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Research article

PREDICTIVE MODEL TO MONITOR DEGREE OF POROSITY INFLUENCED BY VELOCITY ON RADIAL FLOW IN LATERITIC AND SILTY FORMATION IN PORT HARCOURT METROPOLIS

Eluozo, S N.

Subaka Nigeria Limited Port Harcourt, Rivers State of Nigeria
Director and principal consultant, Civil and Environmental Engineering,
Research and Development
E-mail: soloeluozo2013@hotmail.com

Abstract

The deposition of porosity has lots of influences that are determined by geological setting in soil, this expression were found significant on the study carried out to monitor other influences that may pressure it deposition in various soil formation, velocity and radial flow were considered to pressured the deposition of porosity degree in lateritic and silty formation, the influences are from the structural disintegration from porous rocks that deposit various degree of void between the intercedes, these condition allowed for fluid flow velocity at different level that includes radial flow, these condition has not been observed by experts, investigation carried out express these stated parameter as one of the formation influences that may have pressured the variation of porosity in lateritic and silty formation, the developed modelling approach were found imperative on the these subject matter, the expressed model were developed base on the generated system through these variables, experts in soil engineering will applied these concepts as one way porosity influences radial flow through the predictive model.

Keywords: predictive model, porosity, velocity, radial flow, lateritic and silty formation

1. Introduction

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. According to Sherwood George (1993 2012) fine-grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization (Sherwood, 1993). Peat soils and organic soils are rich in water content of up to about 2000%, high porosity and high organic content. The consistency of peat soil can vary from muddy to fibrous, and in most cases, the deposit is shallow, but in worst cases, it can extend to several meters below the surface (Pousette, et al 1999; Cortellazzo and Cola, 1999; Åhnberg and Holm, 1999 Nimmo 2004). Organic soils have high exchange capacity; it can hinder the hydration process by retaining the calcium ions liberated during the hydration of calcium silicate and calcium aluminate in the cement to satisfy the exchange capacity. In such soils, successful stabilization has to depend on the proper selection of binder and amount of binder added (Hebib and Farrell, 1999; Lahtinen and Jyrävä, 1999, Åhnberg et al, 2003; George 2012). Particle size and shape reflect material composition, grain formation and release from the mineral matrix, transportation, and depositional environments. Mechanical and chemical processes determine grain shape once it is released from the matrix (Margolis and Krinsley 1974, Rahaman 1995). The transition region from chemical to mechanical shape-control occurs for a particle size between d~50-to-400 μm. Chemical action and abrasion increase with age and older sands tend to be rounder regardless of particle size. The larger the particle the higher the probability of imperfections and brittle fracturing (typically d>400μm). Conversely, smaller particles are stronger by lack of imperfections, then, failure by cleavage along crystal atomic planes becomes energetically advantageous and the resulting particles are more platy (Margolis and Krinsley 1974). Particle shape is characterized by three dimensionless ratios (Wadell 1932, Krumbein 1941, Powers 1953, Krumbein and Sloss 1963, Barrett 1980): *sphericity S* (cf. eccentricity or platiness), *roundness R* (cf. angularity) and *smoothness* (cf. roughness). Sphericity indicates whether one, two, or three of the particle dimensions are of the same order of magnitude, and it is defined as the diameter of the largest inscribed sphere relative to the diameter of the smallest circumscribed sphere Roughness describes the surface texture relative to the radius of the particle. Spehricity, roundness and smoothness form an independent set. While sphericity and roundness increase by abrasion, they do not increase proportionally. Furthermore, chipping of a particle may increase the sphericity, but it decreases the roundness (Wadel 1932). Sphericity and roundness can be effectively characterized by visual comparison with charts (Folk 1955, Barrett 1980). Digital image analysis facilitates the evaluation of mathematical descriptors of particle shape including Fourier analysis, fractal analysis and other hybrid techniques (e.g., Meloy 1977, Clark 1987, Hyslip and Vallejo 1997, Bowman et al. 2001, Sukumaran and Ashmawy 2001

2. Theoretical background

The deposition of porosity are base several structural setting through it geological setting of any area, these has always been the case of porosity in most formation, the study of porosity through radial flow influences and it velocity has been stress in several dimension by experts, the deposition of soil porosity are basically depend on the rate of disintegration from porous rock including other mineral of natural origin, this condition has express different variations of porosity degree in various level in deltaic formations. The effect of porosity on soil bearing capacity are also reflected on these basic formation of soil at various depth and location, the study look at the engineering properties of soil to be homogeneous due these variances deposition of the formation characteristics. Furthermore several challenges from soil developed circumstances such as collapsible of soils, these are known to determine the ability of soils susceptible to express hydroconsolidation, they are geologically young, unconsolidated, low-density, loose, more so dry soils, commonly present in arid to semi-arid regions. These soils generally occur within the top 10 to 15 feet of wind deposited sands or silts (loess), alluvial fans, colluvial soils, stream banks or residual mudflow soils. Collapsible soils have granular particles that are supported by clay or silt and can be chemically cemented in place creating a porous structure. The bonds supporting this porous structure generally has enough shear strength to support loads, however once water is introduced, the porous structure collapses and the granular particles are re-arranged. Foundation systems on collapsible soils condition shall be constructed in a manner that will minimize damage to the structure caused by hydro-consolidation settlements. The effects of collapsible soils is usually evidenced in the form of cracks in perimeter footings, separation between footing and slab, cracks in slabs and minor stucco cracks

3. Governing equation

$$K\frac{\partial \phi_{(x)}}{\partial t} = Dv_{(x)}\frac{\partial \phi}{\partial x} + V_{(x)}\frac{\partial \phi}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

The expressions here are the equation that governs the prediction of porosity in the study locations. The system expresses the functional parameters that pressure the degree of porosity at various depositions. The expressed governing equations are developed in such a way that it will be thoroughly derived the solution considering several conditions in the deposited formation

Nomenclature

K = Permeability [LT^{-1}]

ϕ = Porosity [-]

D = Dispersion in number [-]

V(x) = Velocity [LT^{-1}]

T = Time [T]

X = Depth [L]

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

$$K\,T^1 Z = D_v\,TX^1 + V_{(x)}\,TX^1 \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$K\frac{T^1}{T} = D_v\frac{X^1}{X} + V_{(x)}\frac{X^1}{X} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

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

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

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

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

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

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

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

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

$$Ln\,T = \frac{\tau^2}{K\phi}t + c_1 \qquad \text{..............................} \qquad (11)$$

$$LnZ = \frac{\tau^2}{K\phi} + c_1 \qquad \text{..............................}$$

(12)

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

Since the influences on porosity are basically from velocity on radial flow, this condition may be from other development that took place, during weathering of these porous rocks. the consideration of time are base on the

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facts that radial flow express it under the influences of permeability of the formation, such development relate with movement of fluid under the influence of velocity of fluid flow in the strata, these condition were considered in the system that generated model with respect to time.

From (7)

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

$$\int \frac{dx}{x} = \frac{\tau^2}{D_v + V_{(x)}} \int dx \quad \text{.................................} \quad (15)$$

$$Ln\ x = \frac{\tau^2}{D_v + V_{(x)}} X + c_1 \quad \text{.................................} \quad (16)$$

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

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

Combining (17) and (18), we have

$$C, TX = TX$$

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

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

The expression in twenty is the final developed model that wills definitely predict degree of porosity in lateritic and silty formation, the study express several condition that could be able to influences porosity at various dimension. A soil's porosity and pore size distribution characterize its pore space, that portion of the soil's volume that is not occupied by or isolated by solid material. The pore space has fluid pathways that are tortuous, variably constricted, and usually highly connected. The pore space is often considered in terms of individual pores--an artificial concept that enables quantifications of its essential characteristics.

4. Conclusion

There are several conditions that affect the deposition of porosity in the formation; these generated the governing equation considered in various level of soil porosity in different conditions of geological setting. The effect from engineering dimensions has also been stressed to generate the derived model for the study. More so the porosity degree are base on the type of grain size, thus, Porosity φ is the fraction of the total soil volume that is taken up by pore space. Thus it is a single-value quantification of the amount of space available to fluid within a specific body of soil; Porosity is often conceptually partitioned into two components, most commonly called textural and structural porosity. The textural component is the value the porosity would have if the arrangement of the particles were random, as described above for granular material without cementing the structural component represents nonrandom structural influences, including macropores and is arithmetically defined as the difference between the textural porosity and the total porosity. The texture of the medium relates in a general way to the pore-size distribution, as large particles give rise to large pores between them, and therefore is a major influence on the soil water retention curve. The volume of water contained in a saturated sample of known volume can indicate porosity. You could recall that the mass of saturated material less the oven-dry mass of the solids, this is divided by the density of water, giving the volume of water. This divided by the original sample volume that gives porosity. The expression on the influences of radial flow consider the pressure from velocity of flow, the developed models were able to monitor the conditions of soil porosity in various dimensions.

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