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Research article

PERMEABILITY COEFFICIENT MODEL INFLUENCED BY VOID RATIO ON HETEROGENEOUS COMPRESSIBILITY OF FINE SAND FORMATION IN OBIOAKPOR, PORT HACOURT

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Abstract

The deposition of permeability under the influences of soil compressibility in natural condition or in impose loads has been thoroughly expressed. permeability in fines sand formation were to monitor coefficient of permeability which depends on characteristics of both soil medium and pore fluid, these includes particle size, void ratio, composition, fabric, degree of saturation as major characteristics and viscosity, unit weight polarity as major pore fluid characteristics, heterogeneous influences from void ratio may have pressure permeability coefficient in fine sand, the expression has proven different dimensions that will always generate heterogeneous setting in the deltaic formation, to predict this types of coefficient, mathematical modelling approach were applied, the developed system generated governing equation that were derived to produced predictive model on permeability coefficient for fine sand formation. Soil and water engineers will definitely apply these concepts when they are doing construction of various options where this parameter is highly significant.

Keywords: permeability coefficient, void ratio, compressibility and fine sand

1. Introduction

The development of roads that generate compaction of traffic has been identified as a major process that affects the production and the environment by changing the soil structure. It has been observed in physical properties of soils

(Anh et al 2011). More so it has also experienced changes in mechanical strength, further more water and gas transports and thus affects the root and shoot growth. It changes also express soil nitrogen and carbon cycles observed to cause increases in soil erosion due to water flow (Soane and van Ouwerkerk, 1994). Enumerating soil damage by compaction is consequently significance when establishing strategies for unindustrialized and forest management on a local scale and for ecological fortification measures on a larger scale. The assessment of the soil compaction effects on soil physical properties is normally based on the contemplation of the changes in soil mechanical strength, aeration and hydraulic properties (Horn et al., 1995; Kozlowski, 1999; Lipiec and Hatano, 2003; Schäfer- Landefeld et al., 2004; Hemmat and Adamchuk, 2008; Anh et al 2011). Different concept have been projected to evaluate soil degradation due to compaction using relatives between soil compaction parameters and soil capacity parameters such as air-filled porosity, degree of saturation, water content, etc: (i) Håkansson (1990) there should be thorough description on soil compactness in terms of relative soil porosity variations; (ii) Koolen and Kuipers (1989) observe the soil understanding thought about compaction and proposed various compaction criteria in terms of variations of soil strength parameters such as the pre-compression pressure; (iii) Horn et al. (2007) and Mosaddeghi et al. (2007) investigated the relationships between applied stress and soil air permeability; (iv) Håkansson and Lipiec (2000) analysed soil compaction using relations between soil capacity parameters and air permeability. Note that after Horn and Kutilek (2009), a capacity parameter defines a general status, while an intensity parameter includes dynamic aspects over time and space. Goss and Ehlers (2010) presented their disagreement about these definitions, arguing that both intensity and capacity properties can vary in both space and time. In the present work, the term "capacity parameter" is adopted and it defines a general status, i.e., the composition of a given volume but not the internal structure and function (as proposed by Horn and Kutilek, 2009); at the same time, it is admitted that the capacity parameters can vary with time (following Goss and Ehlers, 2010). Laboratory studies on air permeability have shown its dependency on various soil parameters related to the capacity parameters, such as the degree of saturation (Seyfried and Murdock, 1997; Juca and Maciel, 2006), the water content (Sanchez-Giron et al., 1998) and the air-filled porosity (Olson et al., 2001; Moldrup et al., 2003). In general, the air permeability is lower at a higher degree of saturation with a lower air-filled porosity. Based on the experimental data of compacted silty soil, Delage et al. (1998) concluded that airfilled porosity is the unique parameter affecting the air permeability. Moon et al. (2008) found that the air permeability of compacted soils depends on the compaction energy as well as the moisture content at moulding; the lowest value of air permeability being at the optimum moisture content (maximum dry unit weight). Studies on undisturbed and repacked soils have shown significant effects of the soil structure and pore-space characteristics on the air permeability (O'Sullivan et al., 1999; Moldrup et al., 2001; Tuli et al. 2005; Dörner and Horn, 2006).

2. Theoretical background

Soil is one of the most significant engineering materials. Nevertheless, different numerous other materials of apparently equal significance, its properties cannot be predestined for it is naturally occurring material. The Engineer is consequently burden with the liability to either make his design outfit the soil or carry out process intended at improving its properties to the desired or an acceptable condition through the applications of soil stabilizing agents. The solidity of soil is of utmost significance to the field of construction/soil Engineering. The solidity of structures observed on soil depends on the shear strength of fundamental soil which is influenced by the movement of water within its matrix. It has also express the way it is governed by the quantity of pores distribution setting present in the soil (i.e., the soil porosity), the consequences has generated several results of which makes the soil to either be of high or low permeability. Soil permeability is fundamentally a measure that will definitely ease water that can flow through a soil (Donald, 2001). Permeability depends on porosity – the higher the porosity the higher the permeability. It is one of the most important geotechnical parameters that determine the behaviour of soil under load (Verruijt, 2010). Some soil types in the tropics (e.g. black cotton soil) absorb large amount of water during the raining seasons and do not allow easy passage of such water – they are of low permeability (Alhassan, 2008 Gbenga and Oluwatobi,2013).

2. Governing equation

$$\phi \frac{\partial K_{(x)}}{\partial t} = Dv_{(x)} \frac{\partial K}{\partial x} + V_{(x)} \frac{\partial K}{\partial x} \quad \text{..............................} \quad (1)$$

The developed governing equation express the deposition of the system, this generated the equation to be derived by expressing various way that the variables has displayed there function to generate model that can predict permeability coefficient, the developed governing equation will definitely express model base on the behaviour of permeability depositions on soil as the derived solution will be expressed bellow.

Nomenclature

K = Permeability $[LT^{-1}]$
ϕ = Porosity [-]
D = Dispersion in number [-]
V(x) = Velocity [LT]
T = Time [T]
X = Depth [L]

Let $K = X\,T$ from equation (2), we have

$$\phi\, T^1 Z = D_v\, TX^1 + V_{(x)}\, TX^1 \quad \text{..............................} \quad (2)$$

$$\phi \frac{T^1}{T} = D_v \frac{X^1}{X} + V_{(x)} \frac{X^1}{X} \quad \text{..............................} \quad (3)$$

$$\phi \frac{T^1}{T} = \tau^2 \quad \text{..............................} \quad (4)$$

$$D_v \frac{X^1}{X} = \tau^2 \quad \text{..............................} \quad (5)$$

$$V_{(x)} \frac{X^1}{X} = \tau^2 \quad \text{..............................} \quad (6)$$

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This implies that equations (5) and (6) can be written as:

$$\left[D_v + V_{(x)}\right]\frac{X^1}{X} = \tau^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (8)$$

From (4) $\phi \frac{T^1}{T} = \tau^2$

i.e. $\phi \frac{\partial T}{dT} = \tau^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (9)$

$$\int \frac{dT}{T} = \frac{\tau^2}{\phi}\int dt \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (10)$$

$$Ln\ T = \frac{\tau^2}{\phi}t + c_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (11)$$

$$LnZ = \frac{\tau^2}{\phi} + c_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (12)$$

$$\boxed{T = A\ell^{\frac{\tau^2}{\phi}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (13)$$

In most condition of the disintegration of the grain size to various particles are express in different condition, these are base on the deposition of deltaic formation in the study locations, the period were considered in the system base of fluid flow velocity as a results of permeability coefficient on the soil, the express model has shows the period of permeation that ease passage of fluid between the permeable formations.

From (7)

$$\left[D_v + V_{(x)}\right]\frac{X^1}{X} = \tau^2\, dx \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (14)$$

$$\int \frac{dx}{x} = \frac{\tau^2}{D_v + V_{(x)}}\int dx \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (15)$$

$$Ln\ x = \frac{\tau^2}{D_v + V_{(x)}}X + c_1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (16)$$

$$Z = \exp\left[\frac{\tau^2}{D_v + V_{(x)}} X + c_1\right] \quad \text{................................} \quad (17)$$

$$X = B\exp\frac{\tau^2}{D_v + V_{(x)}} x \quad \text{................................} \quad (18)$$

Combining (17) and (18), we have

$$C, TX = TX$$

$$Ae\frac{\tau^2}{\phi} Z\, B\left[\exp\frac{\tau^2}{D_v + V_{(x)}}\right] \quad \text{................................} \quad (19)$$

$$C\ X, T = AB\exp\left[\frac{t}{\phi} + \frac{X}{D_v + V_{(x)}}\right]\tau^2 \quad \text{................................} \quad (20)$$

The behaviour of permeability in soil as an engineering properties soil has various variation base on several influence from other formation characteristics, the variables depend on the rate of predominance's in any deposition, and this may pressure the degree of permeability in the formation which will either make the rate of permeability low or high in the deltaic formation. The study were to developed predictive model that generate values that can be applied in any deltaic location on permeability coefficient, the express model consider several rate of soil compressibility base on geological and manmade activities in the study area.

4. Conclusion

The coefficient of Permeability depends on porosity – the higher the porosity the higher the permeability. These expression are base on the relationship that both parameters has as a characteristics in soil formation, It is one of the most significant geotechnical parameters that determines the behaviour of soil under load, Some soil types in the tropics (e.g. black cotton soil) develop depositional variation known as heterogeneity, this determine the rate of permeability in assessments of it generally in those heterogeneous setting, more so some formation that has low permeability absorb large amount of water during the raining seasons and do not allow easy passage of such water. The stability of structures depends on the amount and nature of moisture in the underneath soil. This hinges on the soil permeability – flow depend on movement of water within the soil. The Engineer is therefore burden with the accountability to either make his design suit the soil or carry out procedures aimed at improving its properties to the desired or an acceptable state through the introduction of soil stabilizing agents if the soil are not to be easily managed in normal setting. The stability of soil is of utmost importance to the field of construction /soil

Engineering. The expressed model will definitely generate values that will be use to construct /soil engineers in deltaic environment.

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