COMPARATIVE STUDY OF THE CALIFORNIA BEARING RATIO TEST AND UNDRAINED TRIAXIALCOMPRESSIVE STRENGTH TEST FOR LATERITIC SOILS

Aboshio, A.

Civil Engineering Department Bayero University, Kano

ABSTRACT

This paper assesses the possibility of substituting the Undrained Triaxial Compresion Test (UTCT) for the California Bearing Ratio (CBR) test for use in pavement design and construction. The UCTC and the CBR tests were performed on samples obtained on site as well as specimens subjected to 24 hours soaking to simulate possible field conditions. Using regression analysis, relationship between UTCT and CBR tests results was developed. The apparently high value of 0.945849 correlation coefficient of this relationship indicate the possibility of substituting the UTCT for the CBR test in the characterization of lateritic soils for pavement design and construction. A model: $UTCS=0.0257(CBR)^2 + 0.3183CBR + 114.48$ was developed for obtaining UTCS values in terms of CBR and vice versa. Statistical test carried out on the results shows that the coefficient of determination (R-squared) is 0.9191. Hence the adoption of the new equation is strongly recommended.

SIGNIFICANCE: The results of the research study presented in this paper are promising and encouraging as they promote simplistic methods of laboratory testing that can be used in the design of pavements. It confirms the possibility of substituting the CBR test results with the UTCT test results and vice –versa in evaluating the characteristic of lateritic soils.

KEYWORDS: California Bearing Ratio, Undrained Triaxial Compression Test, Correlation Coefficient, Regression Analysis

1.0 INTRODUCTION

A good understanding of the properties of any given soil is essential for its use both in building and pavement design. An index most commonly used to determine the suitability of a soil as a construction material in pavement design is the California Bearing Ratio (CBR) test. In this test procedure, a compacted, soaked soil specimen is loaded at a constant rate until a defined deformation is reached. This test provides an indirect measure of the shear strength of a soil. Some researchers such as Garber and Hoel, (1997) cited in Vogrig et al (2003) have reservations in using the *CBR* test procedure, as it does not properly simulate the shearing forces imposed on sub-soils that underlie a pavement structure. Determination of shear strength parameters of soil needed in foundation designs for building works however employs the use of either the shear box test method or the more accurate undrained triaxial compression test method.

Lateritic soils have been identified as the most common material that is routinely used in Civil Engineering works in the tropical as a result of its availability and cost effectiveness (Uche 2007). Smith (1990) cited in Aboshio (2002) defines laterite as residual ferruginous clay-like deposit which generally occur below a hardened ferruginous crust or hardpan. He added that laterite are formed by chemical weathering under warm humid tropical condition when the rain water leaches out the soluble rock material leaving behind the insoluble hydroxides of iron and aluminium, given them their characteristic red-brown colour.

Remillion (1967) cited in Obeahon (1989) used crushing test and field penetration test results to report that the strength test of lateritic soils vary mainly with texture. He added that CBR test is the most popular test for assessing strength of lateritic soils. Badorin (1969) also cited in Obeahon (1989) report that Triaxial Compression test have been used in assessing the strength of a few of lateritic soils.

Correlation of soil material properties using different laboratory methods has been investigated by many researchers in the recent past. Sivaruban and Vipulandan (2008) correlated the Houston area Clay with artificial soil mixtures of Kaolinite, Bentonite and Sand mixtures. Sicrikaya and Kayadelen (2008) correlated compaction energy with compaction parameters like maximum dry density and optimum moisture content. Danistan and Vipulandan (2009) developed a model that relates the shear strength of soil material mixed with Bentonite, Kaolinite and Sand with the CBR laboratory results. Hussin (2008) correlated shear strength parameters of marine clay, white clay and white kaolin of Jahor Bahru town in Malaysia using Vane shear test method with the CBR. The relationship (model) between CBR and other strength evaluation methods vary with the type of soil and method employed. It is against this background that this research was conducted on the readily available lateritic soil materials.

2.0 MATERIALS AND METHODS

2.1 Materials: The lateritic soils used in this study were all obtained in Kano-Nigeria and from a borrow pit in Janguza along Gwarzo road and within Bayero University, Kano Senior Staff quarters at various depths of 0.5m, 1.2m and 2m.

2.2 Methods: Soil Samples collected were prepared and tested for Atterberg limits, Moisture -Density relationship, California Bearing ratio (CBR) and the Unconfined Triaxial Compression Test (UTCT) in accordance with BS 1377 (1990). *CBR* test Specimens were compacted in *CBR* moulds (Heavy British Standard Proctor) for 24 hours soaked and un-soaked conditions. Unconfined Triaxial Compression strengths (*UTCS*) were also determined on specimens that were prepared in a similar manner as the *CBR* test specimens. The unconfined triaxial compression test was chosen in this study because it is a quicker and simpler test to perform. Statistical methods were employed to establish a relationship between the two test methods.

3.0 RESULTS AND DISCUSSION

Results of tests carried out on the samples are summarized in Table 1. Using the Casagrande-A line chart, samples 2, 4 and 8 can be classified to contain inorganic clay of medium plasticity while the other samples contains inorganic clay of low plasticity.

Table 1: Summary of laboratory tests results

Sample No.	Classification based on Casangrande 'A line chart'	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Moisture Content (%)	Dry Density (Mg/m^3)	CBR (%)	Shear strength (kN/m^2)	Remark
1	Inorganic clay of low plasticity	27.20	18.05	9.15	8.4	2.05	68	265.68	Un-soaked samples
2	Inorganic clay of medium plasticity	36.00	19.50	16.5	8.6	2.04	70	275	‘’
3	Inorganic clay of low plasticity	28.20	16.60	11.6	6.7	2.22	32	177	‘’
4	Inorganic clay of medium plasticity	34	23.9	10.1	8.9	2.14	86.5	320	‘’
5	Inorganic clay of low plasticity	26	17.1	8.9	7.2	1.98	58.2	230	‘’
6	Inorganic clay of low plasticity	30	18	12.0	6.8	1.71	23.5	99.56	Soaked sample
7	Inorganic clay of low plasticity	20	12.2	7.8	9.1	1.69	14.75	149.8	‘’
8	Inorganic clay of medium plasticity	32	21	11	8.4	1.58	18.24	135.71	‘’
9	Inorganic clay of low plasticity	28	18.8	9.2	5.9	1.87	32.2	127.65	‘’
10	Inorganic clay of low plasticity	26	16.3	9.7	7.6	1.84	37.01	146.32	‘’

CBR values obtained in this study range between 14.75% and 86.5% and the shear strengths (UCTS) results range between 99.56kN/m^2 and 320kN/m^2. Strength results for both CBR and UTCT recorded are low for soaked samples when compared with the un-soaked samples. This simulates the effect of water on the strength parameters of these samples.

Regression analysis results are summarised in Table 2 and the variations of UTCS with CBR values are presented in Figure 1. A polynomial relationship: UTCS=0.0257(CBR)^2 + 0.3183CBR + 114.48 with correlation coefficient of 0.945849 describes the relation. The correlation coefficient of the two set of data indicates a possibility for substituting the CBR values for the UTCS results.

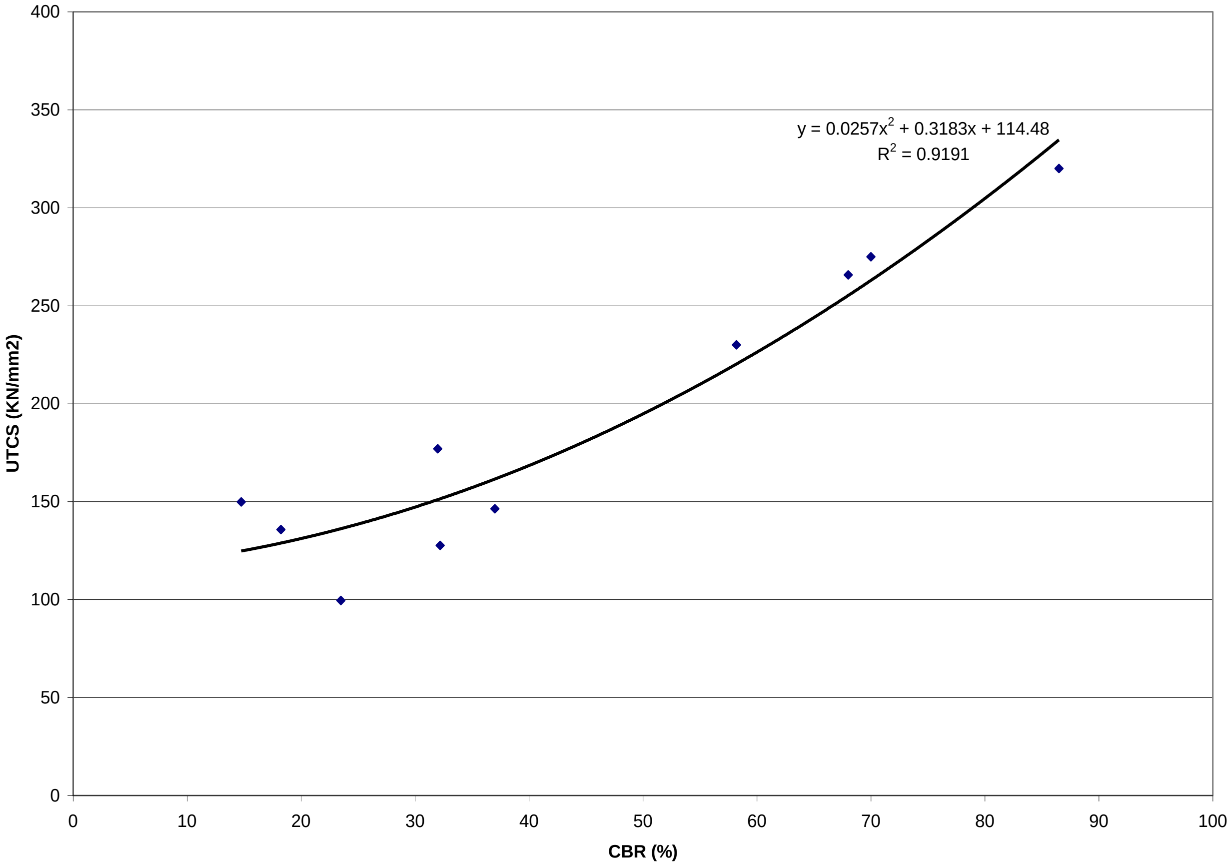

Figure 1: The variation of UTCS with CBR values

Table 2: Regression Statistics

Parameter	Result
Correlation coefficient	0.945849
R Square	0.91910
Adjusted R Square	0.964182
Standard Error	27.38278
Observations	10

4.0 CONCLUSION

On the study presented in this paper, it was concluded that a strong relationship exists between CBR and UTCS. On the basis of this relationship, the UTCS results can possibly replace the CBR test results in the characterization of Lateritic soils for pavement design and construction.

4.0 REFERENCES

Aboshio, A (2002); An alternative to California Bearing Ratio test for lateritic soils, an unpublished B. Eng thesis submitted to the Department of Civil Engineering, Bayero University, Kano

BS 1377 (1990); Method of testing soils for civil engineering purposes, British standard institude London

Danistan, J. and Vipulanandan, C. (2009); Relationship between CBR values (unsoaked) and undrained shear strength of artificial CH soils, Conference paper of the Center for Innovative Grouting Material and Technology, Department of civil engineering and environment, University of Houston, Houston, Texas

Hussin, N.A (2008); Correlation between CBR value and Undrained shear strength from vane shear test; published B. Eng thesis submitted to the department of Civil engineering Tekoloji, Malasia

Vogrig, M, McDonald, A, Vanapall, K., Siekmeir J, Roberson R and Garven E (2003); A Laboratory technique for estimating the Resilient modulus of unsaturated soils specimens for CBR and Unconfined compression test; A paper presented at the 54th Conference of Canadian geotechnical engineers, Canada.

Obeahon, O. S., (1989); The use of burn clay bricks powder for the stabilization of Kano laterites, An unpublished B. Eng thesis submitted to the department of civil engineering, Bayero University, Kano.

Sicrikaya, O and Kayadelen, C (2008); Estimating compaction behaviour of fine grained soils based on compaction energy, Canadian Geotechnical Journal, pp 877-887

Sivaruban, N. And Vipulanandan, C. (2008).Wet Unit weight and moisture content relationship for national clay deposits in Houston – Texas. Conference paper of the centre for Innovative Grouting Materials and Technology, Department of Civil Engineering and Environment, University of Houston, Texas.

Uche, O.A.U (2007); The effect of Donkey-Dung on the properties of lateritic soilcrete blocks, Journal of Engineering and Techniology vol. 2 no. 1 pp 45-54