Paper ID: CE 0317

Effect of Wood Dust on the Shrinkage Behavior of Laboratory Constituted Soil for Use in Cricket Pitch

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Abstract

This study was concerned to check the effect of organic content (wood dust) and its variation on the shrinkage limit, volumetric shrinkage, and linear shrinkage of the cricket pitch. It is important to evaluate the soil prior to the preparation of the pitch. To evaluate the soil, some specific criteria and codes are required. Soil samples were collected from selected international cricket pitches in Bangladesh. The venues are Sher e Bangla, Fatullah, and BUET cricket pitch. The required properties of collected soil samples were determined in the laboratory. ASTM and BS test procedures were followed in determining these properties. The investigation involves the preparation of a new laboratory composite soil, which is a uniform mixture of Bentonite clay, viti balu passing #200 sieve(silt), viti balu (sand), and wood dust (organic matter) according to grain size analysis and organic content test. This composite soil is used to perform a series of shrinkage limits, volumetric shrinkage, and linear shrinkage test programs with variations of organic content. In this study, laboratory-constituted soil is expansive soil and during its preparation as the percentage of organic content is increased, the amount of clay matter (Bentonite) ratio decreases proportionally which is also valid from the geotechnical point of view. As the organic matter gets higher, and clay or Bentonite content gets lower, it was found that shrinkage limit, volumetric shrinkage, and linear shrinkage limit decreased accordingly.

Keywords: *Cricket pitch; grain size; organic content; shrinkage. composite soil.*

1 Introduction

Cricket is a very popular game all over the world. It is commonly recognized that only excellent pitches allow for good cricket to be played. A cricket pitch is a prepared area of tightly mowed turf and compacted earth where the bowler launches the ball. To provide a decent playing surface, cricket pitches should be prepared with hard, level surfaces (Ekwue et al., 2017). Preparation of a cricket pitch involves the collection of loose soils which are required to sort out and to be compacted to increase the soil density and improve their strength characteristics (Shipton et al., 2006). For this purpose, the initial organic content of the soil is determined. Moisture is added in desired quantity because the moisture content is one of the most important governing factors of pitch performance (Anik et al., 2020). Moisture content should be maintained properly during pitch construction. Moisture content has a strong relationship with organic content, and both are useful for growing grasses and grasses are also an important factor because it ensures the consistency of a good pitch (Taiton and Klug, 2002). After the completion of any cricket pitch, there are only two criteria to check out and revise. One is compaction and another is organic content (Baker et al., 1998).

The cracks in a cricket pitch are also an important parameter to check out. Cracks are measured by shrinkage limit and linear shrinkage. Crack or shrink controls the movement of the ball when its drops on the pitch. Cracks make a change in the spin and swing of the cricket pitch (Kanhaiya et al., 2019). The state of shrinkage due to the alteration of organic content is the main objective of this research. This study will present the result of the laboratory investigation of the effect of organic matter on shrinkage properties on laboratory-constituted soil based on characterization test.

2 Methodology

Soil samples are collected from different venues of Bangladesh. Preliminary soil characteristics and classification are investigated. New laboratory composite soil is prepared according to primary soil classification and characteristics. Newly prepared composite soil is used to perform a series of shrinkage limit tests and linear shrinkage tests with variations of organic content. The shrinkage limit is determined by ASTM D4943 and linear shrinkage is determined by BS1377: PART 2: 1990.

Moisture content (%) (W),
Wt. of oven dry soil pat, (W_0 gm),
Volume of wet soil pat (V cm^3),
Volume of dry soil pats (V_0 cm^3), And g= Gravity acceleration
Shrinkage limit (WS) = [W * (V- V_0) x gw/W_0] x 100
Volumetric Shrinkage, VS = (V_1-V_2)/V_1 x 100%
Where, V_1= Volume of shrinkage dish (cm^3), V_2 = Volume of dry soil pat (cm^3)
Linear Shrinkage, LS = (L_f-L_i)/L_i x 100% , Where, L_i = Initial thickness (cm), L_f = Final thickness (cm).

2.1 Laboratory Soil Preparation

Soil is constituted for the purpose of investigating the effect of organic content on the shrinkage limit and linear shrinkage. A composite soil is prepared according to the ratio found in the grain size analysis and organics content test. For the preparation of laboratory composite soil, several items were selected:

- ✓ Bentonite is taken as a clay source. Selected Bentonite has Liquid Limit – 375.0, Plastic Limit-133.0
- ✓ Viti sand passing through the #200 sieve is taken as the silt source. Viti sand is taken as the sand source and wood dust is taken as the organic source.

The main aim of the investigation is to check the effect of varying organic content on the newly prepared composite soil. Firstly, organic content is fixed as 4%, 8.81 %, 12%, 16%. The test program involves the preparation of a 100g composite soil sample having a fixed amount of organic content. By fixing the organic content of the soil, other ingredients are decreased accordingly to the ratio. Then, the prepared soil is used for shrinkage limit, volumetric shrinkage, and linear shrinkage test.

3 Result & Discussion

3.1 Laboratory Tests Performed

The laboratory test performed are -Moisture content test, Specific gravity test, Organic content test, Standard proctor test and optimum moisture content determination, Hydrometer test, Wash sieve test, Atterberg limit test, Shrinkage limit, volumetric shrinkage, Linear shrinkage test. Values obtained from these tests were shown in Tables 1, 3, and 4.

There are almost six international venues for cricket stadiums in Bangladesh. The sites included in this study were Sher-e-Bangla Pitch, Fatullah Pitch, and BUET Cricket Pitch. Sher e Bangla and BUET pitches were mainly black clay and Fatullah pitches were made of red clay soil.

Table 1. Laboratory test results of different soil samples

Pitch Site		Sher-e-Bangla	Fatullah	Buet
Initial moisture content (%)		9.30	47.79	24.65
Specific gravity		2.28	2.43	2.47
Organic content (%)		8.81	6.89	10.30
% passing	#200	96.9	97.1	98.10
Liquid limit		62.17	53.78	65.23
Plastic limit		15.04	28.15	18.72
Shrinkage limit		31.12	25.2	29.1
Linear shrinkage		14.93	15.12	14.97
Volumetric shrinkage		43.70	45.30	41.20
Compaction	MDD (kN/m^3)	14.77	16.67	15.47
	OMC (%)	19	14	23

The test results indicate that all the soils used in the present research were fine (cohesive) in nature. From the grain size distribution curve, the soil samples were further analyzed. A combined percent finer is obtained for the corresponding particle size. Percent finer vs particle sizes are presented in graphical form in Figures 1, 2 and 3. As the percentage passing number 200 sieve (finer than 0.075 mm) for all of the soils was in the range of 93 to 99, Cassgrande's plasticity chart was used for soil classification, listed in Table 1.

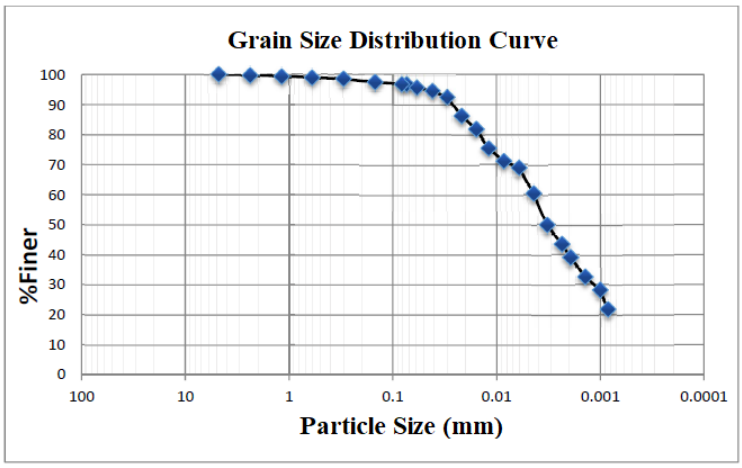

Figure 1. Grain size distribution of soil of Sher-e-Bangla cricket pitch

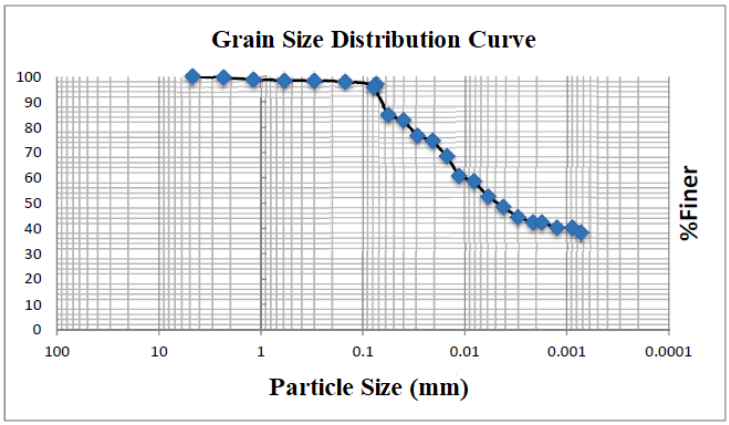

Figure 2. Grain size distribution of soil of Fatullah cricket pitch

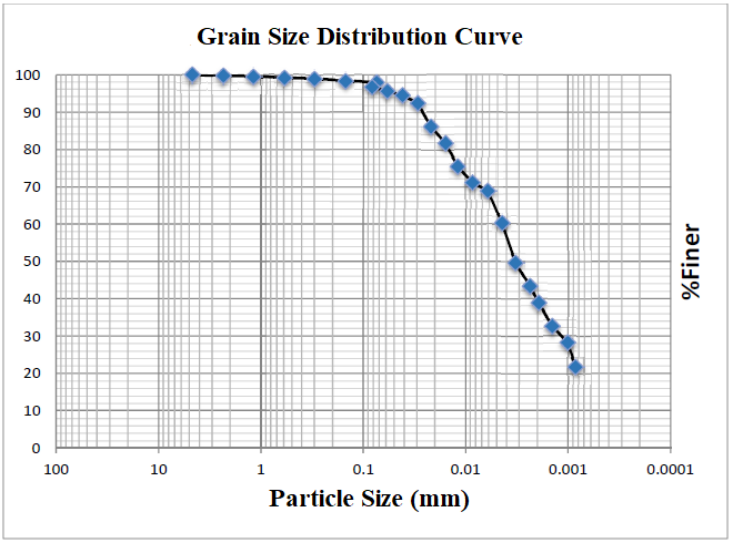

Figure 3. Grain size distribution of soil of BUET cricket pitch

From the Grain Size Distribution Curve (Figures 1, 2, 3), the percentage of different particle size in different cricket pitches was obtained according to MIT soil classification (Table 2) as shown in Table 3.

Table 2. Particle size according to MIT classification

	Materials										
	Boulder	**Gravel**			**Sand**			**Silt**			**Clay**
		Finn	**Medium**	**Course**	**Finn**	**Medium**	**Course**	**Finn**	**Medium**	**Course**	
Prticle Size (mm)	>60	2-6	6-20	20-60	0.06-0.2	0.2-0.6	0.6-2	0.002 - 0.006	0.006 - 0.02	0.02 - 0.06	<0.002

Table 3. Soil ingredients according to grain size analysis

Soil Ingredients	**Size Fraction**	**Sher-e-Bangla**	**Fatullah**	**BUET**
Clay%		40	42	40
Silt%	Coarse	12	9	12
	Medium	16	18	14
	Fine	28	26	30
Sand%	Coarse	1	1	1
	Medium	1	1	1
	Fine	2	3	2

To classify the soil samples, Atterberg limit tests (Test Methods: ASTM D 4318, ASTM D 2216) were done. From the test plastic limit and plasticity index were determined.

Linear shrinkage is a very important parameter for cricket pitches. The more the linear shrinkage the more the crack in the pitch will be. The tolerable range of linear shrinkage for topsoil is 0.08 to 0.15 (8%-15%). It is a well-known fact that organic content in the soil reduces the binding strength and so reduces pace and bounce. The linear shrinkage and the organic content of collected soil samples are shown below in Table 4, where tolerable limits and remarks are mentioned based on the South African Cricket Pitch Code (1998). From this Table, it may be concluded that the Bangladesh cricket pitches are generally prone to cracks because of the soil shrinkage properties.

Table 4. Test results of linear shrinkage and organic content

Site	**Linear shrinkage (%)**	**Tolerable range (%)**	**Remarks on the pitch**
Sher-e- Bangla	14.93	8 to 15	Cracked surface
Fatullah	15.12	8 to 15	Cracked surface
BUET	14.97	8 to 15	Cracked surface
Site	**Organic content (%)**	**Tolerable range (%)**	**Remarks on the pitch**
Sher-e-Bangla	8.81	3 to 8	Reduced pace and bounce
Fatullah	6.92	3 to 8	Good pitch
BUET	10.30	3 to 8	Reduced pace and bounce

3.2 Changes in Shrinkage Behaviors Due to Addition of Organic Content (Wood Dust)

In this section, the effect of variation of organic content on shrinkage limit, Volumetric Shrinkage, and Linear Shrinkage have been observed. For the present investigation, we choose only the Sher e Bangla national stadium because of its utmost importance as a national and international.

Table 5. Variation of shrinkage limit, Volumetric Shrinkage, and Linear Shrinkage according to organic content.

Organic content (%)	Shrinkage limit	Volumetric Shrinkage	Linear Shrinkage
4	72	90.67	14.34
8.81	66	85.82	12.54
12	65	72.72	12.09
16	63	64.40	11.61

From Table 5 and Figures (4-6), it is evident that shrinkage limit, volumetric shrinkage, and linear shrinkage decrease with the increase in organic content.

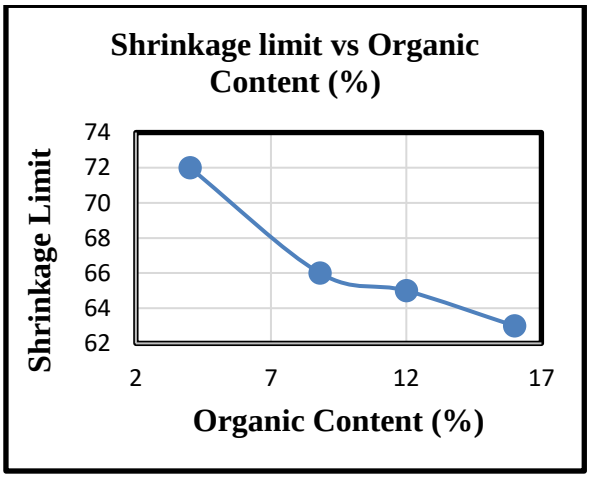

Figure 4. Shrinkage limit vs Organic content (%)

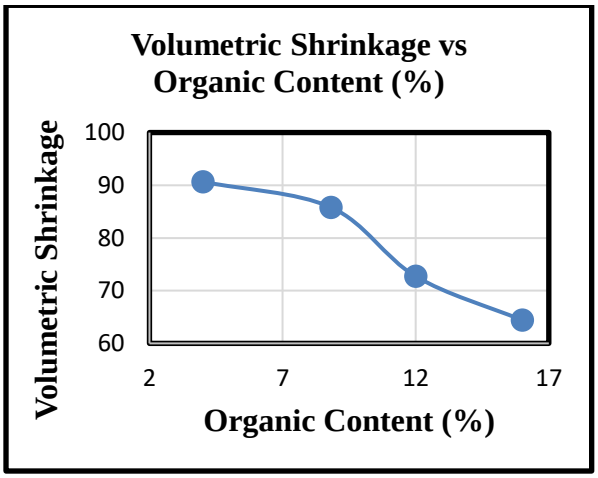

Figure 5. Volumetric shrinkage vs Organic content (%)

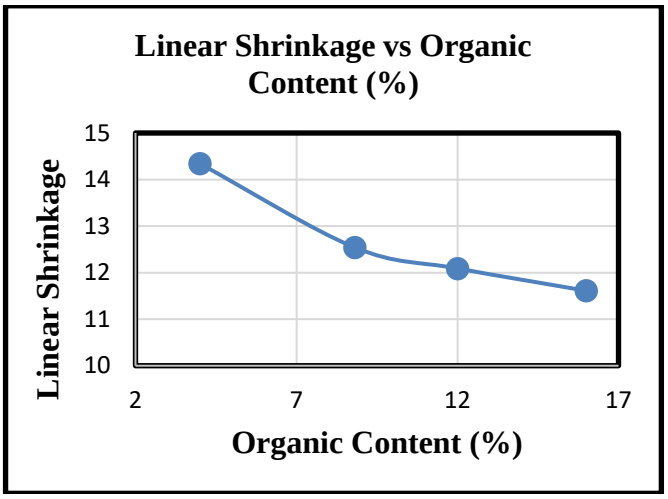

Figure 6. Linear shrinkage vs Organic content (%)

Expansive soils expand as water is added and shrink when they dry. This continuous change in soil volume can cause soil to move unevenly and shrink or crack. In the research laboratory constituted soil is an expansive soil and they expand as water is added and shrinks when they dry out. Bentonite clay is essentially impure clay consisting mostly of Montmorillonite. Montmorillonite is the main reason to expand the soil as it absorbs water and shrinks when water dries out. In laboratory-constituted soil preparation, wood dust was used and is totally non-expansive in nature. So, in the laboratory constituted soil preparation as the percentage of organic content was increased, the amount of clay matter (Bentonite) ratio decreased proportionally. So, the soil will become more non-expansive in nature.From geotechnical point of view shrinkage limit, volumetric shrinkage and linear shrinkage will certainly go down as organic matter increases. That exact investigation indicates as the organic matter gets higher, and clay or Bentonite content gets lower shrinkage limit, volumetric shrinkage, and linear shrinkage limit will get decreasing.

4 Conclusion

In this study, the variation of shrinkage limit, volumetric shrinkage, and linear shrinkage is observed with variation of organic content in composite soil. As the organic content gets higher, the shrinkage limit gets lower, it is mainly due to the ratio of Bentonite and wood dust in the composite soil. A similar trend has been observed for volumetric shrinkage and linear shrinkage. As the organic content gets higher, volumetric shrinkage and linear shrinkage get lowered. It happened due to the reason, when the organic matter percentage gets higher, Bentonite clay lowers proportionally. As Bentonite is the main ingredient to shrink soil, when its amount is decreased, shrinkage limit, volumetric shrinkage, and linear shrinkage limit will be decreasing.

Acknowledgment

The author expresses his sincere gratitude and profound indebtedness to Professor Dr. Sarwar Jahan Md. Yasin of the Civil Engineering Department, Bangladesh University of Engineering and Technology, Dhaka, under whose supervision this study was carried out. I am also indebted to Professor Dr. Md. Zoynul Abedin for his valuable suggestion, inspiration, and guidance.

References

Anik, M. K. A., Sadiq, M. F., & Abedin, M. Z.(2020), Effect of Organic Content on Stiffness of cricket pitch soil.

Baker, S. W., Cook, A., & Binns, D. J. (1998). The effect of soil type and profile construction on the performance of cricket pitches. I. Soil properties and grass cover during the first season of use. Journal of turfgrass science, 74, 80-92.

Ekwue, E. I., Ramsumair, A., & Birch, R. A. (2017). Effects of Water Content and Compaction on Ball Movement on Major Cricket Pitch Soils in Trinidad. West Indian Journal of Engineering, 39(2).

Kanhaiya, K., Gupta, R., & Sharma, A. K. (2019). Cracked cricket pitch analysis (CCPA) using image processing and machine learning. Global Journal on Application of Data Science and Internet of Things [ISSN: 2581-4370 (online)], 3(1).

Shipton, P., James, I., & Vickers, A. (2006). The mechanical behaviour of cricket soils during preparation by rolling. In The Engineering of Sport 6: Volume 1: Developments for Sports (pp. 229-234). Springer New York.

Tainton, N. M., & Klug, J. (2002). The cricket pitch and its outfield. University of Kwazulu Natal Press

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