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EFFECT OF ORGANIC CONTENT ON STIFFNESS OF CRICKET PITCH SOIL

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ABSTRACT

The main objective of this study was to investigate the effect of organic content on the stiffness of cricket pitch soil. Limited research has been carried out focusing on the preparation of grass mixed pitch soil in the laboratory that could simulate in-situ conditions. Soil samples were collected from selected international cricket pitches of Bangladesh. Soil mixture was prepared by mixing pitch clay powder specimens thoroughly with fixed portions of wooden dust (as an organic content like grass) and water (near optimum moisture content). A number of test specimens with varying proportions of wooden dust were prepared. The prepared soil specimen placed in the compaction mold and compacted as per ASTM D1557-12. The prepared soil cakes were tested just after preparation and also after saturation in 24 hours beneath the water. Both soil cake used as unconfined compression test specimens. The investigation reveals that approximately 2% of organic content may be preferable considering stiffness and other factors like maximum dry density, optimum moisture content.

Keywords: *Cricket pitch, Maximum dry density, Organic content, Optimum moisture content, Unconfined strength.*

1. INTRODUCTION

The quality and behavior of the cricket pitch surface is the prime concern of the cricketers. As per ICC operating manual 29.1, guidance for very good pitch rating outfields is well grassed, even covering, no bare patches, no irregularity of bounce, fast/medium pace, etc. The favorable conditions for consistent pitches may vary considerably from country to country, venue to venue and even from match to match depending upon prevailing soil physical/chemical parameters (Baker et al., 2003). The relationships among pace and bounce depend on particle size distribution, dry bulk density and organic content (Baker et al., 2003). He studied the positive correlation between pace and the dry bulk density and sand content of a soil, but there was a negative correlation between pace and moisture content, silt content and organic matter. Factors like moisture content, temperature, humidity, compaction, soil texture and composition, organic matter, etc. affect the properties of a pitch (James et al, 2004). Grasses are also an important factor because it ensures the consistency of a good pitch (Taiton and Klug, 2002). However, the accumulation of grassroots in the pitch increases organic content in pitch. As a result, the bouncing capacity of the pitch becomes low (Taiton & Klug, 2002).

A well-developed root system could increase moisture content in the range of two to five percent with depth (Taiton & Klug, 2002). However, the shear strength of clay soil is known to be highly sensitive to moisture content (Henkel, 1959). Therefore, during preparing pitches, soil moisture content must be kept to a minimum. Hence, for a good bouncy pitch, the optimization of grasses is required to balance the organic and moisture content and maintain stiffness of the pitch soil.

The present study introduces a simplified sample preparation method, which can be used as a representative of grass mixed cricket pitch soil. Cricket pitch clay was first collected from a number of stadiums in Bangladesh. Those clay samples were naturally dried, grounded and passed through 75 µm sieve. To obtain a wide range of moisture content, various amounts of organic content (wooden dust of Shal tree) were added with the clay to prepare the reconstituted samples. Compaction tests were then completed on reconstituted samples. The shear strength characteristics of these samples were studied on both optimum moisture and saturated soil condition. The test results were also compared with the established relationships.

2. SAMPLE COLLECTION AND PREPARATION

In Bangladesh, there are seven international venues of the cricket stadium. For the present study, three samples were collected from different stadiums. The soil collecting sites were namely Bangladesh Cricket Board (BCB-Mirpur), Bangladesh University of Engineering and Technology (BUET) and Rangpur Stadium. The samples were clay soil. Clays collected from BCB had black color, samples collected from BUET and Rangpur had a brown color. The collected clay sample used in this study contained 93% to 98% fines passing through 75 µm sieve. The specific gravity (Gs) of the samples ranged from 2.62 to 2.67. The results obtained from the tests provided liquid limit (LL) ranging from 61% to 84% and plasticity limit varying from 17% to 25%. Table 1 shows a summary of the physical properties of the soil samples collected from several locations. It is noted that the clays of Bangladesh predominantly consisted of illitic or chloritic minerals (Islam et al., 2002).

There are different types of organic matter available. Wooden dust was used as organic material having a specific gravity of 1.57. Wooden dust is locally available and less expensive. The properties of the wood dust were determined and presented in Table 1.

Table 1: Physical properties of clay samples

Material	Specific Gravity, G_s	Liquid limit, LL (%)	Plastic limit, PL (%)	Shrinkage limit, SL (%)	Linear Shrinkage, LS (%)	Flow Index
BCB	2.67	84	25	31	14.9	46.5
BUET	2.62	64	17	13	7.9	39.9
Rangpur	2.65	61	18	8	7.8	17.1
Wooden Dust (shal tree)	1.57	-	-	-	-	-

Table 2: Test scheme used for assessment of stiffness of cricket pitch soil

Pitch Sample	Organic Content	Compaction Test(CT)	Unconfined Compressive Strength(UCS)	
			Saturated Condition	Optimum Moisture Condition
BCB	0%	CT-1	UCS-1	UCO-1
	2%	CT-2	UCS-2	UCO-2
	4%	CT-3	UCS-3	UCO-3
BUET	0%	CT-4	UCS-4	UCO-4
	2%	CT-5	UCS-5	UCO-5
	4%	CT-6	UCS-6	UCO-6
Rangpur	0%	CT-7	UCS-7	UCO-7
	2%	CT-8	UCS-8	UCO-8
	4%	CT-9	UCS-9	UCO-9

3. TEST METHODOLOGY

Reconstituted clays were prepared using collected clay samples with different proportions of organic content. The concept of a reconstituted (RC) soil sample was introduced in the past to simulate the behavior of a normally consolidated clay sample. RC samples were used to assess the influence of soil structure on the mechanical behavior of natural sedimentary clays (Nagaraj & Srinivasa Murthy, 1986; Burland, 1990; Hong & Tsuchida, 1999; Liu and Carter, 1999; Chandler, 2000; Cotecchia & Chandler, 2000). Existing methods for preparing reconstituted clay samples can roughly be divided into two categories, i.e., the compaction and consolidation methods respectively (Yin & Miao, 2015). The reconstituted clay samples were conducted under compacted conditions. Standard testing procedures followed by ASTM D1557-12 was carried out to obtain the maximum dry density and optimum water content. Soil samples were then mixed at optimum water content and cured for a certain period of time. Then the samples were compacted in the compaction mold to prepare test specimen.

Prepared soil cakes were compacted to assess the shear strength behavior of reconstituted modified clays. The soil cakes were submerged in water for 24 hours to observe the behavior in a saturated condition. After submerging, prepared soil cakes were trimmed to retrieve test specimens. To obtain optimum moisture conditions, the test specimen was prepared from reconstituted soil cake after trimming to the required dimension (diameter of 38 mm and height of 76 mm). The test specimen was preserved in an air controlled desiccator. The loading device was adjusted carefully so that the upper plate just made contact with the specimen. Each specimen was tested under strain-controlled conditions. During the progress of the test, load was applied continuously and without shock at a deformation rate of approximately 0.5 millimeters per minute. The total load and corresponding deformations were recorded at sufficient intervals. The test was continued until failure or 20% axial strain of the specimen. The test scheme is presented in Table 2 where CT, UCS, and UCO represent the compaction test, unconfined compression in saturated and unconfined compression in optimum moisture condition.

4. TEST RESULTS

4.1 Compaction Test

A series of compaction test was conducted and results are presented in Figure 1. The ideal water content for maximum compaction is known as the optimum water content. Determining the optimum water content is time-consuming, but once known for a specific bulli, it can be used to assist in achieving a range of compaction options (Hillel, 1980). Optimum moisture content was determined by plotting a curve of dry density versus moisture content of the soil sample. The maximum compaction can be achieved by rolling with a roller at the optimum moisture content of pitch soil. From the test result, it is observed that optimum moisture content value is decreasing with the increasing of organic content

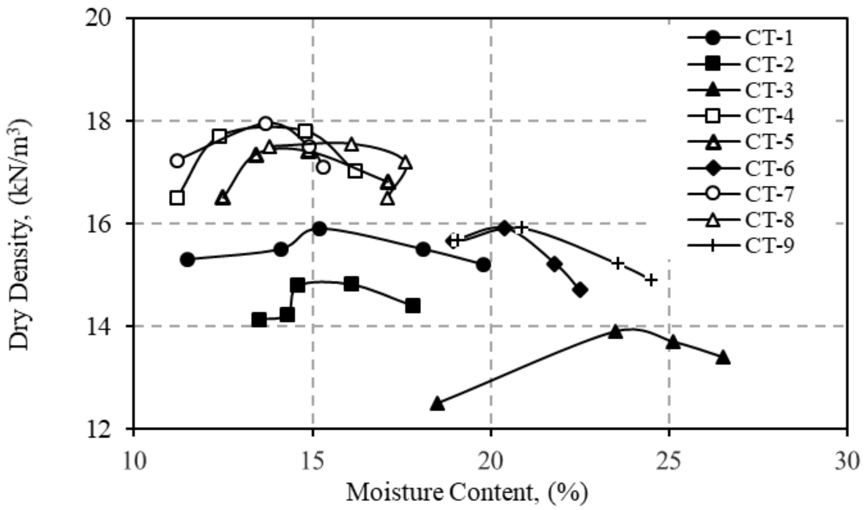

Figure 1: Dry density and optimum moisture content curve of different mixtures of clay

4.2 Effect of organic content on maximum dry density

Physical properties of soil like maximum dry density are affected by organic content. The dry density of soil decreases with an increase in the percent of organic content. This means organic content takes up the spaces that would have been occupied by soil particles and as a result, dry density is reduced. The results are shown below in Figure 2.

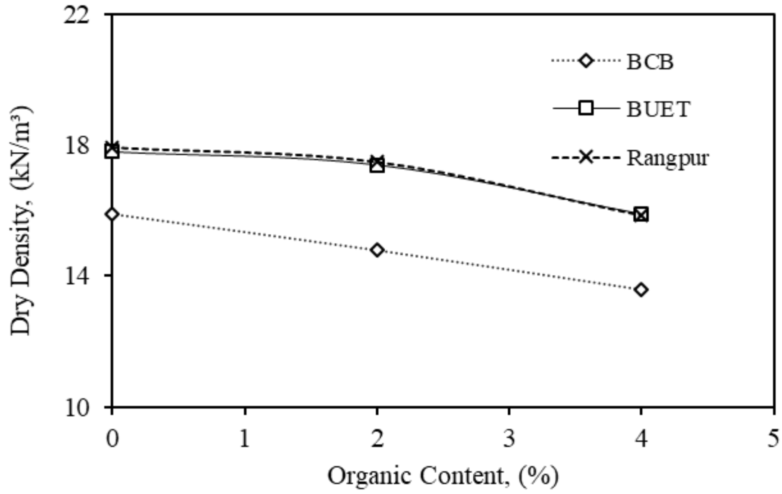

Figure 2: Variation of maximum dry density with percent organic content curve

4.3 Effect of organic content on optimum moisture content

Moisture content is one of the most important governing factors of pitch performance. Moisture content should maintain properly during pitch construction. Moisture content has a strong relationship with organic content. The test result revealed that by adding 4% of organic content with soil, the mixture could hold moisture in the range of 20% to 25%. The test result is shown in Figure 3.

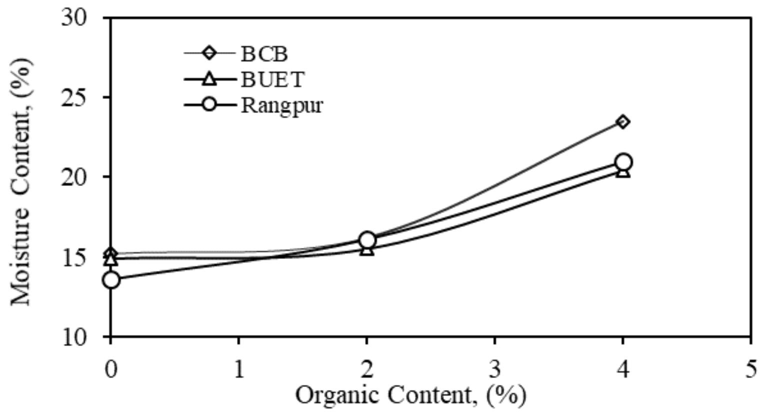

Figure 3: Variation of optimum moisture content and percent organic content curve

4.4 Unconfined compression test

Test specimen were prepared in two ways. Firstly, after submerging in water and other just after extracting from the mold. Both soil cake trimmed to retrieve test specimens. Figure 4 depicts the variation of deviator stress with axial strain at the saturated condition. The test result shown that deviator stress becomes half due to addition at 4% organic content.

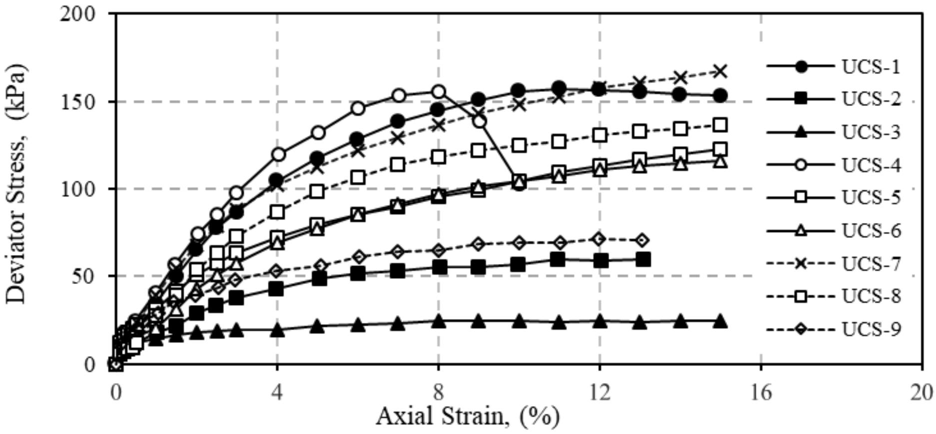

Figure 4: Variation of deviator stress with axial strain in clay at the saturated condition

The test specimen was also prepared by compacting the soil samples at optimum moisture content. The test result is shown in Figure 5. The results indicate that each type of reconstituted modified clays shows a similar trend under the same loading condition. The variation of deviator stress with the increase of organic content followed narrow-band than saturated condition.

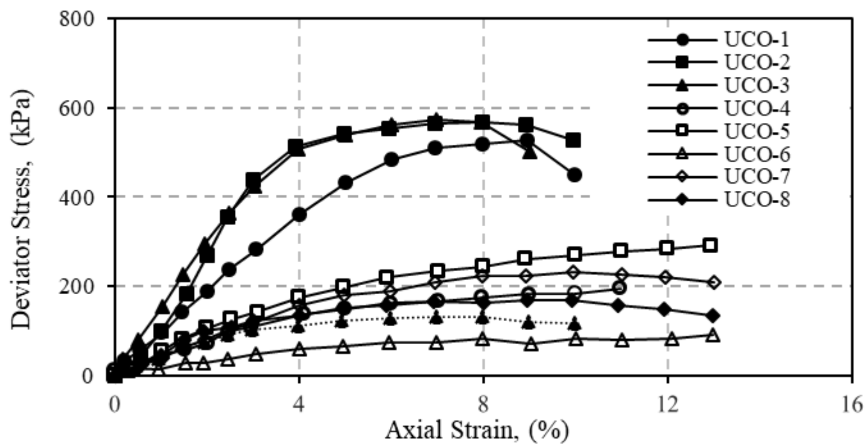

Figure 5. Variation of deviator stress with axial strain in clay at the saturated condition

For saturated cohesive soil, the deviator stress at failure, q_f and shear strength is $s_u = q_f/2$ in an unconfined compression test. The shear strength measured from the deviator stress at failure as shown in Figure 2. The undrained shear strength obtained from Figure 4 was plotted versus organic content in Figure 6. In general, the unconfined compressive strength (stiffness) at saturated water content found to decrease with increasing wooden dust because wooden dust can hold moisture that can reduce shear strength.

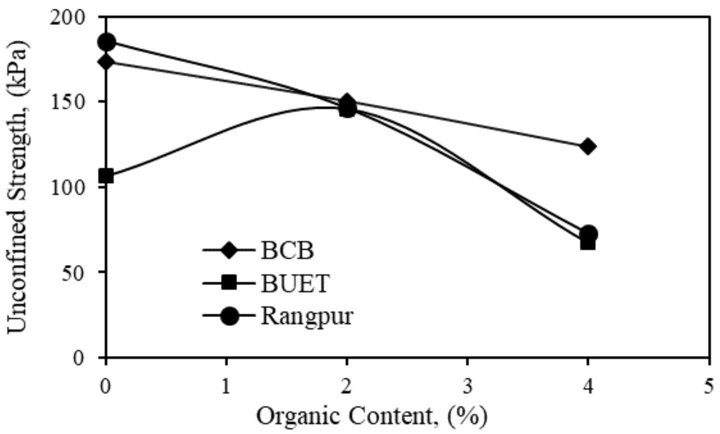

Figure 6: Effect of organic content on unconfined compressive strength (Saturated soil condition)

4.6 Effect of organic content on stiffness at optimum moisture content

When the percent of organic content was gradually increased, unconfined compressive strength (stiffness) also gradually increased. Beyond a certain organic content, any increase in the amount of organic content tends to reduce the strength. This phenomenon occurred because the organic content takes up the spaces that were occupied by soil particles, the organic content at which maximum strength is obtained is generally referred to as the optimum amount of organic content for this soil sample. Similarly, the shear strength measured from the deviator stress at failure as shown in Figure 5. The undrained shear strength obtained from Figure 5 was plotted versus organic content in Figure 5. The test result shown that with the increase of organic content, strength variation was small.

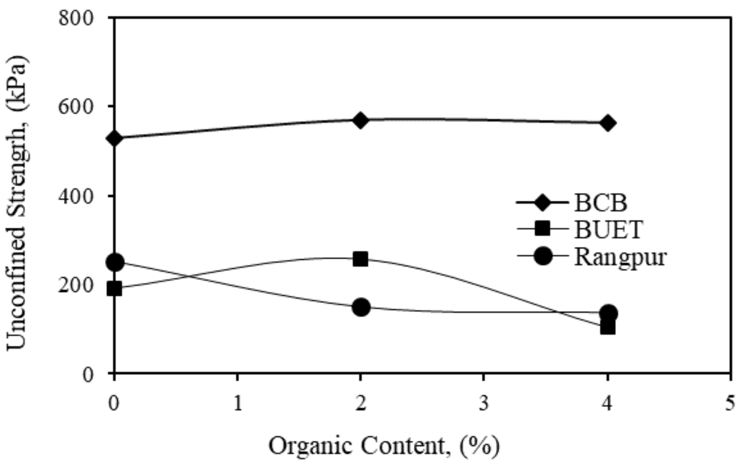

Figure 7: Effect of organic content on unconfined compressive strength(Optimum moisture condition)

5. CONCLUSIONS

The procedure proposed in this study is used to prepare the sample specimen. Moreover, the prepared soil samples successfully simulated the shear strength nature of the cricket pitch soils. The test results suggested that optimum moisture content value is decreasing with the increasing of organic content. Besides, the dry density of soil decreases with an increase in the percent of organic content From the test result, it can be concluded that the optimum percent organic content found in an order of approximately 2% in this investigation. At this percentage, a variation of undrained strength was small in both saturated and optimum moisture content conditions and could hold moisture up to 30 percent. The percent presented are based on a limited number of data. It is noted that the findings reported in this study are part of an ongoing extensive research program focusing on the Characterization of Reconstituted Clay.

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REFERENCES

Baker, S.W., Hammond, L.K.F., Owen, A.G. and Adams, W.A. (2003), Soil physical properties of first-class cricket pitches in England and Wales. 2. Influence of soil type and pitch preparation on playing quality, Journal of the Sports Turf Research Institute, 79, 13–21.

Chandler, R. J. (2000), "Clay Sediments in Depositional Basin: the Geotechnical Cycle", Quarterly Journal of Engineering Geology and Hydrology, Vol 33, No. 1, 7–39.

Cotecchia, F. and Chandler, R. J. (2000), "A General Framework for the Mechanical Behaviour of Clays", Géotechnique, 50, No. 4, 431–447.

Hillel (1982), Introduction to soil physics. Academic Press, New York.

Henkel, D.J. (1959), The relationship between the strength, pore-water pressure and volume-change characteristics of saturated clays. Geotcchnique, 9, 119–135.

Hong, Z. S. and Tsuchida, T. (1999), On Compression Characteristics of Ariake Clays, Canadian Geotechnical Journal, 36, No. 5, 807–814.

Islam, M. R., Stuart, R., Risto, A. and Vesa, P. (2002), "Mineralogical Changes during Intense Chemical Weathering of Sedimentary Rocks in Bangladesh", Journal of Asian Earth Sciences, 20, 889–901.

James, D.M., Carré, M.J., Haake, S.J. (2004). The playing performance of county cricket pitches. Sports Engineering. 7(1): p. 1–14

Liu, M. D., and Carter, J. P. (1999), Virgin Compression of Structured Soils, Géotechnique, 49, No. 1, 43–57.

Nagaraj, T. S., and Murthy, B. R. S. (1986), A Critical Reappraisal of Compression Index Equation, Géotechnique, 36, No. 1, 27–32.

Taiton, N. and Klug, J., (2002), "The cricket pitch and its outfield", University of Natal, Pietermaritzburg.

Yin, J. and Miao, Y. H. (2015), "An Oedometer-Based Method for Preparing Reconstituted Clay Samples", Applied Mechanics and Materials, Vols. 719-720, 193-196.