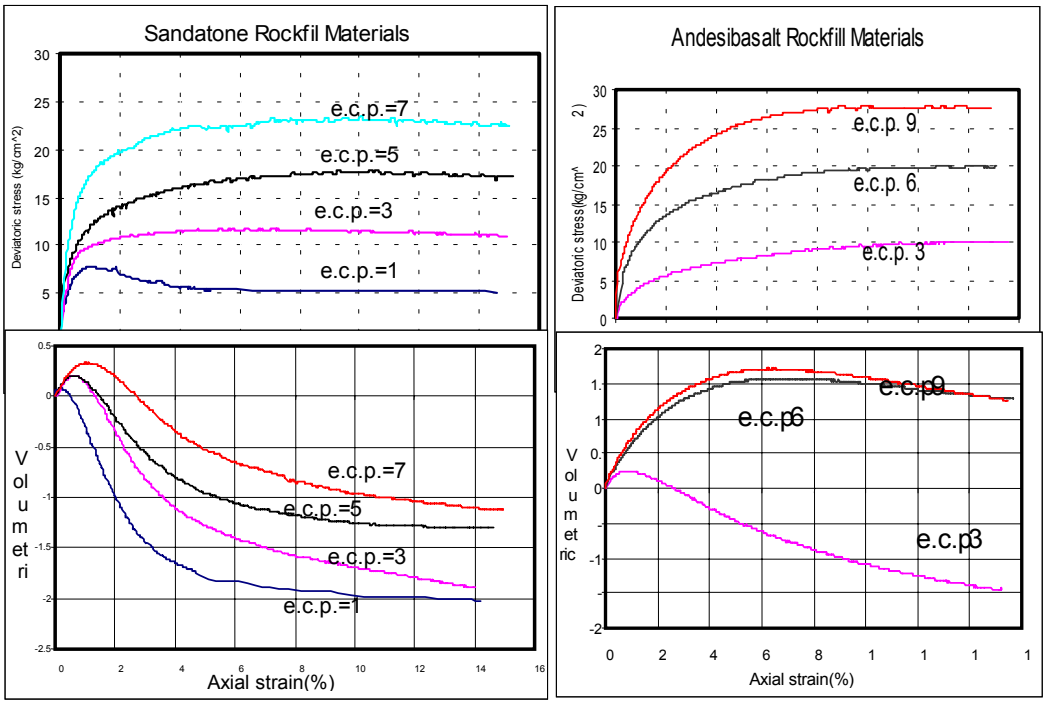


Fig 3. Stress- strain curves for sandstone and andesibasalt materials from triaxial test

It can be seen that the slope of stress- strain curves increases with increasing confining stress. Due to low compressive strength of sandstone, the amount of deviatory stress during failure in sandstone materials is less than andesibasalt samples. The failure of rockfill materials, with the increase of confining stress, occurs in large deformation. This peculiarity is one of the positive points on rockfill embankment dams, particularly in earthquake prone regions.

In these rockfill samples, in low confining stress, the dilation occurs. This can be due to strength of rockfill materials and less particle breakage. Due to the increase of

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confining stress, the particle Breakage occurred in samples and as a result, the dilation and volume of samples decreased [16].

The phenomenon of particle breakage, which is more prominent in weak and soft rock materials, reduces the bearing capacity and the friction angle of materials. On the other hand, particle breakage increases deformability, which in turn causes large deformation during failure.

Consequently, it seems that the bearing capacity and deformation in rockfill materials depends on the strength of the materials [16]. Therefore, the bearing capacity of hard and strong rockfill materials is more and deformability is less, comparedto weak rockfill materials.

Direct Shear Box Test

As for the triaxial test, the stress-strain behaviour from direct shear is evaluated for sandstone and andesibasalt rockfill materials. Figure 4 shows the stress- strain curves. The maximum shear stress during failure in sandstone materials is less than andesibasalt, and this variation increases with increasing surcharge. As for the triaxial test, the deformability of samples during failure increases, with increasing surcharge, and the dilation occurs in low surcharge due to strength of materials and less particle breakage (for example σ_n= 1 Kg/cm^2). The samples in higher surcharge are compacted and reduce volume, and this reduction is larger in high surcharges.

The friction angle in andesibasalts is larger than sandstone materials, because the maximum stress and the bearing capacity of andesibasalt samples are greater, compared to sandstone samples.

Analysis Of Results

The triaxial test as generally is suitable for determination of shear strength parameters and stress-strain behaviour of materials, but direct shear box test is only suitable for measurement of shear strength factors. This test is not suitable for

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determination of stress-strain behaviour of materials, due to heterogeneity of this behaviour in direct shear test (Patter, etal. 1987). However, this test is commonly used for determination of stress- strain behaviour and shear strength parameters of materials, due to the simplicity of test [10].

The stress-strain behaviour of rockfill materials used in this investigation is shown in figure 5. As it can be observed, the trend of the curves in two types of tests is similar to each other. The slope of stress-strain curves increases with increasing confining stress and surcharge. Due to low compressive strength of sandstone, the amount of deviatory stress during failure in sandstone materials is less than andesibasalt samples .The failure

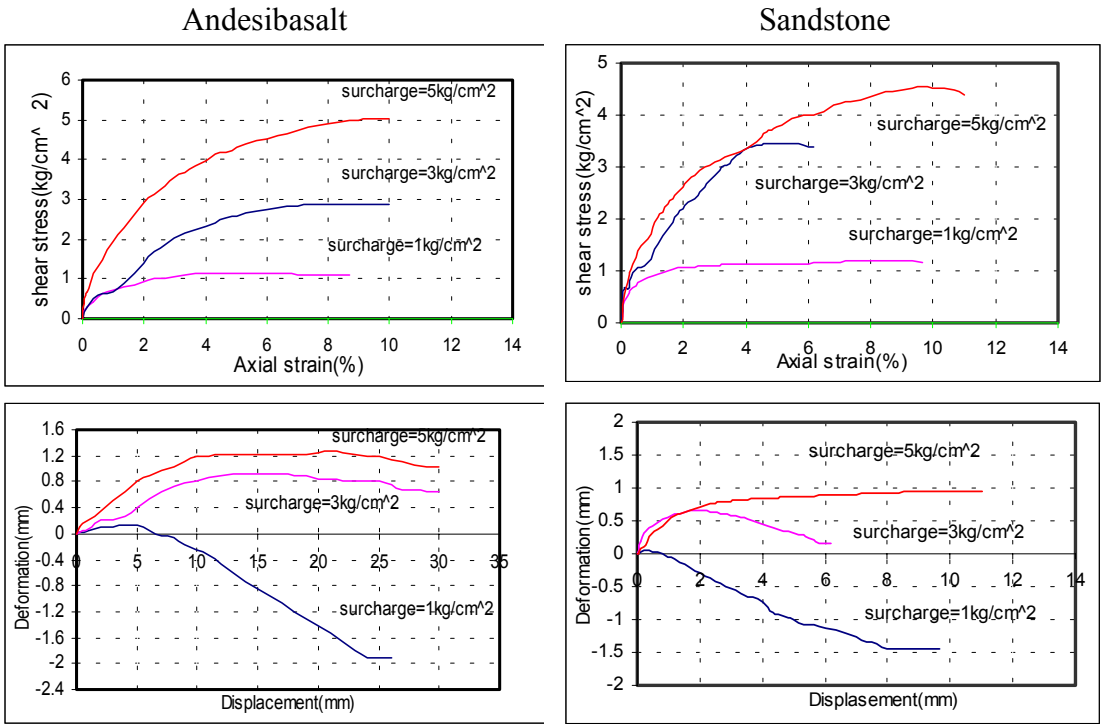


Fig 4. Stress- strain curves for sandstone and andesibasalt samples from direct shear test

of rockfill materials, with the increase of surcharge and confining stress, occurs in large deformation. This peculiarity is one of the positive points for rockfill embankment of dams, particularly in earthquake prone regions [16].

In these rockfill samples, in low surcharge and confining stress, the dilation occurs. This can be due to strength of rockfill materials particularly in weak materials. Due to

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the increase of surcharge and confining stress, the particle breakage occurs in samples and as a result, the dilation and volume of samples decrease.

Table 2. Friction angles of rockfill samples from direct shear box and triaxial tests

Sample	No. of tests	Sandstone	Andesibasalt
Triaxial test	7	36	41
Direct shear box test	6	39.7	43.8

The difference in behaviour between direct shear box test and triaxial compression test could be due to different main stress levels. The bearing capacity of rockfill materials in two types of test increase, with increasing confining stress and surcharge, but the amount of peak stress is different due to different nature of these tests. The deformability of sandstone and andesibasalt materials in direct shear and triaxial tests is similar and the amount of deformation in each set of test increase, with increasing confining stress and surcharge.

The friction angle in direct shear test, under the same condition, is larger (3 to 4 degrees) than triaxial test, due to plane strain nature of this test (Table 2). The analysis of rockfill structures with two-dimensional behaviour is possible, using of shear strength parameters of rockfill samples from direct shear tests.

Conclusions

The interpretation and comparison of results presented that, with increasing confining stress and surcharge, peak stress and deformation during failure, increase and the friction angle decreases. The failure of rockfill mass occurs in large deformation. This peculiarity is one of the positive points of rockfill dams, particularily in earthquake prone regions.

The bearing capacity and shear strength of hard and strong rockfill mass is more and the deformability is less, compared to weak rockfill materials, and this variation

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increases with increasing confining stress and surcharge. The volumetric and vertical strain of rockfill materials is similar in the two types of test, and these factors in andesibasalt samples during failure are more obvious than sandstone samples.

Friction angle of rockfill materials in direct shear test is 3 to 4 degrees larger than triaxial test. Because of plane strain nature of this test, analysis of rockfill structures with two-dimensional behaviour, using shear strength parameters of direct shear test, is possible.

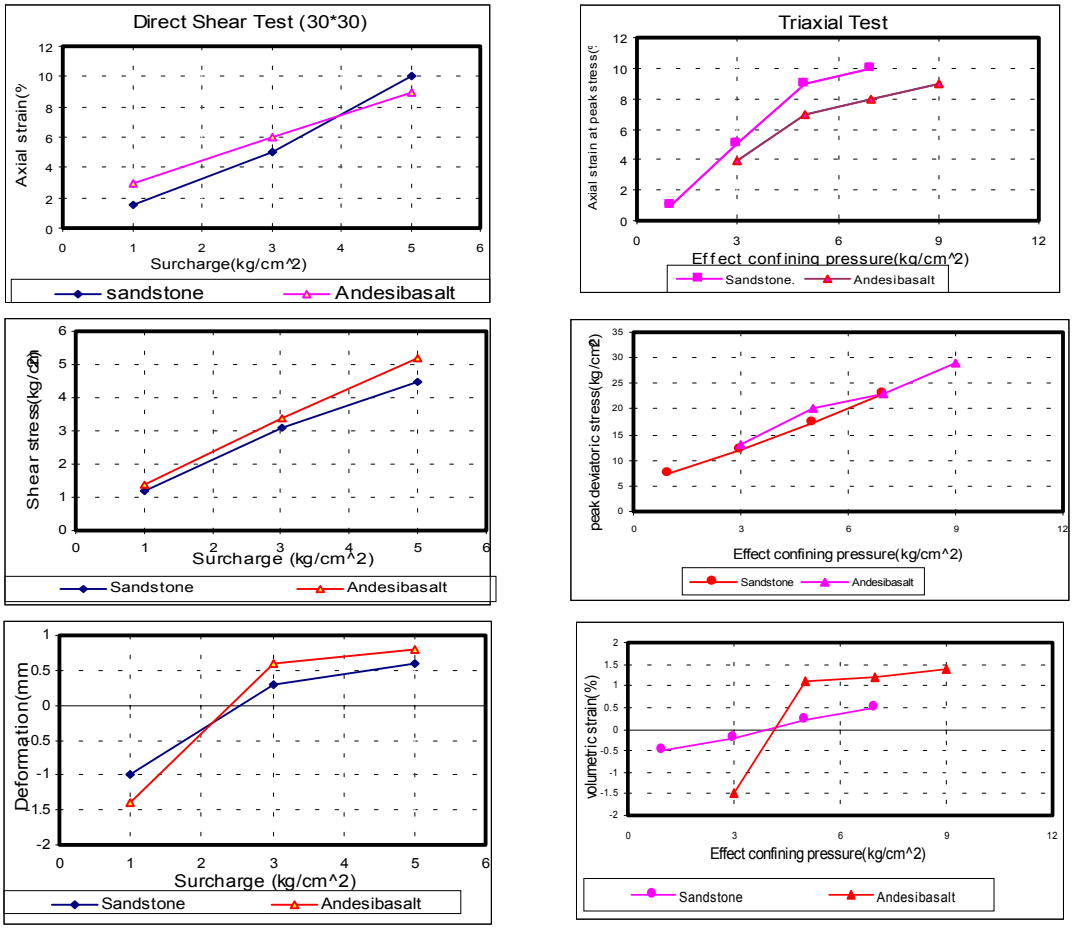


Fig 5. Stress-strain behaviour of sandstone and andesibasalt samples from direct shear and triaxial tests

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