American Journal of Applied Scientific Research
2016; 2(6): 87-90
http://www.sciencepublishinggroup.com/j/ajasr
doi: 10.11648/j.ajasr.20160206.19
ISSN: 2471-9722 (Print); ISSN: 2471-9730 (Online)

Review Article

Influence of Different Soil Properties on Shear Strength of Soil: A Review

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To cite this article:
Vaibhav R. Dhawale, Shrikant M. Harle. Influence of Different Soil Properties on Shear Strength of Soil: A Review. *American Journal of Applied Scientific Research.* Vol. 2, No. 6, 2016, pp. 87-90. doi: 10.11648/j.ajasr.20160206.19

Received: October 29, 2016; **Accepted**: December 6, 2016; **Published**: January 16, 2017

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 unsaturated soil mechanics is receiving increasing attention from researchers and as well as from practicing engineers. The present work is a review of research articles related to shear strength calculations for different conditions of strata and other parameters.

Keywords: Shear Strength, Soil, Moisture Content, Deviator Stress and Displacement

1. Introduction

Investigation that were carried out to determine the influence of clay content on the strength and compressibility of sandy soils in the Voltaian formation of Ghana using the clay content in the naturally occurring soil. Field observations show that the predominant soil type of the Voltain formation is mainly sands, however, the sand occurs with different amounts of clay, silt and gravel [1].

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 [2].

The internal friction angle of soil was not significantly affected by the suction and as well as the drying-wetting SWCCs of soils. The apparent cohesion of soil increased with a decreasing rate as the suction increased. Further, the apparent cohesion obtained from soil in wetting was greater than that obtained from soil in drying. Shear stress-shear displacement curves obtained from soil specimens subjected to the same net normal stress and different suction values showed a higher initial stiffness and a greater peak stress as the suction increased. In addition, it was observed that soil became more dilative with the increase of suction [3].

The strength behaviour of polypropylene fibre reinforced soil samples were studied using unconfined compressive strength test and direct shear test respectively. The results have been interpreted in terms of stress-strain behaviour, variation of failure strain and stress, effect of fibre content, and other strength parameters. Based on study results it is recommended that use of polypropylene fibre in civil engineering for improving soil properties is advantageous because it causes significant improvement in the compressive and shear strengths of the soil [4].

Soil moisture content influences soil failure mechanism machines greatly. Soil moisture content also has a great influence on other soil parameters, this interaction between soil moisture content and other soil parameters is not fully understood, but most of researchers have reported that increasing moisture content will affect in decreasing of shear strength parameters. The soil density was concurrently decreasing alsoas the moisture content was increased [5].

Shear strength of statically compacted samples of Shiraz silty clay was studied using saturated and unsaturated CD triaxial tests. The deviatoric stress was corrected considering the variation of sample average diameter during each test. Volume change and diameter measurements were determined using digital image processing. The effective friction angle and cohesion of Shiraz silty clay were determined as 30.4 degrees and 4.3 kPa, respectively, based on the results of tests on saturated specimens [6].

An increase in in situ density (InD), bulk density (BulD), and maximum dry density (MDD) gave a corresponding increase in the dependent variables of California bearing ratio (CBR) and undrained shear strength (Su). While a decrease inoptimum moisture content (OMC), natural moisture content (NMC), and group index (GI) of the soils led to an increase in the dependent variables for the soils [7].

By using the threshold values of the shear strength parameters and using the typical un-failed cross-sections for both in granitic and sedimentary residual soils, SLOPW W analysis was carried out. It was found that, the values of factor of safety were less than 1, for slope with water table at ground surface. The water table at the ground surface is the most critical slope stability condition of a slope [8].

The density and shear strength variation of the soil with variation of water content between consistency limits has been evaluated. Based on which it is under stood that the shear strength and density decreases with increase in water content of a soil-water mixture. The values of shear strength at consistency limits are observed to be within the range suggested [9].

The rapid growth in population and industrialization cause generation of large quantities of effluents. The bulk effluents generated from industrial activities are discharged either treated or untreated over the soil leading to changes in soil properties causing improvement or degradation of engineering behaviour of soil. If there is an improvement in engineering behaviour of soil, there is a value addition to the industrial wastes serving three benefits of safe disposal of effluents, using as a stabiliser and return of income on it [10].

2. Methodology

2.1. Determination of Undrained Shear Strength

The undrained shear strength of clayey soil is determined by the Laboratory and Field Vane Shear Tests as per IS: 2720. This test is prescribed in ASTM D4648/ D4648 M-10. It provides a rapid determination of shear strength on undisturbed or remolded or reconstituted soils. This test method covers the miniature vane test in very soft to stiff saturated fine-grained clayey soils (ϕ = 0). It was observed that in each test, a shear zone formed after long shear displacement. The soil within the shear zone became very clayey and showed lower internal friction angles. Examination of shear-zone microstructure revealed that the change from sliding shear to turbulent shear may be the mechanism of the displacement-rate-dependent shear strength [11]. Figure 1 shows the details of Relation between undrained shear strength and moisture content.

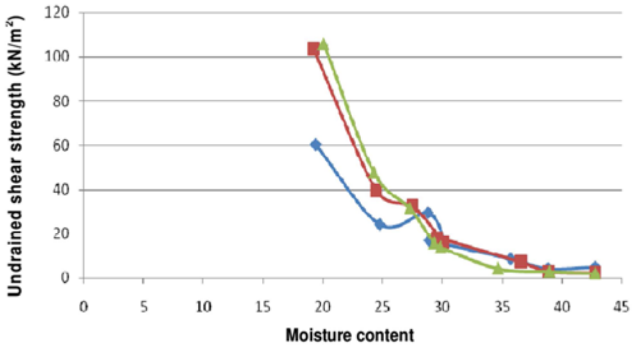

Figure 1. *Relation between undrained shear strength and moisture content [11].*

2.2. Behavior of a Lateritic Tropical Soil

The experimental program was executed to investigate the behavior of a lateritic tropical soil, taking into account the effect of changes in suction as well as in confining pressure. Tests were performed to evaluate the shear strength of the soil under two different compactive states: undisturbed (loose) and compacted. The tests were interpreted using Mohr-Coulomb failure criterion. Stress-strain and volume change curves for undisturbed and compacted saturated soils under different confining stresses are presented in Figure 2 [12].

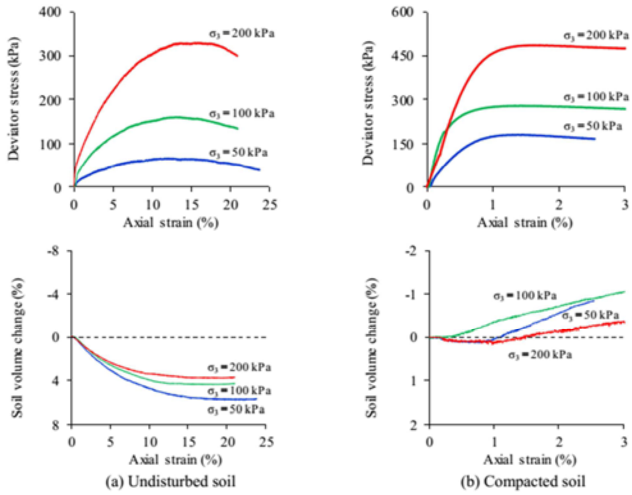

Figure 2. *Stress-strain and volume change curves for undisturbed and compacted saturated soils under different confining stresses.*

2.3. Shear Strength of the Species

The results showed that the shear strength of all species studied increased steadily with increasing displacement and gradually fell down when the maximum strength achieved (Figure 3). Moreover, it was observed that the samples studied increased in the value of shear strength as the stem diameter increasing. However, there was a slight different condition occurred in L. leucocephala, with the stem diameter of 2.5 cm. An abrupt increment occurred in this sample as compared to the sample with 4.3 cm of stem diameter. A different trend was observed where it achieved a higher shear strength and displacement. The results gathered from the field shear box test indicate that the shear strength of most samples increased gradually with increasing of stem diameter. Acacia mangium had the highest shear strength at the higher load (24.3 kPa) compared to the other species. In terms of cohesion factor and average root diameter, Leucaena leucocephala had the highest value. [14].

3. Methodology

3.1. Triaxial Tests with Monotonic Loading

Experimental triaxial tests with monotonic loading to develop empirical relationships to estimate undrained critical shear strength was carried out. The effect of the fines content on undrained shear strength is analyzed for different density states. The parametric analysis indicates that, based on the soil void ratio and fine content properties, the undrained critical shear strength first increases and then decreases as the proportion of fines increases, which demonstrates the influence of fine content on a soil's vulnerability to liquefaction. A series of monotonic undrained triaxial tests were performed on reconstituted saturated sand-silt mixtures. Beyond 30% fines content, a fraction of the silt participates in the soil's skeleton chain force. It was observed that the critical undrained shear strength decreases in a linear manner with increasing equivalent intergranular void ratios, whereas it increases with increasing equivalent relative densities. However, this behavior is only valid for $Fc \leq 30\%$. these results mean that the studied soil exceeds the threshold set by the Chinese criteria and clearly show that this soil is susceptible to liquefaction at fines content of 30% [15].

3.2. Interface Test

From the work reported on the interface tests, it is possible to suggest that if a soil shows a transitional residual mode of behaviour which involves a combination of both turbulent and sliding shear and is sheared against a smooth hard interface (e.g. glass used in this study), the residual conditions can be altered to a sliding shear mode involving a low residual shear strength in comparison to the soil sheared alone. The interface test is a best method to obtain the residual strength of clay soils, constituting a simple, rapid and economical method. This fact is due to easier clay particle orientation at the vicinity of the contact with the interfaces. [16].

3.3. Simple CS Test

Various concepts, devices, and designs were tested including: concentric cylinders, rolling balloons (pcan not be accurately obtained), sliding plates, etc. The selected method presented herein is a very simplified form of axi-symmetric triaxial testing. It allows for the proper measurement of all needed parameters and requires minimum, low-cost components that are readily available in all geotechnical laboratories and field installations. Figure 3 shows the experimental setup for the simple CS test procedure. The following components are needed: vacuum, thin latex membrane, two plexiglass caps, two O-rings, a graduated cylinder, a porous stone, and a transparent hose. The plexiglass cap with the porous stone is connected to one end of the transparent hose, which is used to monitor the volume change in the specimen. The other end of the hose is connected to the vacuum system, which is used to apply effective confinement. On the grounds of economics, effectiveness, and accuracy, the simple CS test procedure appears as a very convenient and reliable alternative approach for the determination of critical state parameters. While verification studies with soils from different regions are needed to corroborate the methodology, it can be concluded that the simple CS test procedure provides adequate critical state parameter, or (at least) good index values to predict the critical state soil parameters [17].

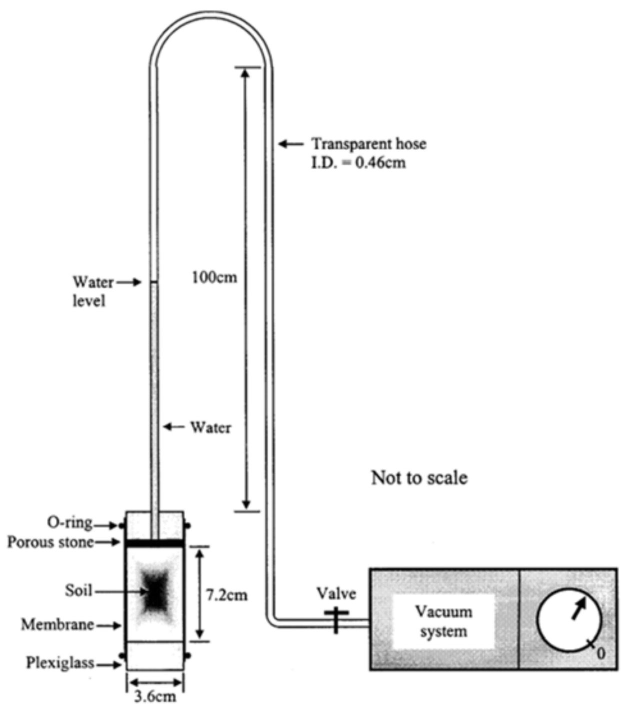

Figure 3. *Device and experimental setup used for the simple CS test [17].*

3.4. Shear Strength of Behavior of Sand Clay Mixture

In order to establish the relationship between the clay Content and shear strength of sandy soil, the shear Strength parameters were plotted against the clay content And the graph were used to determine the correlation Figure 4 shows a graph of the clay content and the cohesion Increases with the increase in the clay content as the more As the more clay is been introduced in the sandy material By this the cohesion increases and the shear strength also increased. It was observed that clay content also increases the cohesion and decreases the friction angle. For such cases, the foundations can be designed as C - Ø soils using the appropriate bearing capacity equations. Assumptions that, the Voltaian soils are mostly sands and foundations designed as granular soils (Ø soils) can lead to catastrophic failures [18].

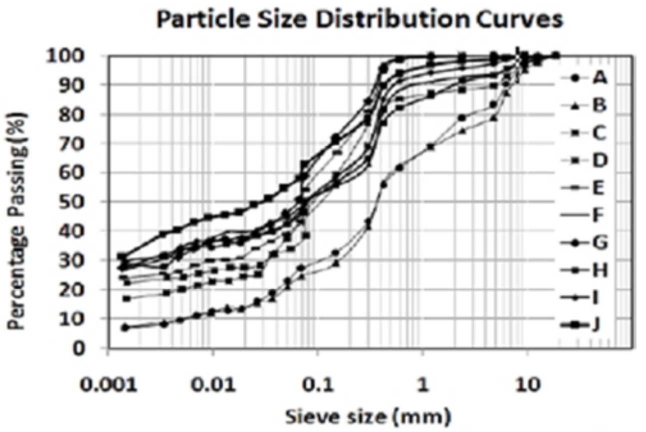

Figure 4. *Particle size distribution curve [18].*

4. Conclusion

The present work is to review the different tests and methodologies adopted by the various researchers. From the above study it is clear that there is a great influence of soil properties on shear strength of soil. The different parameters are needed to study such as undrained shear strength, stress-strain, volume changes, particle distribution, triaxial test, interface test, etc.

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