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Research Article

Unsaturated Hydraulic Conductivity of Bagasse Ash Treated Foundry Sand

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Abstract: Laboratory investigations were conducted to assess the unsaturated hydraulic conductivity of foundry sand waste treated with up to 8% bagasse ash (a pozzolana) by dry weight of soil. Specimens were prepared at molding water contents -2, 0 and +2 of the optimum moisture content using the four energy levels of reduced British Standard light, British Standard light, West African Standard, and British Standard heavy. The predicted unsaturated hydraulic conductivity of specimens were determined using the Brooks-Corey (BC) and Van Genuchten's (VG) models from results of the soil water characteristic curve (SWCC). The unsaturated hydraulic conductivity decreases with increasing matric suction for both models. While the unsaturated hydraulic conductivity decreases with increasing moulding water content regardless of the compactive effort and bagasse ash content. The VG model gave a clearer trend as regarding the influence of increasing bagasse ash content of the unsaturated hydraulic conductivity of treated and untreated specimen. Finally, 2% and 4% bagasse ash treatment of specimens were the main treatment level of interest gave satisfactory for use in covers for waste containment facility as the unsaturated hydraulic conductivity values generally recorded satisfactory low values.

Keywords: Bagasse ash, Compaction, Matric suction, Unsaturated hydraulic conductivity.

INTRODUCTION

The long-term sustainability of engineering designs has become a critical concern in practice especially as regards to the unsaturated soils encountered in the compacted clay covers and linings of waste-management facilities [1]. The knowledge of the unsaturated behavior of compacted soil is essential for the prediction of solute transport behavior; design of drainage and irrigation systems, environmental risk assessment and to predict accurately the performance of these materials as liners. The basic purpose of covers and linings is to minimize fluid flow and contain liquids that might contaminate the subsurface soil and the water table. The movement of moisture, and hence the spread of contaminant, takes place in the region surrounding the waste-containment area, which is mostly unsaturated (vadose zone). This necessitates estimation of unsaturated soil hydraulic conductivity, which would help in designing an efficient containment system [2]. Studies have revealed that one of the most important factors governing the performance of these containment systems is the soil hydraulic conductivity [1], which mainly depends on the water content, dry density, and degree of saturation (i.e., the compaction state) of the soil [3].

In the design, maintenance and operation of landfills and other waste containment facilities, it is generally assumed that the barrier material is saturated during its entire life which in reality is not; as the barrier material is unsaturated and does not necessarily become saturated [4]. The Unsaturated zone thus provides the best opportunities, to limit or prevent ground water pollution from reaching the water bearing saturated zone [5].

Proper evaluation of the hydrology of compacted soil covers should be based on consideration of unsaturated flow and the unsaturated hydraulic conductivity of the soil since covers are unsaturated when compacted [4-9]. Therefore, the design of earthen caps for waste containment facility must be inclusively based on the unsaturated flow and the unsaturated hydraulic conductivity. In geotechnical engineering, such designs will consider soil hydraulic and mechanical behavior under physical and climatic loading in order to reach a quantified level of risk, promote efficient use or re -use of materials, and minimize environmental impacts of a system over its expected lifecycle. Unsaturated soils mechanics provides an important set of tools that can be used to address sustainability concerns in many geotechnical systems. Specifically, prediction of the changes in stiffness, strength, or volume of an unsaturated soil associated with water flow due to climatic interaction can be used to better quantify the long-term response of geotechnical systems above the water table (pavements, retaining walls, landfill covers *etc.*).

General, there are two methods of measuring unsaturated hydraulic conductivity of soils: The direct measurement includes steady state and unsteady state methods [10-11]. Steady state methods; Matric suction is imposed first on a soil specimen using the axis translation technique [12-15]. Equilibrium is attained by constant water content, and then a hydraulic gradient is imposed across the soil specimen. The flow rate is then measured and the permeability is obtained through Darcy's law [16]; unsteady state method or instantaneous profile method. The indirect interpretation follows [17] methodology based on Poiseuille flow applied in a distribution of capillary tubes related to the volumetric moisture content. Method involves determining the water content of the soil specimen at various matric suction values, and then with statistical models obtain the unsaturated hydraulic conductivity. Although the transient or unsteady-state methods do not require a complicated setup, they lead to considerable difficulty in measuring soil parameters at different points inside the soil sample and interpreting the obtained data. For unsaturated soils, details of this method including data analysis are given by [14, 18-20] as well as [15].

The test time for this method is greatly reduced when compared to the direct measurement method since the test only last up to the time the water content in the soil specimen equilibrates with imposed matric suction.

Flow of water in unsaturated soils can be described using three non-linearly related variables, namely the volumetric moisture content (or degree of saturation), the matric suction (or capillary pressure if the air pressure is non-zero), and the hydraulic conductivity *k*. The soil water retention curve (SWCC) is defined as the relationship between volumetric moisture content and suction, and represents the energy needed (*i.e.*, the suction) to de-saturate the soil to a given moisture content. The hydraulic conductivity function (or *k* -function) is defined as the relationship between hydraulic conductivity and suction (or volumetric moisture content), and reflects the decrease in available pathways for water flow as a soil desaturates.

The soil-water characteristic is a conceptual and interpretative tool through which the behavior of unsaturated soils can be understood. As the soil moves from the saturated state to the drier state (unsaturated state), the distribution of the soil, water and air phases change as the stress state changes. The relationships between these phases take on different forms and influence the engineering properties of unsaturated soils [21], the engineering behavior of unsaturated soil such as flow flow, strength and volume change behavior can be understood and predicted [22].

Researchers have developed approaches to predict the shape of the SWCC from the pore size distribution of soils [23, 24] or through empirical correlations [25], poor results may be obtained because the hydrualic properties of unsaturated soils are a function of many variables. Specifically, the SWCC and k -function are sensitive to soil structure variables such as pore size distribution [24, 26], proportions of sand and clay fractions [8] clay mineralogy [27], compaction conditions [9], volume changes [28, 29], and stress state [30]. Further, the hydraulic characteristics are affected by hysteresis upon wetting and drying [31] so they are not unique soil properties as inferred by empirical and theoretical predictions.

A typical curve describes the relationship between water content and pore water suction for foundry sand presented in Fig.1. Several defining parameters of the curve include the air entry suction head (ψ_a), residual water content (θ_r) and saturated water content (θ_s). SWCC is hysteretic, with curves defining the sorption (wetting) and desorption (drying) processes. However, standard practice is to determine only the desorption curve due to experimental difficulties associated with the measurement of the sorption curve [32] as discussed by [28, 33]. This curve is applicable only to desorption processes.

Traditionally, SWCC has been defined over a range of suction that is from 0 to 1500 kPa. A suction value 1500 kPa has been taken on significance as 'residual suction' because it corresponds to the wilting point for many plants [34]. However, this arbitrary value may not likely correspond to the residual state of saturation condition [21]. At zero water content the soil matric suction is approximately 1000,000, kPa [35]. This dry condition is achievable by oven drying the soil. It is necessary to define the residual state of saturation condition in order to obtain the fitting parameter in numerical models for predicting unsaturated hydraulic conductivity [34, 36].

The shape of the SWCC is a function of the soil type. Soils with smaller pores have higher air entry pressure (ψ_a). Soils with wider ranges of pore sizes exhibit greater changes in matric suction with water content [14, 32]. The SWCC of compacted clay soils depend on the compaction water content, compactive effort and plasticity index [34].

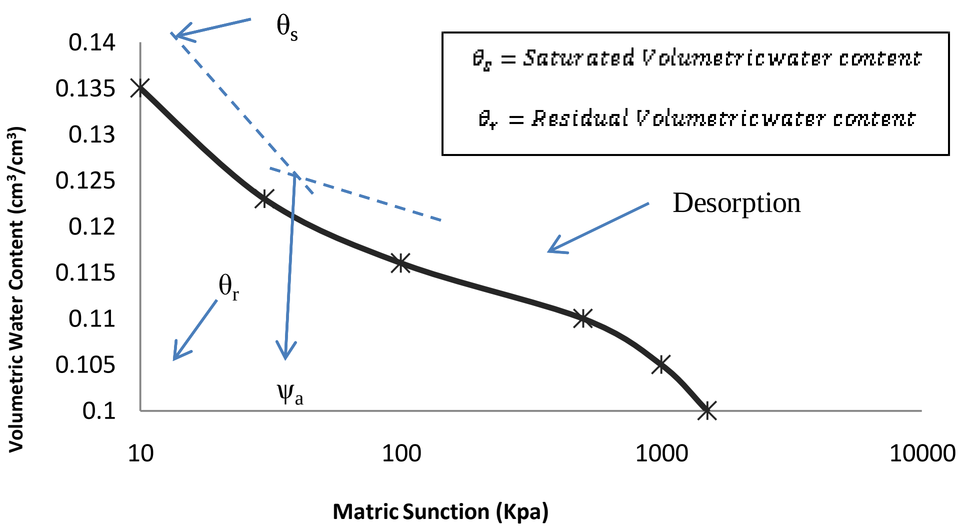


Fig.1: Typical soil characteristics curve

Several models have been used to describe the SWCC, commonly used models include Van Genuchten [35], Brooks and Corey [37] and Fredlund and Xing [38]; and these were reviewed by Leong and Rahardjo [39]. The two most important models are the Brooks-Corey equation [37] and Van Genuchten equation [35]. These two models have been used in this work to describe the saturated behavior of the test soils.

Brooks – Correy model is equation is expressed as

$$\Theta = \frac{\theta_w - \theta_r}{\theta_s - \theta_r} = \left(\frac{\psi_a}{\psi}\right)^{\lambda} \qquad \psi > \psi_a \qquad (1)$$

$\Theta = 1$ And $\theta = \theta_s$,

where $\psi < \psi_a$

Where Θ is a normalized, dimensionless volumetric water content, and λ=a fitting parameter called the pore-sized distribution index [40] that is related to the slope of the curve and s function of the distribution of pores in the soil.

Van Genuchten (1980) model is equation is expressed as

$$\frac{\theta_w - \theta_r}{\theta_s - \theta_r} = \frac{1}{\left[1 + \left(\frac{\psi}{\alpha}\right)^n\right]^m} \qquad (2)$$

The relative hydraulic conductivity k_r of unsaturated soils is typically obtained from the models of [37] and [35] based on water retention curve (SWCC) and is expressed in the equation as a ratio of the unsaturated hydraulic conductivity to that of the unsaturated hydraulic conductivity.

$$K(\psi) = K_r(\psi) K_{sat} \qquad (3)$$

Foundry green sand has been used with other additives such as bentonite etc. [41-43] Compacted foundry sand waste (FSW) treated with bagasse ash recorded successful saturated hydraulic conductivity values that meet the minimum regulatory requirements for liners [44-45]. In contrast to lining systems, covers are exposed to a much different environment where stress are low, unsaturated conditions persists and interaction with the atmosphere occurs continuously [43]. Therefore, the study of the unsaturated hydraulic conductivity of the cover in a waste containment system becomes essential.

The work in [46-47] studied the unsaturated hydraulic conductivity behavior of soil using bagasse ash pozzolana. However, no work has been done on the unsaturated hydraulic conductivity behavior of bagasse ash treated foundry sand for use in waste containment. Thus, this study was aimed at evaluating the unsaturated hydraulic conductivity behavior of bagasse ash treated foundry sand in waste containment system.

Soil Water Characteristics

Materials and Methods

Materials

Foundry sand: used in this study was obtained from Defense Industries Corporation of Nigeria (DICON industries), in Kaduna State of Nigeria. The location lies within latitude 10° 30'N and longitude 7°27'E. Specimens were varied with 0, 2, 4, 6 and 8% of bagasse ash by dry weight of foundry sand.

Bagasse ash

The bagasse ash utilized in this work was obtained from Anchau Local Government Area of Kaduna State The location lies within latitude 10° 30'N and longitude 7°27'E. Bagasse husks (i.e. the residue after extraction of the sugar juice) was openly incinerated with in a temperature range of 500^0-700^0C The bagasse ash is brownish in color with a specific gravity of 2.20. The bagasse ash was sieved through BS sieve No. 200 and was stored in air-tight containers before usage. Chemical analysis of CKD was carried out at Chemical Laboratory of the Energy Research Centre, Ahmadu Bello University Zaria. The X-ray Analyzer together with Atomic Absorption Spectrophotometer (AAS) was employed for the analysis except for Sodium and Potassium Oxide where the Flame Analyzer was used. The chemical composition of the bagasse ash is shown in Table1.

Table 1: Oxide Composition of bagasse ash.

Oxide	Bagasse ash (%)
CaO	3.23
SiO_2	57.12
Al_2O_3	29.73
Fe_2O_3	2.75
Mn_2O_3	0.11
$Na_2O + K_2O$	-
K_2O	8.72
SO_3	0.02
TiO_2	1.10
Loss on Ignition	9.57

Methods

Compaction Tests: Four compactive energies namely reduced British Standard light, British Standard light, West African Standard, and British Standard heavy, were used (simulating the variation in compactive efforts that might occur in the field) on tests involving moisture – density relationship and hydraulic conductivity. Air dried soil samples passing through BS sieve with 4.76mm aperture mixed with 0%, 2%, 4%, 6% and 8% bagasse ash by weight of dry soil were used. Reduced British Standard light compactive effort was used, it is the effort derived from 2.5kg rammer falling through 30cm onto three layers, each receiving 15 uniformly distributed blows; British Standard light and British Standard heavy effort were carried out in accordance with [48-49]. West African Standard (WAS) compaction on is the effort derived from a 4.5kg rammer falling through 45 cm onto five layers, each receiving 10 blows.

Preparation of Specimen

All the specimens were prepared by compacting at -2%, 0%, +2% and +4% of the optimum moisture content (OMC) from the dry to the wet side of the line of optimum for the four compactive energy level stated above in the compaction mould and extruded. Specimen were then cored with rings having inside diameters of 50mm. Sixty (60) samples obtained were sealed at both ends prior to saturation, they are unsealed and samples contained in the stainless steel rings were placed in an immersion tank containing water. Water was allowed to saturate the samples by capillary action which lasted for about 3 weeks. Full saturation was confirmed when water rose to the surface of the soil specimens.

Pressure Plate Extractors

The SWCC is measured in the laboratory using the volumetric pressure plate extractor. Pressure plate extractors work on the principle of axis translation which employs matric suction (pressure difference across the air-water interfaces, $\psi = u_a - u_w$, where u_a is the pore air pressure and u_w is the pore water pressure). In the pressure plate extractor, u_w is maintained constant ($u_w = 0$) and u_a is increased to obtain the desired matric suction [34, 50].

A pressure plate extractor consist of two main components: a porous plate with air-entry pressure higher than the minimum matric suction to be applied during the test and a sealed pressure cell [14]. The porous plate is made of either ceramic or polymeric membranes. In the drying test, the soil starts at saturation condition and the matric suction is gradually increased leading to a reduction in the water content in the soil specimen. The air-entry ceramic disk and the soil are first saturated. After saturation, excess water is removed from the cell. The cell cover is then mounted and tightened into place and air-pressure is applied to the soil specimen in series of increments to achieve different matric suction (ψ). Each increment in air-pressure cause water to be expelled from the specimen until an equilibrium state is reached for the ψ that has been established. Additional increments in outflow are applied only after outflow from the specimen has stopped. The volume of the water expelled during each increment is measured (gravimetrically or volumetrically) to define the water content corresponding to each suction [49-51].

Pressure Application

Pressure was applied in three batches as the pressure plate equipment could only contain 16 specimens at once. The entire process from specimen preparation, saturation and pressure application lasted about three months. Pressure was applied using regulated compressed air from compressor. The soils were subjected to pressure of 10, 30 100, 500, 1000 and 1500 kPa, respectively. On completion of the test, the equipment was disassembled, the soil specimen removed and placed in an oven to determine its final gravimetric water content. All computation made were based on the as compacted volume.

Discussion of Test Results

Index properties

The index properties and compactions of the untreated and treated foundry sand are shown in Table 2. The non-plastic sand is classified as A-2-4(0) according to [52] classification system and SM according to [53] Classification System. The liquid limit slightly decreased initially in value from 19 to 18% and later increased to a peak value of 23.3% at 4% bagasse ash treatment. This increase can be attributed to the increase in water absorption or changes in the particle packing of the mixture. Beyond 4% bagasse ash content the liquid limit reduced in value. Foundry sand has been reported by [54] as not possessing plasticity, largely due to the presence of a high percentage of fine sand and due to the high temperature bentonite has been subjected to. Treatment of foundry sand with bagasse ash did not improve its plasticity, while the linear shrinkage was not significantly affected since the soil is predominantly sand.

Table 2: Index properties of treated and untreated foundry sand

Properties	Bagasse ash content (%)				
	0	**2**	**4**	**6**	**8**
LL, %	19.0	18.0	23.3	19.4	18.8
PL, %	N.P.	N.P	N.P.	N.P	N.P
PI, %	N.P.	N.P.	N.P.	N.P.	N.P.
SL, %	0.9	1.0	0.0	0.9	0.7
% PASSING No. 200 SIEVE	31	26.5	27	27.5	26.5
AASHTO	A-2-4(0)	A-2-4(0)	A-2-4(0)	A-2-4(0)	A-2-4(0)
USCS	SM	SM	SM	SM	SM
GS	2.64	2.65	2.66	2.60	2.56
MDD (Mg/m^3)					
RBSL	1.91	1.84	1.83	1.86	1.91
BSL	1.96	1.89	1.89	1.88	1.89
WAS	2.00	1.92	1.92	1.97	1.91
BSH	2.08	2.08	2.05	1.99	1.99
OMC (%)					
RBSL	12.0	12.5	13.0	13.0	13.0
BSL	11.5	11.6	11.7	12.0	12.2
WAS	9.5	8.6	9.5	10.0	11.3
BSH	8.3	8.6	7.7	8.6	8.3
pH	8.9	9.9	10.2	10.6	10.8
COLOUR	Brown				

NP= Non-plastic

Soil Water Characteristic Curves

Effect of Moulding Water Content on SWCCs

The water content at compaction affects the shape and orientation of the SWCC's. This is because water content affects the micro and macro fabric of the compacted soil [34]. The effects of molding water content on SWCCs for bagasse ash treated foundry sand are shown in Fig.2a-e. The variations are clearly shown as specimen prepared on the dry side of optimum are lowest on the graph of the SWCC, while specimen prepared on the wet side of optimum are higher. The reason for this is that on the dry side of optimum compacted specimen normally contains bimodal pore size distribution, with the larger macro pores existing between clods that are not remoulded during compaction. In contrast, soil compacted wet of optimum water content typically has a broad unimodal pore-size distribution that primarily consist of micro-pores. The soil micro structure is described as the elementary particle association within the soil, while the macrostructure is the arrangement of soil aggregates [55]. However, specimen compacted at the optimum moisture content have pore-size distribution falling between these extremes [56-59].

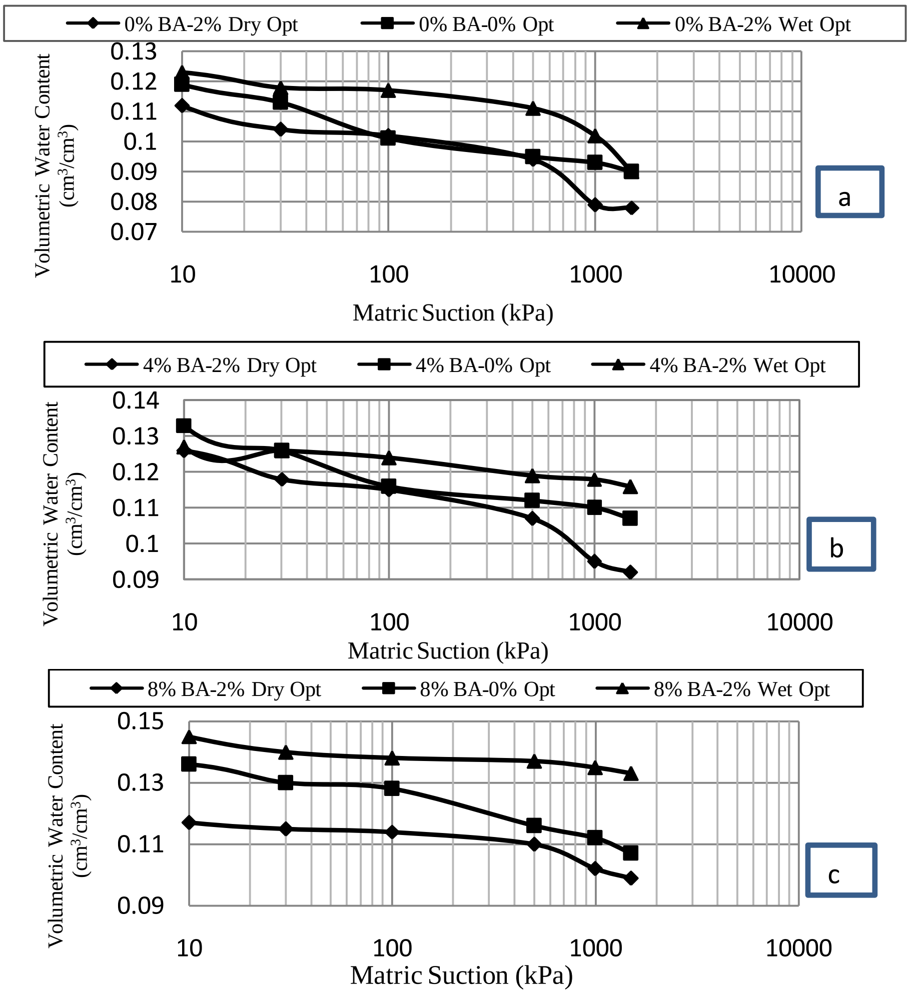
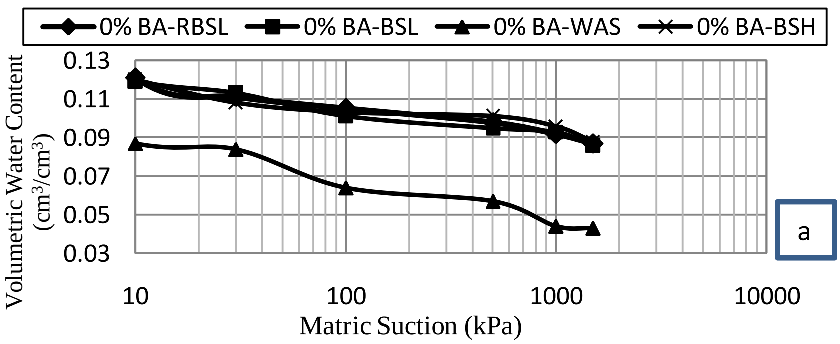


Fig.2: Varriation of soil water characteristic of foundry sand with matric suction at BSL compaction (a) 0% BA (b) 4% BA (c) 8% BA

Effect of Compactive Effort on SWCCs

The effect of compactive efforts on the SWCCs of specimens treated with specified bagasse ash content (BA) and prepared at optimum moisture content are shown in Fig.3a-e. For the untreated foundry sand specimen (see Fig.3a-e) the trends observed are similar to those reported by [29, 34]. Higher compactive efforts produced specimens with broad unimodal pore-size distribution that primarily consisted of micro-pores in smaller pores that led to increase in suction. However, specimens compacted using lower energies normally contain larger pore size distribution, with the larger macro pores that led to reduction in suction. While the trends observed for the bagasse treated specimens had reversed positions as those reported by [46], this can be largely attributed to pozzolanic bagasse ash that probably had more water available at lower bagasse ash treatment to complete pozzolanic reaction.



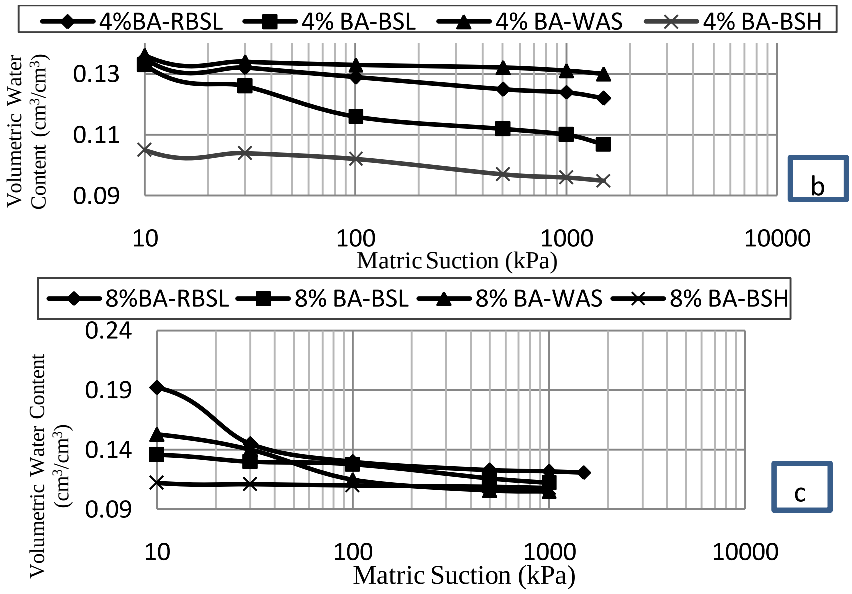
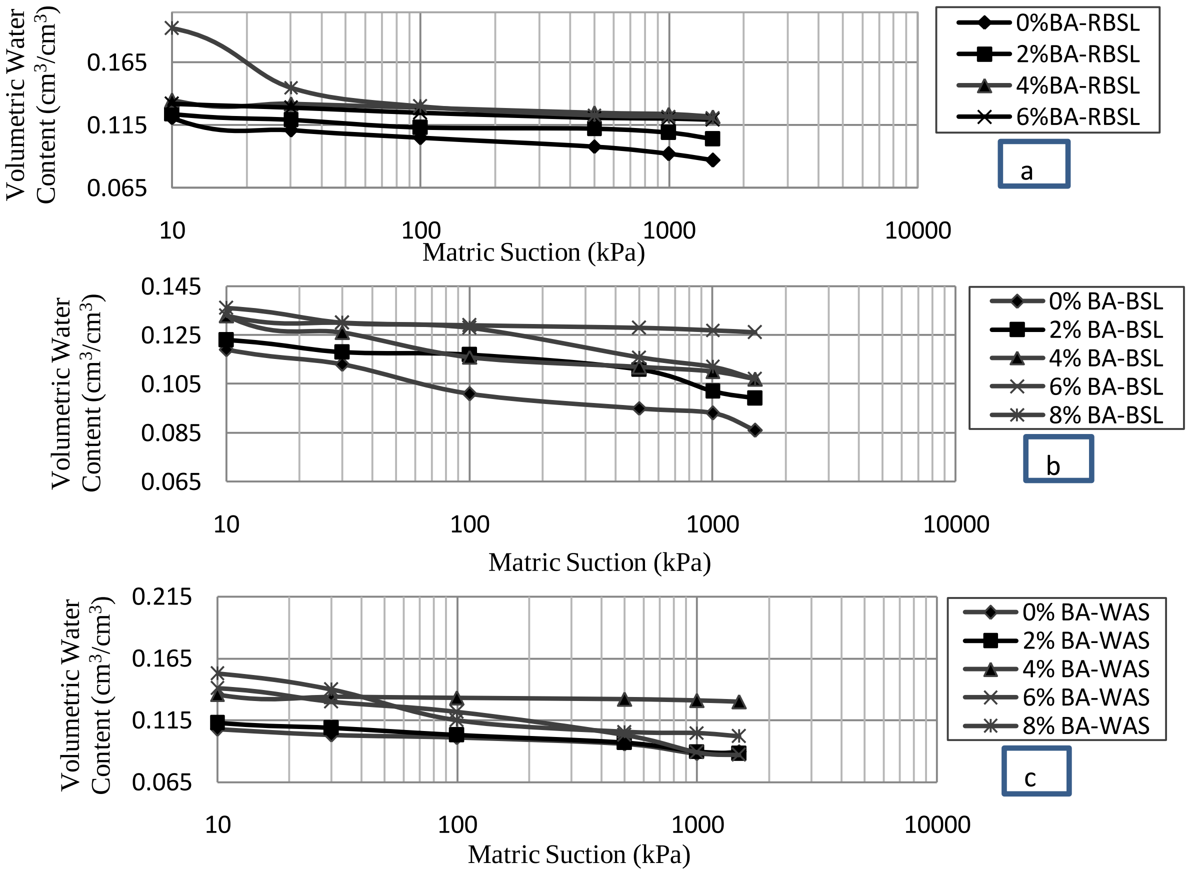


Fig.3: Variation of soil water characteristic of foundry sand with matric suction at optimum moisture content compactive efforts (a) 0% BA (b) 4% BA (c) 8% BA

Effect of Bagasse Ash Content on SWCCs

The effect of bagasse ash content on the SWCCs for the four compaction energy levels is shown in Fig.4a-e. Generally, the observed trend for SWCC shows that specimen with higher bagasse ash content are at the top of the plots for the four energy levels considered. This indicates that micro level structure dominates leading to micro scale pores, since there is more water due to increase in optimum moisture content [46].



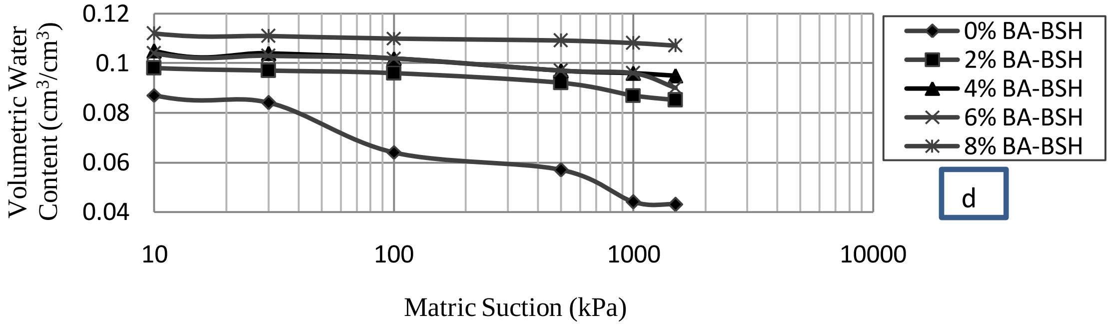


Fig.4: Variation of soil water characteristic of foundry sand with matric suction at optimum moisture contents and different bagasse ash contents (a)RBSL (b) BSL (c) WAS (d) BSH

Prediction of SWCCs

Van Genuchten and Brook-Corey's models were utilized to predict the SWCC parameters. The predicted SWCCs were then plotted closely to the laboratory measured SWCCs for both models as shown in Fig.5a-e. Volumetric water content were plotted against matric suction for specimens compacted at BSH compactive effort at optmum moistue content. For 0% to 4% bagasse ash treatment of foundry sand Van Genuchten model over estimates the volumetric water content while Brook-Corey's model underestimates the volumetric water content this trend are not similar to those observed by [27, 34, 60] this variation could have possibly been as a result of the foundry sand utilized for this research work which is predominantly fine sand. Thus, significant amount of water has been absorb under short range absorbtion mechanism, unlike the predominantly clay soil utilized by other researchers. At 6% and 8% bagasse ash treatment of foundry sand Van Genuchten and Brook-Corey's models closes estimates the volumetric water content except for matric suctions less than 100 KPa. General both model over estimate the residual volumetric water content with the exception of 8% bagasse treated foundry sand specimen.

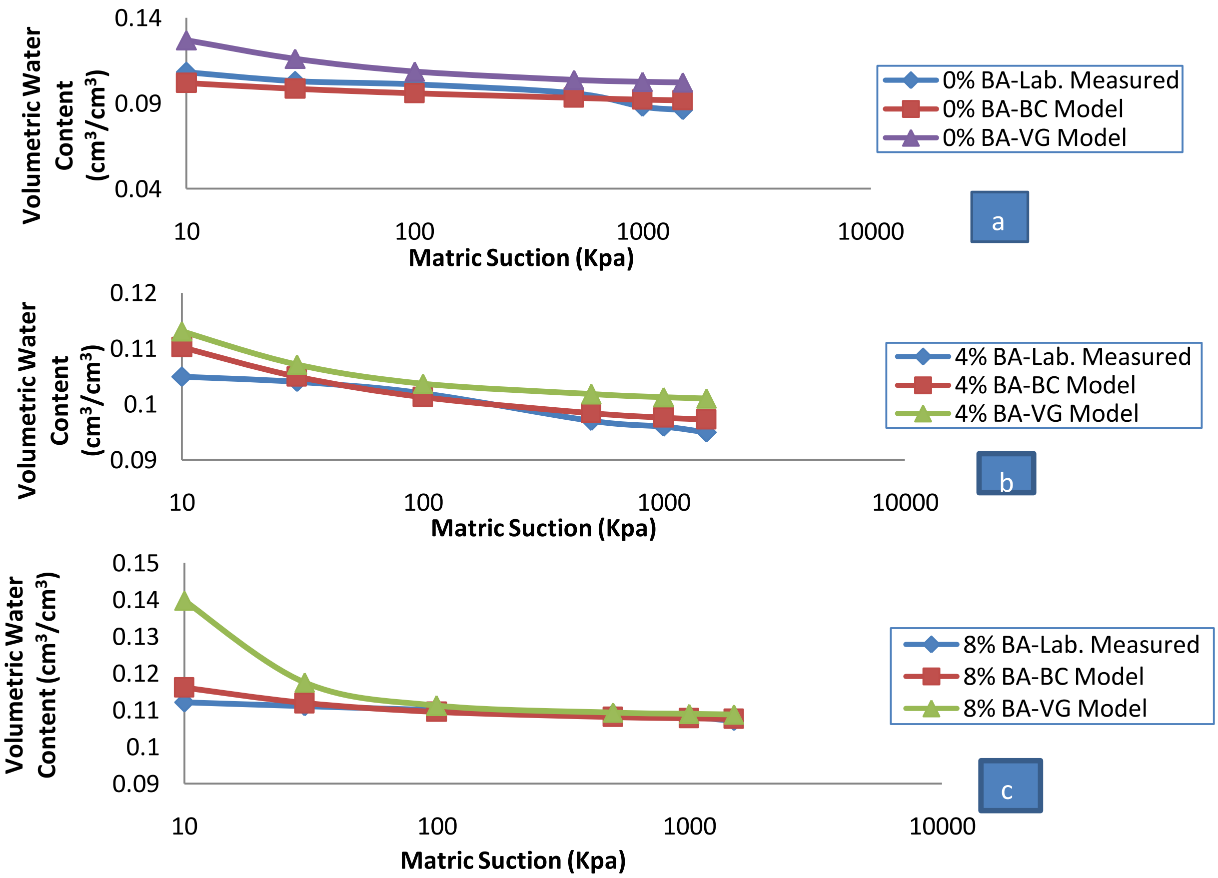


Fig.5: Variation of soil water characteristic with matric suction at optimum moisture content for (a) Reduced British Standard light (b) British Standard light (c) West African Standard (d) British Standard heavy

Effect of Moulding Water Content on Unsaturated Hydraulic Conductivity

The variation of unsaturated hydraulic conductivity with water content relative to optimum for specimens compacted using British Standard heavy (BSH) compactive effort is shown in Fig.6a-c and Fig.7a-c for van Genuchten model and Brooks-Corey models respectively, at matric suctions of 10, 500, 1500 kPa. The observed trend for Brooks-Corey models irrespective of bagasse ash treatment level in most cases showed decreasing unsaturated hydraulic conductivity with increasing moulding water content, this relationship of lower unsaturated hydraulic conductivity with increasing water content relative to optimum is generally similar to those recorded for saturated hydraulic conductivity by other researchers such as [30, 61]. The lowest value of unsaturated hydraulic conductivity is usually obtained on the wet side of compaction, especially at +2% OMC for most of the specimen can be attributed to the deflocculation of the particle structure thus reducing the void due to increasing moulding water content. In unsaturated hydraulic conductivity state, the larger pores empty first and fill last; hence larger pores are responsible for high unsaturated hydraulic conductivity dry of optimum and gradually become hydraulically inactive as soil is de-saturated. This trend is similar to those recorded by other researchers [30, 33, 46].

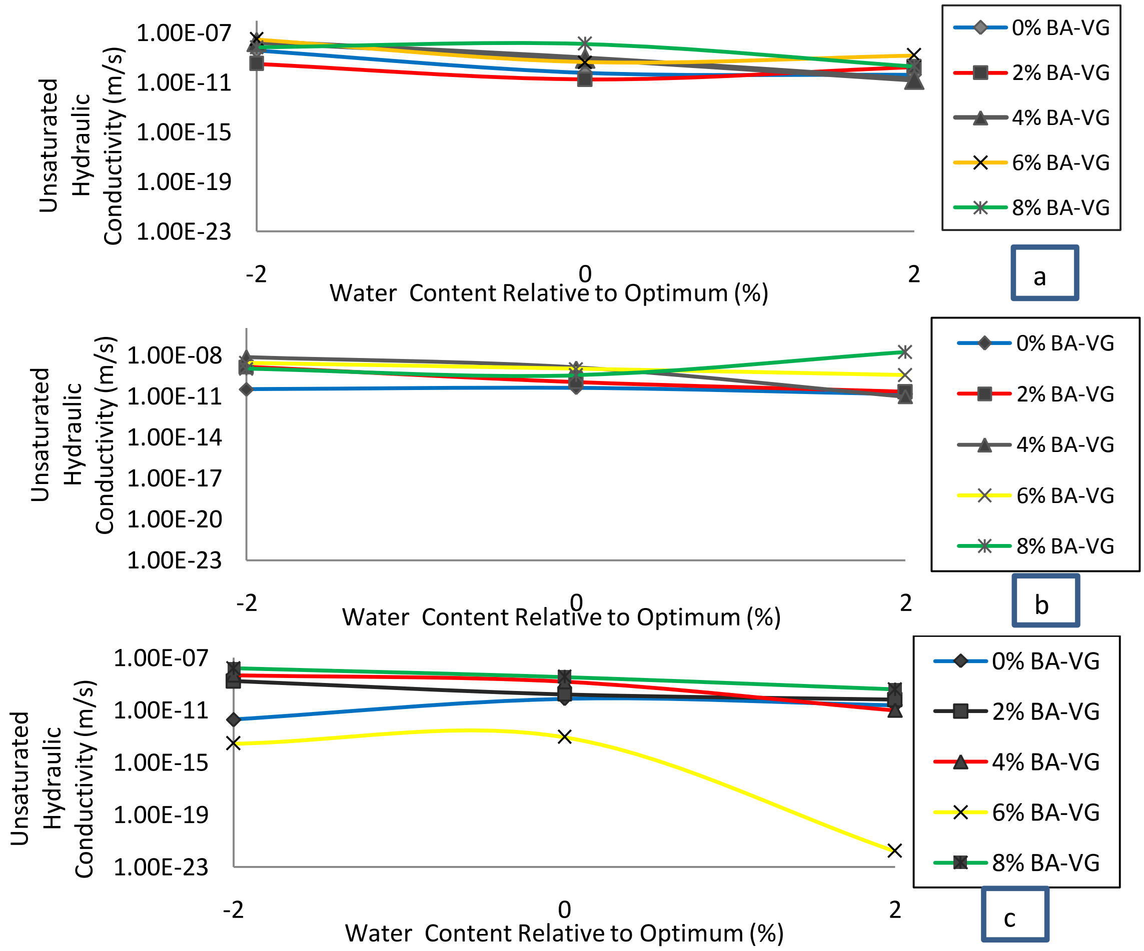
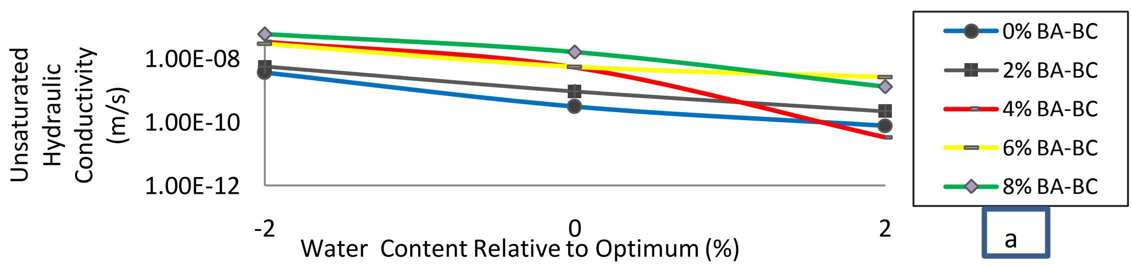


Fig.6: Variation of unsaturated hydraulic conductivity of foundry sand-bagasse ash mixtures with water content relative to optimum for BSH compaction for van Genuchten model (a) 10 kPa (b) 500 kPa (c) 1500 kPa



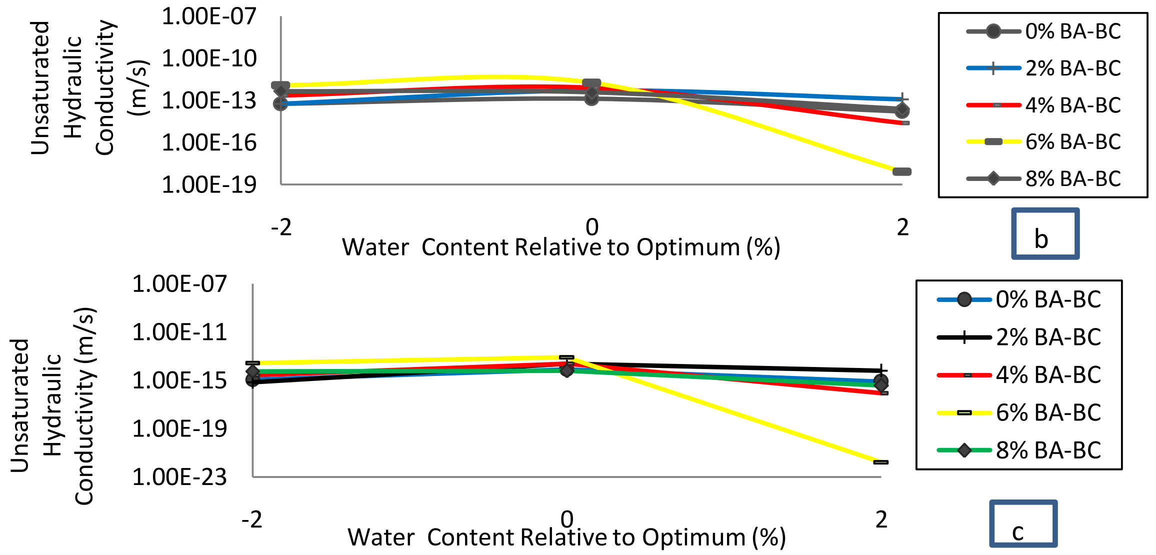
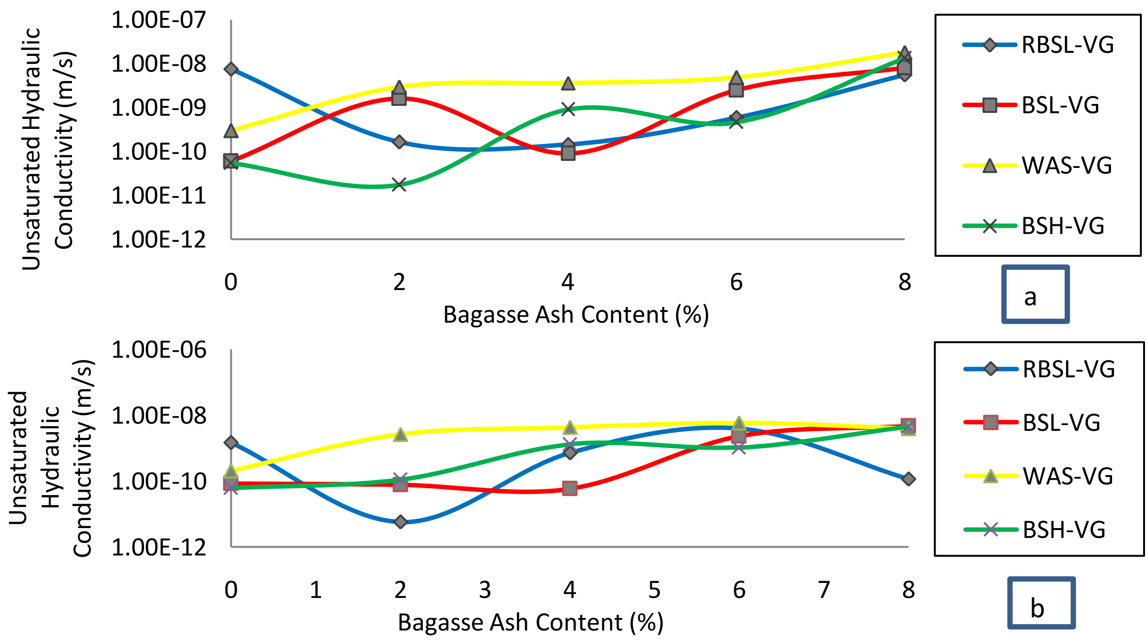


Fig.7: Variation of unsaturated hydraulic conductivity of foundry sand-bagasse ash mixtures with water content relative to optimum for BSH compaction for Brooks-Corey model (a) 10 kPa (b) 500 kPa (c) 1500 kPa

Effect of bagasse ash on Unsaturated Hydraulic Conductivity

Fig.8.a-c for van Genuchten model and Fig.9.a-c for Brooks-Corey model shows the variation of unsaturated hydraulic conductivity with bagasse ash content for specimens prepared for specimens optimum moisture content and compacted using reduced British Standard light (RBSL), British Standard light (BSL), West African Standard (WAS) and British Standard heavy (BSH) energy levels. van Genuchten models at matric suctions of 10, 500, 1500 kPa were also utilized. Generally, British Standard light (BSL), West African Standard (WAS) and British Standard heavy (BSH) energy levels resulted in increasing unsaturated hydraulic conductivity with bagasse ash content. These trend can be attributed the bagasse ash displacing or reducing the clay content in foundry sand. Thus the lesser the fines or clay content the higher the hydraulic conductivity for both van Genuchten (1980) and Brooks-Corey (1964) models. However, No clear trends were observed for reduced British Standard light (RBSL) energy level for both van Genuchten (1980) and Brooks-Corey (1964) models



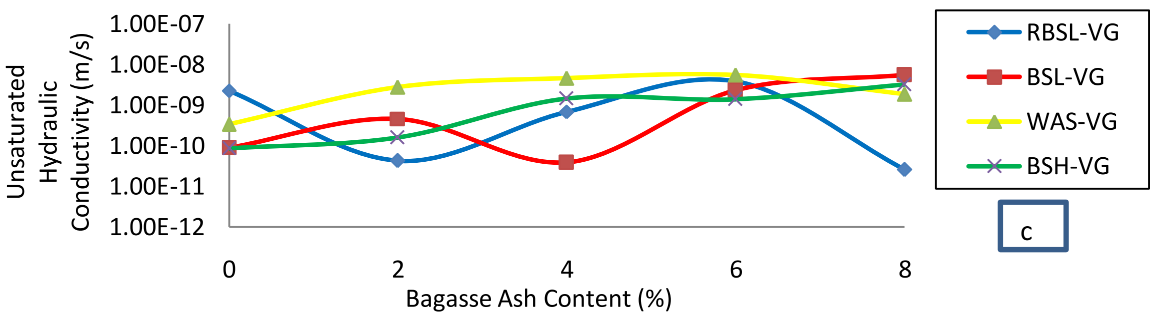


Fig.8: Variation of unsaturated hydraulic conductivity of foundrysand with bagasse ash content at optimum moulding water content for (a) 10 kPa (b) 500 kPa (c) 1500 kPa

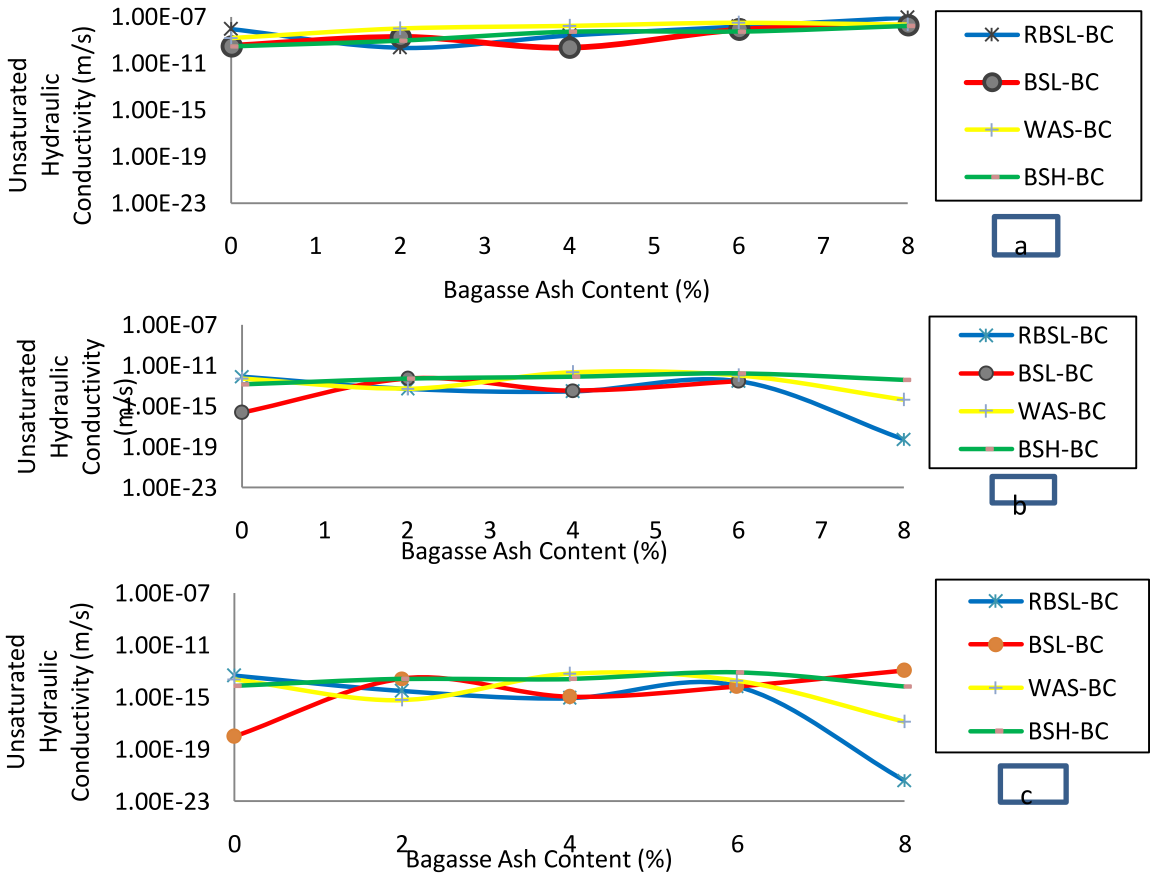


Fig.9: Variation of unsaturated hydraulic conductivity of foundrysand with bagasse ash content at optimum moulding water content for (a) 10 kPa (b) 500 kPa (c) 1500 kPa

Effect of Unsaturated Hydraulic Conductivity of Foundry Sand-Bagasse Ash Mixtures with Matric Suction At Optimum Moulding Water Content

The effect of unsaturated hydraulic conductivity of foundry sand-bagasse ash mixtures with matric suction at optimum moulding water content for reduced British Standard light (RBSL), British Standard light (BSL), West African Standard (WAS) and British Standard heavy (BSH) are shown in Figs.10a-e and 11a-e. van Genuchten (see Fig.7 a-e) and Brooks-Corey (see Fig.8a-e) models at matric suctions of 10,30,100, 500,1000, 1500 KPa were also utilized. The observed trend showed that van Genuchten (1980) model gave more consistent values on the effect of bagasse ash content on the unsaturated hydraulic conductivity than Brooks-Corey (1964) model. Specimens compacted at higher energy level especially as predicted by van Genuchten (1980) model did record a clear trend on the hydraulic conductivity values. Although, the BSL energy recorded lower values than the other energy levels. Generally, reductions in the frequency of large pores and average pore sizes result in lower unsaturated hydraulic conductivity. Brooks-Corey (BC) and Van Genuchten's (VG) models from results of the soil water characteristic curve (SWCC) recorded a consistent pattern of predicting the unsaturated hydraulic conductivity.

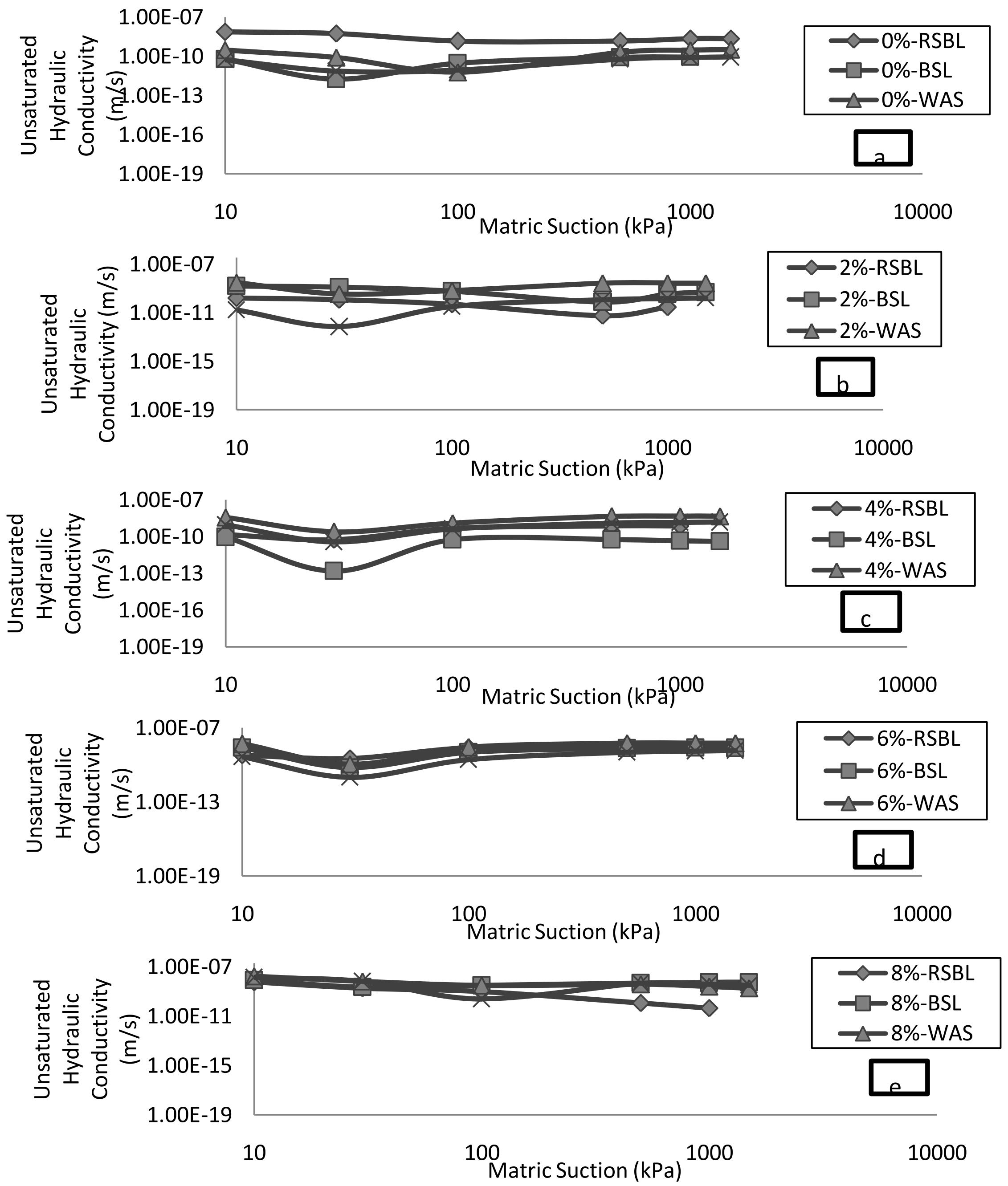


Fig.10: Variation of unsaturated hydraulic conductivity of foundry sand-bagasse ash mixtures with matric suction at optimum moulding water content using van Genuchten model (a) 0% BA 2% BA (b) 4% BA (d) 6% BA (e) 8% B

CONCLUSION

The predicted unsaturated hydraulic conductivity of specimens was determined using the Brooks-Corey (BC) and Van Genuchten's (VG) models from results of the soil water characteristic curve (SWCC). The observed trend for van Genuchten (1980) and Brooks-Corey (1964) models irrespective of bagasse ash treatment level in most cases showed that the unsaturated hydraulic conductivity decreased with increasing moulding water content. British Standard light (BSL), West African Standard (WAS) and British Standard heavy (BSH) energy levels resulted in increasing unsaturated hydraulic conductivity with bagasse ash content. These trend can be attributed the bagasse ash displacing or reducing the clay content in foundry sand. Thus the lesser the fines or clay content the higher the hydraulic conductivity for both VG and BC models. However, No clear trends were observed for reduced RBSL energy level for both for both VG and BC models.

The unsaturated hydraulic conductivity decreases with increasing matric suction for both models. The BC and VG model gave a clearer trend as regarding the influence of increasing bagasse ash content. The knowledge of the unsaturated behavior of compacted foundry sand treated bagasse ash as investigated essentially recorded better values such that the performance of these materials as liners with bagasse ash content as a pozolanna is better understood due to reported results of its unsaturated hydraulic conductivity.

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