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An Experimental Study on Variation of Shear Strength for Layered Soils

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Abstract- Compacted soils in embankments of dams, and roads, dikes, liners, etc. are commonly used in geotechnical engineering. Soil variability and uncertainty of a natural soil deposit and its properties are common challenges in geotechnical engineering design. The shear strength characteristics for different types of soil for different combinations of soils were used which are compacted in layered to form homogeneous and heterogeneous soils of thickness L, L/2, L/3 and 2L/3 i.e., 72mm, 36mm, 24mm and 48mm to form two and three layer system. It is observed that addition of layer of course grained soil with the fine grained soil leads to increase in the angle of friction and decrease in the cohesion.

Key words: Shear strength**,** unconsolidated undrained triaxial test

1. INTRODUCTION

The problems of cohesive soil behavior under static and dynamic conditions have been the wide range of interest. Soil variability and uncertainty of a natural soil deposit and its properties are common challenges in geotechnical engineering design. Comparing to homogeneous soil, heterogeneous soil with equivalent average geotechnical properties possesses excess pore water pressure during an earthquake. In the present study, an attempt is made to analyze the shear strength of the layered soil. Three soils of different physical and index properties (two types of black cotton soils i.e., BC_1 and BC_2 and red soil i.e., R) were collected from different sites and testing can be done on soil samples by compacting in three layers with different properties in different combination. Unconsolidated undrained triaxial test was carriedout on these layered soil samples. The inclusion of granular material between the two clayey soils which leads to decrease in the cohesion (*c*) and increase in the angle of internal friction (ϕ).

2. NECESSITY

In the present study, attempts to establish the variations in strength by adopted usual laboratory tests such as unconsolidated undrained triaxial test on different soils which are locally available The data obtained from basic laboratory tests on some soil samples, the soil samples had been grouped as per the IS soil classification. In many situations, soils in natural state do not achieve adequate geotechnical properties which have to be used for road embankment, foundation and construction material, etc., but it involves the innovative techniques by utilizing local available environmental or industrial waste material has to be used for the modification and stabilization of deficient soil usually used in the present days, so that cost of construction may be minimized to the minimum extent, but in the present project study the utilization of natural soils like black cotton soil and red soil has been used in the form of layers by putting alternatively at different depth and studying the behavior of these type of soils in finding out desired strength such as shear strength.

3. MATERIALS AND EXPERIMENTAL METHODOLOGY

This chapter includes the properties of the materials and methodology used in the present study, preparation of testing samples and detailed procedure of testing methods adopted.

In the present study soil samples of two different properties collected from different area namely; black cotton soil and red soil and are classified as *CH* (Lean clays of high plasticity) and *CL* (Lean clays of low plasticity) according to IS soil classification system were used. The methodology is adopted in this experimental project work for making soil samples which has been compacted layer-by-layer for different type of soil having different shear parameter has been shown in the fig 3.1. The test is used to determine the shear strength of the soil samples. in layered form is conducted by triaxial test.

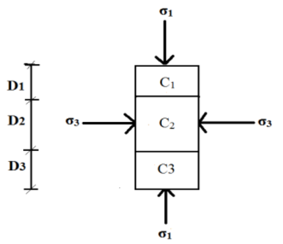

Fig 3.1 Preparation of sample for triaxial test

Where

C_1, C_2 and C_3 are the cohesions of different soil samples.

D_1, D_2 and D_3 are the layer thicknesses of soil samples.

σ_1 is the major principal stress on soil specimen.

σ_3 is the minor principal stress or confining pressure on the soil specimen.

3.1 LABORATORY TEST METHODS

Unconsolidated undrained triaxial test (UU triaxial test)

As drainage is not permitted and consolidation is not necessary, this test is very quick, and also referred as Quick test. The triaxial test gives shear strength of soil at different confining stresses. Shear strength is important in all types of geotechnical designs and analyses. The unconsolidated undrained triaxial test was conducted as per IS 2720 Part XI-1993.

Calculated by using Mohr's – Coulomb equation is as follows:

$$\tau_f = c + \sigma \tan\phi$$

Where,

τ_f is shear strength at failure of the soil specimen.

c is the cohesion

σ is the normal stress

ϕ is the angle of internal friction

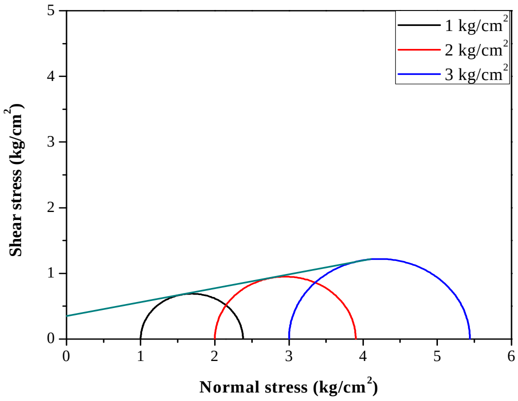

Fig 3.2 Mohr's circles with failure envelope

3.2 Preparation of soil samples for triaxial test

For this experimental testing program soil which is available at site is directly used for the preparation of the specimens. First soil is kept for air drying then compacted in three layers in the triaxial cylindrical mould. The soil passing through 475µ sieve for different soil samples of *CH* and *CL*. A cylindrical steel mould of the size L = 72 mm and dia is d = 34 mm is selected in which the soil is compacted in three layers at 25 blows for each layers. The *MDD* (Maximum dry density) and *OMC* for the soil is determined from standard proctor tests. By knowing the density of soil to be compacted and the volume of the mould the required mass of the soil are arrived. The varying height of at L, L/2, L/3, and 2L/3 i.e. L = 72mm, d = 34mm for different soil such as *CH* and *CL* which is compacted in three layers at different density namely 1.46 gm/cm^3 for BC_1 (black cotton soil one) at water content 28%; 1.52 gm/cm^3 for BC_2 (black cotton soil two) at water content 23% and 1.92 gm/cm^3 for R (red soil) at water content 18%. The total 60 samples are prepared at room temperature.

Fig 3.2 Photograph shows the soil specimen is prepared with different layered combinations of soils is compacted by using triaxial steel mould

4. RESULTS AND DISCUSSION

The following table 4 content the test results on triaxial test was conducted as per IS 2720 (Part XI)-1993 as follows:

Table 4 Results on triaxial test for the different type of soils combinations in layers.

Sl. No.	Combination	Cohesion c kg/cm^2	Angle of internal friction ϕ (Deg.)	Shear stress σ kg/cm^2	**Shear strength τ_f kg/cm^2**
1	BC_1	0.60	09	1.25	0.80
2	BC_2	0.56	10	1.20	0.77
3	R	0.15	21	1.90	0.88
4	BC_1-R-BC_2	0.35	12	0.96	0.55
5	BC_1-R-BC_1	0.32	09	0.70	0.43
6	BC_2-R-BC_2	0.35	11	0.90	0.52
7	R-BC_1-R	0.14	20	1.45	0.67
8	BC_2-BC_1-BC_2	0.57	10	1.00	0.75
9	R-BC_1-BC_2	0.39	12	1.00	0.52
10	R-BC_2-R	0.13	19	1.35	0.59
11	BC_1-BC_2-BC_1	0.52	08	0.85	0.64
12	R-BC_2-BC_1	0.42	14	1.15	0.71
13	R-BC_2-BC_2	0.30	14	1.10	0.57
14	R-BC_1-BC_1	0.30	11	0.85	0.47
15	R-R-BC_1	0.17	15	1.10	0.46
16	BC_1-BC_2-BC_2	0.62	10	1.00	0.80
17	R-R-BC_2	0.15	17	1.17	0.51
18	BC_2-BC_1-BC_1	0.59	11	1.15	0.81
19	R-BC_1	0.14	14	0.36	0.36
20	R-BC_2	0.16	16	0.46	0.46

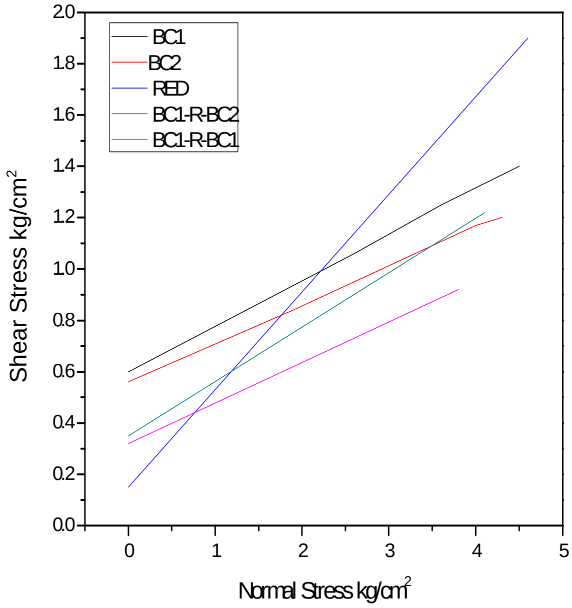

Fig 4.1 Shows variation of shear strength of different layer of combinations of soils for BC1, BC2, RED, BC1-R-BC2,BC1-R-BC1

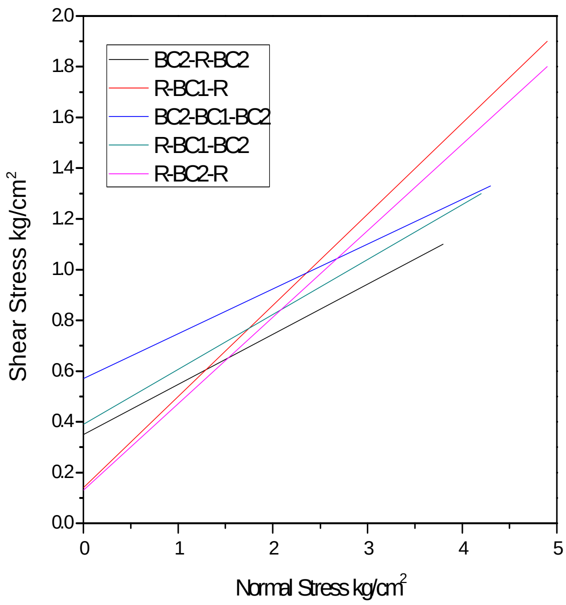

Fig 4.2 Shows variation of shear strength of different layer of combinations of soils for BC2-R-BC2,R-BC1-R,BC2-BC1-BC2, R-BC1-BC2, R-BC2-R.

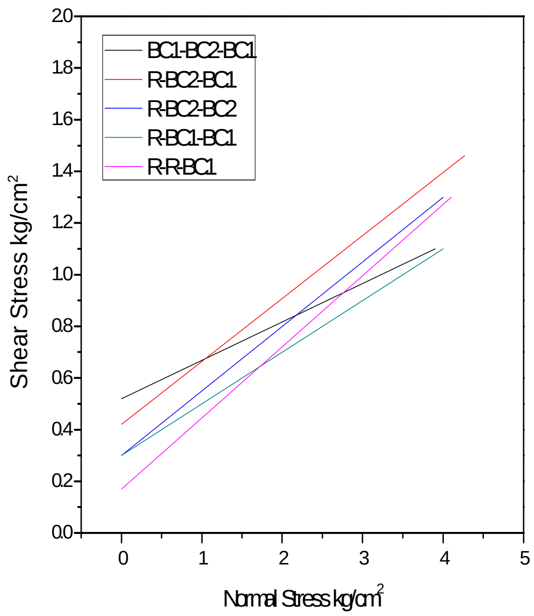

Fig 4.3 Shows variation of shear strength of different layer of combinations of soils for BC1-BC2-BC1, R-BC2-BC1, R-BC2-BC2,R-BC1-BC1,R-R-BC1.

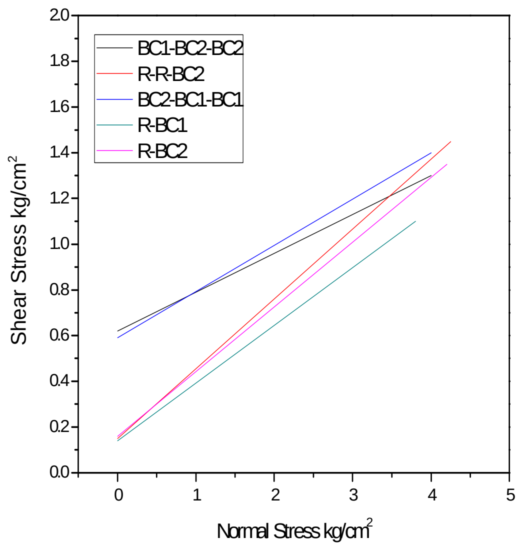

Fig 4.4 Shows variation of shear strength of different layer of combinations of soils for BC1-BC2-BC2, R-R-BC2, BC2-BC1-BC1, R-BC1, R-BC2.

5. CONCLUSIONS

Based on the results and discussions, the following conclusions were drawn;

1. Addition of the layer of course grained soil (red soil) with the fine grained soil (BC_1 and BC_2) leads to increase in the angle of friction and decrease in the cohesion.
2. The minimum and maximum shear strength of 0.43 kg/cm^2 (BC_1-R-BC_1) and 0.71 kg/cm^2 (R-BC_2-BC_1) is obtained when course grained soil layer is in between and top of the cohesive soil layer respectively for the three equal thickness layered soil system.
3. The shear strength for the fine grained soil without insertion of the course grained soil layer in the fine grained soil layer. The maximum and minimum shear strength of 0.81 kg/cm^2 (BC_2-BC_1-BC_1) and 0.64 kg/cm^2 (BC_1-BC_2-BC_1) is obtained for the three equal thickness layered soil system respectively.
4. With insertion of the course grained soil layer on the fine grained soil layer, the maximum and minimum shear strength of 0.46 kg/cm^2 (R-BC_2) and 0.36 kg/cm^2 (R-BC_1) is obtained for the two equal thickness layered soil system respectively.
5. For the two unequal thicknesses layered soil system, the minimum and maximum shear strength of 0.47 kg/cm^2 (R-BC_1-BC_1) and 0.57 kg/cm^2 (R-BC_2-BC_2) is obtained when the insertion of the course grained soil layer in the fine grained soil layer respectively.
6. It is observed that, the increase in the normal stress with increase in shear stress.

6. SCOPE FOR FURTHER INVESTIGATION

- The present experimental work can be conducted on dynamic method on cyclic loading.
- The study on liquefaction of heterogeneous and homogenous of various soils by using dynamic method.
- This present project study can be carriedout for different types of soils such as shedi soil, sandy soil etc., for the different combination of layers for both dynamic and static methods

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