International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

Replacement of Conventional Proving by Load Cell in Triaxial Test Apparatus

Prashant B. Pande,
Assistant Professor, YCCE, Nagpur
Dr. S.R Khandeshwar,
Professor, YCCE, Nagpur
Dr. S.P.Bajad,
Lecturer, Government Polytechnic, Murtizapur

ABSTRACT:
It is necessary to make modifications to conventional shear strength testing equipment in order to independently measure or control pressures in the voids of unsaturated soil. The arrangement to measure or control air pressure to the soil specimen in a triaxial apparatus is discussed in this paper. Proposed work is planned for determining unsaturated shear strength parameters by measuring pore-air and pore-water pressures. One small modification has been made by replacing conventional proving ring 'S' type load cell to get precise axial load (Deviator) stress. The results obtained by performing unconsolidated undrained tests for four different initial water content with conventional proving ring are well agreed with 'S' type load cell results.

Keywords: Unsaturated soil, Triaxial Test apparatus, Suction measurement.

INTRODUCTION

The safety of many engineered structures is dependent upon the strength of the underlying soil. Bearing capacity, lateral earth pressures, and slope stability are examples of common geotechnical applications that depend on the shear strength of the soil. The soils used for the construction of engineered structures are often unsaturated soils. To evaluate the shear strength of unsaturated soils it is necessary to make modifications to conventional shear strength testing equipment in order to independently control pressures in the voids (air and water phases). The presence of air and water in the pores of the soil causes the testing procedures and techniques to be considerably more complex than when testing saturated soils.

Modifications to shear strength testing apparatuses to accommodate unsaturated soils were commenced in the 1950s. The primary modifications are associated with the independent measurement and/or control of the pore-air and pore-water pressures. In this paper the final attempt to measure or control is discussed by reviewing the various methods already used for measurement and/or control of the pore-air and pore-water pressures and one small attempt to replace the conventional proving ring by 'S' type load cell is presented. In this study we are trying to propose a simple, low cost, and quick way for predicting unsaturated soil shear strength parameters by using uncomplicated testing procedure.

LITERATURE REVIEW AND THEORY

The last few decades has seen an enormous development in the science of geotechnical engineering. This development comprises modification of various test apparatus like digitization, computer process or attachment required to measure various parameters. In advance geotechnical engineering the new concept of unsaturated soil mechanics it is required to measure suction.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

The triaxial shear device evolved over a period of years. Triaxial shear invented by A. Casagrande and Karl Terzaghi in 1936-1937 in U.S.A. Early devices with many of the characteristics of current triaxial devices were originated by Buisman (1924) and Hveem (1934) according to Endersby (1950) but the first devices that resembled modern equipment were developed in the early 1930's by Casagrande at Harvard and Rendulic in Vienna, both apparently under the direction of Terzaghi.

Over the past 50 years, several advancements have been made in the research area of the mechanics of unsaturated soils. One of the area of advancements is development (or improvement) of testing techniques (or apparatus) require to determine the mechanical properties of unsaturated soil. In last two decades in the mechanics of unsaturated soils, various techniques of measuring and controlling suction have been adopted and/or further developed. These techniques have been described in detail in various papers (including Ridley and Wray 1996, Agus and Schanz 2005, Rahardjo and Leong 2006).

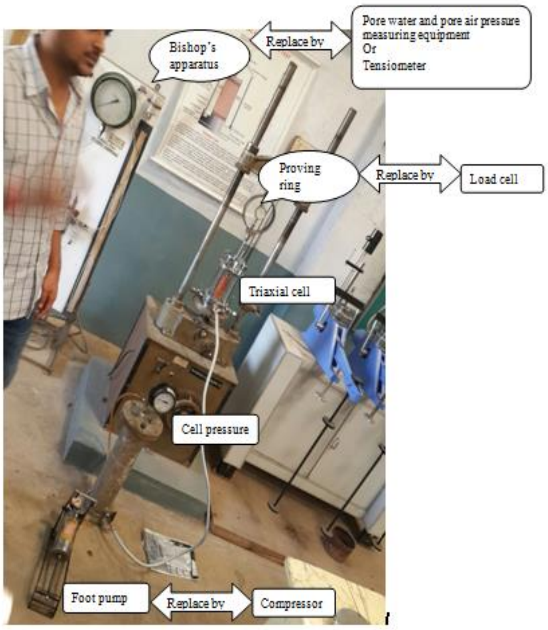

Fig. 1 Plan for modification of conventionnal triaxial test apparatus

Plan of Work

Conventional triaxial equipment requires that a number of modifications be made to the equipment prior to attempting to test unsaturated soils. All modification were planned for characterization of unsaturated and saturated black cotton soil by using modified triaxial test apparatus under various drainage conditions. But initially proving ring was replaced by ‘S’ type load cell (digital load cell). This modification is to get accurate results at lower cost and lesser time with high degree of precision.

Conventional proving ring is replaced by ‘S’ type load cell to get precise axial load (Deviator) stress. Total six unconsolidated undrained tests has been performed on black cotton soil (Nagpur region) having some fines. Preliminary results obtained from unconsolidated undrained tests on specimens representing four different initial water content i.e. 16%, 18%, 20%, 22% saturated shear strength parameters by using conventional proving ring are compared with ‘S’ type load cell results and presented in this paper. An attempt to provide quick, simple and economical results with accuracy is necessary in the field of soil mechanics.

Above figure gives the master plan for modification of Triaxial Test apparatus from which one modification has been done.

Soil Properties

According to IS:1498-1970 grain size classification the soil used in this work can be classified as uniformly graded fine clayey soil having 20 to 25 % fines (SW-SM). Specific gravity (G) of a soil was found to be 2.06. Liquid limit and Plastic limit was found to be 40.1% and 25% respectively. Plasticity Index(I_p) & Flow index(I_f) & Toughness index (I_t) were 15.1, 10.2 & 1.48 respectively.

Maximum dry density is = 1.62 gm/Cu.cm

Optimum moisture content was found to be 18%.

Experimental work

In order to carry out the test program in the laboratory on soil sample of varying water content, all the errors were removed. For comparing the results obtained from conventional as well as modified traxial test apparatus. To obtained the shear strength parameters of each soil sample test were conducted with three different cell pressure i.e. 1 kg/cm2, 1.5 kg/cm2, 2 kg/cm2.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

Sample preparation

Before commencing the test, sample is prepared to simulating the required condition. The compaction of the soil for the extraction of sample is done after pulverization of the soil. The Standard Proctor is used for the compaction soil. Before placing the soil into the compaction mould the soil is properly mixied with desired water content. Then the soil is compacted in three layers by putting 25 numbers of blows on each layer. Now the samplers (hollow metallic pipe) were penetrate into the compacted soil with the help of mechanically driven jack as shown in fig 2a. . Then the sampler containing soil sample placed on the extractor machine where it is manually driven to extract the soil sample as shown in Fig. 2

Fig. 2a Mechanically driven jack

Fig. 2b Sample Extractor

The extracted soil sample was covered with rubber membrane with the help of fabricated rod having the arrangement of covering the sample with rubber membrane. The soil sample covered with membrane was fixed in the Triaxial chamber. The arrangement of Triaxial set up attached with conventional proving ring is as shown in fig. 3a which is used for measuring applied axial load. The constant cell pressure is then applied with help of foot pump and the compressor cylinder.

The triaxial shear test were carried out as per IS code with different initial water content such as 16%, 18%, 20% and 22% to obtained saturated shear strength parameters by using conventional proving ring.

Fig. 3a Triaxial loading arrangement with proving ring

Fig. 3b Triaxial loading arrangement with 'S' type load cell

One sample e.g. initial water content 16 % is tested for three different cell pressure i.e. 1kg/cm^2, 1.5 kg/cm^2, 2 kg/cm^2. We observed the proving ring reading for three different cell pressures by application of axial load at ____ strain rate. Graphs between cell pressure and ultimate deviator stress were plotted for obtaining shear strength parameters (C and phi) as shown in fig. 4

The same procedure was followed by replacing the proving ring 'S' type load cell having digital display as shown in fig. 3b . In this paper we include the graph for 16% water content as shown in fig. 5.

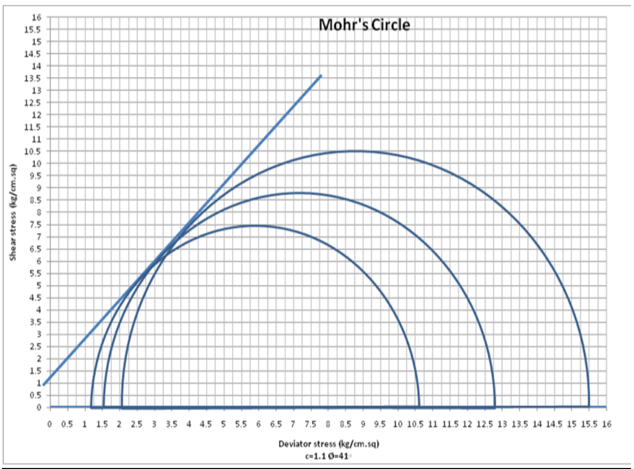

Fig. 4 Graph between deviator stress and shear stress obtained from conventional triaxial test apparatus

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

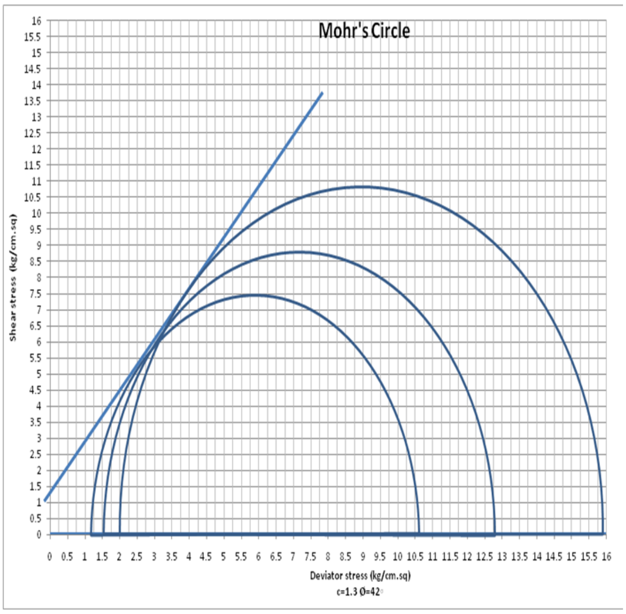

Fig. 5 Graph between deviator stress and shear stress obtained from Modified triaxial test apparatus

EXPERIMENTAL RESULTS AND CONCLUSION

Table 1 Comparision of conventional and modified Deviator stresses

Water content %	Cell pressure (kgf/sq.cm)	Deviator stress (kgf/sq.cm)	
		Conventional	Modified
16	1	10.517	10.615
	1.5	12.739	12.896
	2	15.416	15.762
18	1	6.650	6.716
	1.5	8.079	8.180
	2	9.911	9.992
20	1	5.495	5.696
	1.5	7.073	7.120
	2	8.858	8.779
22	1	4.330	4.150
	1.5	4.890	6.065
	2	7.676	7.741

Table 2 Comparision of conventional and modified C and Phi values

Water conte nt (%)	C (kgf/sq.cm)		Phi (o)	
	Convention al	Modifie d	Convention al	Modifie d
16	1.1	1.3	41	42
18	0.9	1	34	33
20	0.65	0.8	32	31
22	0.4	0.4	30	30

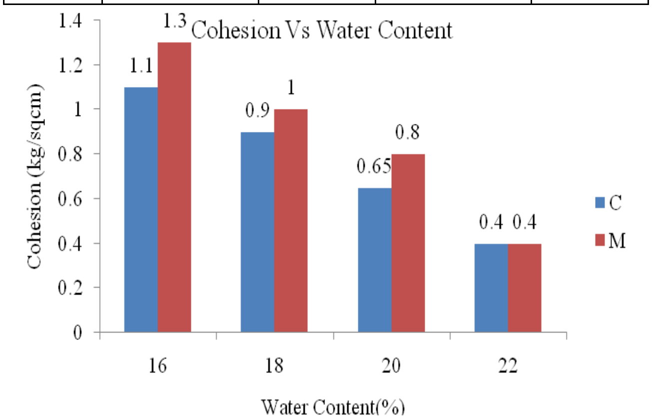

Fig. 6a Graph between Cohesion and water content

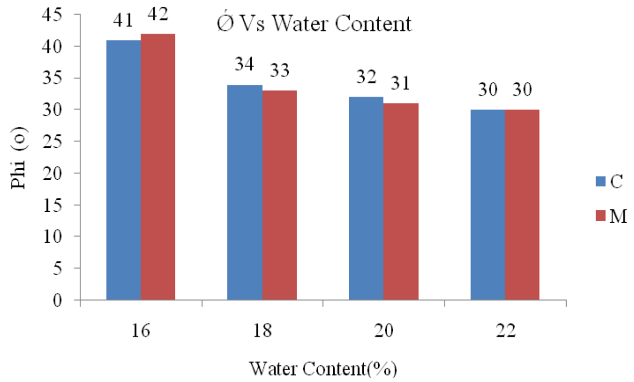

Fig. 6b Graph between Ó and water content

- From the graph as shown in figure 6a and 6b it is found that values of cohesion and angle of internal friction is nearly same.
- From the detailed analysis performed and the results obtained it can be inferred that the conventional shear test apparatus has many limitations. Some limitations are being removed in the proposed modified shear test apparatus used in this project.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 1
January 2018

- The accuracy of readings is improved and the working and understanding of this apparatus is relatively easy.
- The results obtained are faster and economical than conventional test. Further, pore pressure apparatus can be also installed along with the apparatus used in the project for the measurement of pore pressure.
- The results found are nearly same but the accuracy is increased due to digitalization of the readings. Errors are also reduced. The relationship between shear strength and the ratio of shear strength to net normal stress is coincide with the effective angle of internal friction of the saturated soil.
- The distinct differentiation between the conventional and the modified apparatus can be tabulated as below
- The distinct differentiation between the conventional and the modified apparatus can be tabulated as below

Conventional apparatus	Modified apparatus
1. It has complex design	1. It has simple design
2. Cost is more.	2. Cost is lesser than conventional one.
3. Readings are less accurate due to some external affects like magnetic deflection.	3. Readings are accurate as compared to conventional apparatus.
4. It requires more attention	4. It requires less attention while taking reading
5. There may be errors in reading.	5. Errors can be minimized.
6. Calculation process is quite lengthy.	6. Calculation procedure is simple.

FUTURE SCOPE

Hence, a detailed research in the field of shear strength parameters measurement of Unsaturated Black Cotton soil can be undertaken. This work has been carried out for Black Cotton soil available in Vidarbha region (India). Further study can be proceed with further modifications.

In this work we have replaced conventional proving ring with 'S' type load cell. But as plan of this research work it could not possible to replace or attach the equipment for measuring pore-air and pore-water pressures due to some constraints. So, the further modifications are associated with the independent measurement and/or control of the pore-air and pore-water pressures. It is necessary to make modifications to conventional shear strength testing equipment in order to independently control pressures in the air and water phases. The use of the axis translation technique in the shear strength measurement of unsaturated soil is recommended.

REFERENCES

1. C. Venkatramaiah, Geotechnical Engineering, New age international publishers.
2. Vikas Thakur, 'Laboratory Investigations on Extremely High Suction Measurements for Fine-grained Soils', Article In Geotechnical And Geological Engineering, January 2014.
3. C. Venkatramaiah,'' Geotechnical Engineering, New age international publishers'
4. Murthy, V. N. S. (1974), Soil Mechanics and Foundation Engineering, Dhanpat Rai& Sons, Delhi
5. Soil Mechanics & Foundation Engineering 7th Edition2009Arora K.R. Standard Publisher Distributors
6. Soil Mechanics & Foundations 16th Edition 2009 Punmia B. C. Standard Book House, New Delhi
7. Fredlund, D. G. and Vanapalli, S. K. 2002. Shear Strength of Unsaturated Soils. *Agronomy Soil Testing Manual*, Agronomy Soiciety of America, 329-361.
8. Fredlund, D.G. and Rahardjo, H. 1993. Soil mechanics for unsaturated soils. John Wiley and Sons, INC., New York.
9. Fredlund, D.G. and Xing, A. 1994. Equations for the soil-water characteristic curve. Canadian Geotechnical Journal. 31: 517-532.
10. Gan, J. K. and Fredlund, D. G. 1988. Multistage direct shear testing of unsaturated soils. *Geotechnical Testing Journal*, 11 (2), 132-138
11. Terzaghi, K. 1943. Theoretical soil mechanics. Wiley Publications, New York.
12. Uchaipichat A. Prediction of Shear Strength for Unsaturated Soils under Drying and Wetting Processes

Vanapalli, S.K., Fredlund D.G., Pufahl, D.E. and Clifton, A.W. 1996. Model for the prediction of shear strength with respect to soil suction. Canadian Geotechnical Journal, 33: 379-392.