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Spatial Analysis on Permeability of Soil of Unnao

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Abstract : The coefficient of permeability of stratified soil deposits, when the flow is normal to the orientation of the bedding planes, has been observed to deviate from the value calculated theoretically. The coefficient of permeability is calculated by Darcy's law. The present technical study deals with the results from the study of permeability behaviour of two layer soil system and three-layer soil system. For two layer soil system the coefficient of permeability of exit layer is considering as controlling factor for three layer soil system the coefficient of permeability depends upon the relative positioning of soil. This study reinforces the point that the coefficient of permeability of a layered soil system, when the flow is normal to the orientation of the bedding planes, depends upon the relative positioning of the layers with different values of coefficient of permeability in the system.

***Index Terms*—Permeability, Soil, Darcy's law, Black soil, Sand, Clay.**

I. Introduction

The capacity of a soil to permit the passage of fluids through its interconnecting voids, is one of the most important soil engineering properties. The study of the permeability of soils is important in soil mechanics. It is essential for calculating the quantity of underground seepage under various hydraulic conditions, In common practice, the permeability coefficient is usually obtained by constant head permeability test, and is utilized in filtration-drainage, settlement, and stability calculations. These problems are extremely important for environmental aspects such as waste water management, slope stability control, erosion, and structural failure related with the ground settlement issues. The drainage and water movement in fine-grained soils are of primary importance to geotechnical engineering, soil science, and hydrology. In the field of geotechnical engineering, permeability has a significant influence on the consolidation characteristics of soil and as a consequence of drainage, on the mobilization of shear strength of soils. In addition, the study of the seepage through the body of earth dams, slope stability problems, ground water flow, and many related topics requires reliable information on permeability characteristics of fine-grained soils.

For layered soil system the bedding planes of the layers may be horizontal or vertical or inclined. Each layer will have its own value of coefficient of permeability, k. The average or equivalent coefficient of permeability of the stratified deposit, k_{eq}, depends upon the direction of flow in relation to the orientation of the bedding planes.

The equivalent coefficient of permeability in both the cases is calculated assuming the Darcy's law to be valid. If L_1, L_2, ..., L_n represent the thicknesses of individual layers and k_1, k_2,......., k_n are the corresponding coefficients of permeability, then the equivalent coefficients of permeability normal to the bedding plane, $(k_{eq})_n$ and parallel to the bedding plane, $(k_{eq})_p$ are obtained by$(K_{eq})_n$. The permeability characteristics of homogeneous soil deposits are known to be functions of void ratio and the soil type. The permeability characteristics of stratified deposits (i.e., layered systems), predominantly when the flow is normal to the bedding plane, can further be complicated by the possible mutual interaction among the soils of different layers and their relative position in the deposit. Hence, in the present experimental investigation, it is proposed to study the permeability characteristics of stratified deposits when the flow is normal to the bedding planes, the factors affecting them, and the possible mechanisms controlling such flows. For the sake of simplicity, the simple cases of a two layer system and three layer system are considered.

II. Literature Review

Uppot et al. (1989): Two clays are subjected to organic and inorganic permeants to study the changes in permeability caused by the reaction between clays and permeants.

Haug et al. (1990): The laboratory permeability tests were conducted on a prototype liner formed of Ottawa sand and sodium bentonite. This material was mixed, moisture-conditioned, and compacted into reinforced wooden frames. The in situ permeability test results were verified with low gradient, back-pressure saturated triaxial permeameter tests conducted on undisturbed cored and remolded samples

Sridharan and Prakash (2002): A detailed study of two-layer soil systems indicates that the mutual interaction among different layers of different soil types forming a stratified deposit affects the equivalent permeability of the stratified deposit, which cannot be simply calculated by the use of the equation for the equivalent coefficient of permeability of a stratified deposit when the flow is normal to the orientation of the bedding planes based on the Darcy's law. The permeability of the exit layer controls whether the measured permeability is greater or lesser than the theoretical values for a stratified deposit. The coefficient of permeability of a soil appears to be also a function of the interaction between the soil and the surrounding soil(s) with which it is in contact, in addition to the void ratio, thickness, and the soil type in the case of layered system. In this context, the coefficient of permeability of a soil in a layered system has to be considered as dependent upon how the layers of different *k* are relatively placed, their thicknesses, and the flow direction. While the present investigation is purely experimental, it opens up the scope for further work in that the validity of the results and proposed hypothesis have to be ascertained mathematically.

Galvaeo et al. (2004): coefficient of permeability of saprolitic soil increased about five times when two percent lime was added and then decreased on further addition of lime. This is assign to the creation of chemical bonds and aggregation. As for lateritic soil, the coefficient of permeability decreased as lime was added. This is also assign to the same mechanism except that the bonds are weaker than those developed in Soil.

Nikraz et al. (2011): A series of laboratory permeability tests carried out to evaluate fiber effect on hydraulic conductivity behavior of composite sand. Clayey sand was selected as soil part of the composite and natural fiber was used as reinforcement.

Sridharan and Prakash (2013): A comparative study of the measured equivalent coefficient of permeability of three-layer soil sediments with the theoretically calculated values has been made. The results demonstrate that, by and large, the coefficient of permeability of thebottom layer controls whether the measured value of equivalent coefficient of permeability is greater or lesser than the theoretically calculated value. The consequence of this observation is the realization that the equivalent coefficient of permeability of any layered soil deposit is notjust dependent upon the values of k of the individual layers constituting the deposit, and that it also depends upon the relative positioning of the layers in the system

III. MATERIALS AND METHODOLOGY

a) Materials

- Clay: This project consists of clay that we got from Sector 5 in Rourkela. Clay is actually quite plastic according to its water content and tends to turn hard and brittle. Minerals of clay normally get formed over certain periods of time when the rocks get weathered continuously.

- Black Soil: Black soil in India is commonly used for agricultural uses, but in civil engineering, the black earth are offered risky issues to the creators. In this study, we get black earth from a place near Ambazari Nagpur, and it could be employed to know the porosity of the ground layers.

- Sand: The kind of sand that is utilized in the test in lad was brought from the kind of riverbed of the Koel. It should be devoid of any organic elements and roots etc. The sample was then taken to an oven for drying and was sieved in an IS Sieve of 710 microns where the retention was at 300 microns to get the desired grading.

b) Methodology

- Preparation of Sample: - the collected sample i,e clay, black soil and sand were prepare for the characterization
- Geotechnical Characterization of sampled material: - the prepared sample were subjected for geotechnical analysis. The tests that were performed to fulfill the purpose are as below: -
    1. Liquid Limit
    2. Optimum moisture content
    3. Specific gravity
    4. Maximum dry density
    5. Sieve Analysis
    6. Standard Proctor test
    7. Constant head permeability test
    8. Variable head permeability test

- Mixing of soil: - three types of mix were prepared in the combination of black soil and sand, sand and clay, black soil and sand and clay
- Preparation of Permeable layer: - A total eighteen sample, six samples in different ratio from each mix were prepared for analysis
- Permeability analysis of soil: - Falling head permeability test were conducted on each sample in permeability system and then result is obtained.

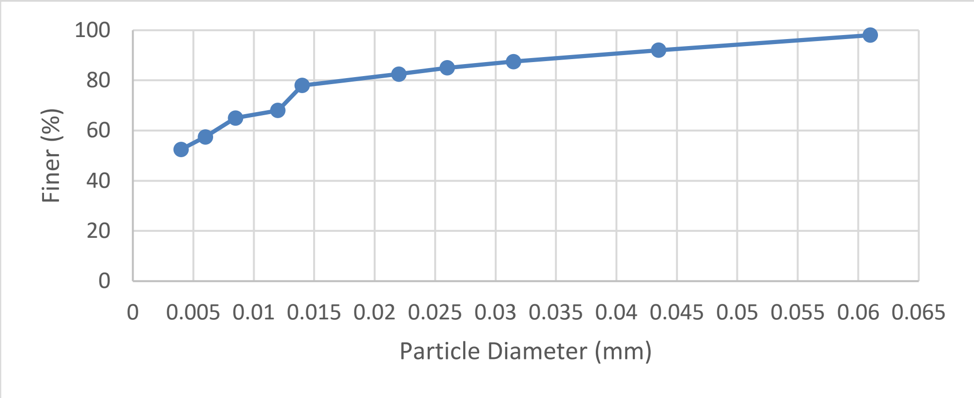
IV. RESULTS AND DISCUSSION

- Results for specific gravity of soils

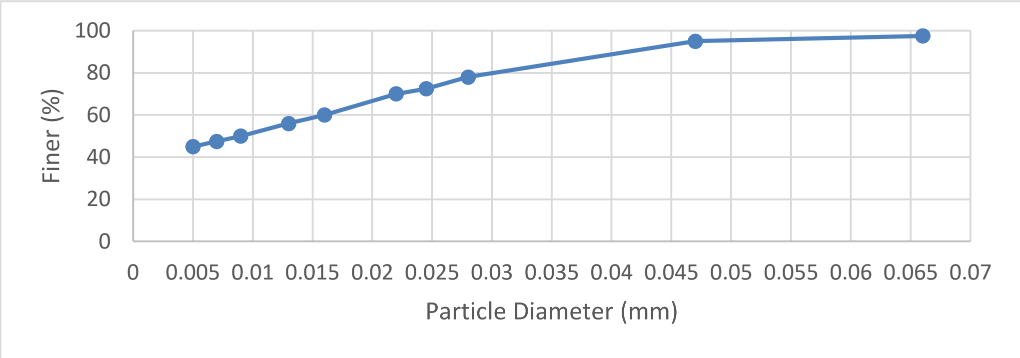
Clay	2.46
Black soil	2.29
Sand`	2.65

- Result for Grain size analysis

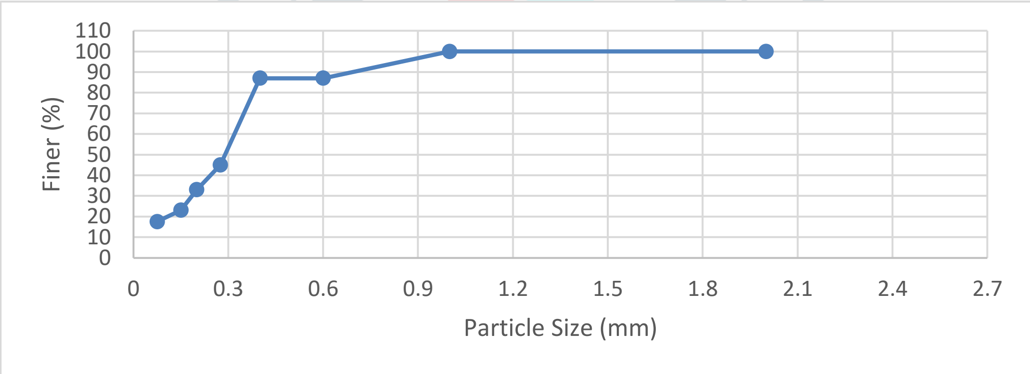
1. Clay



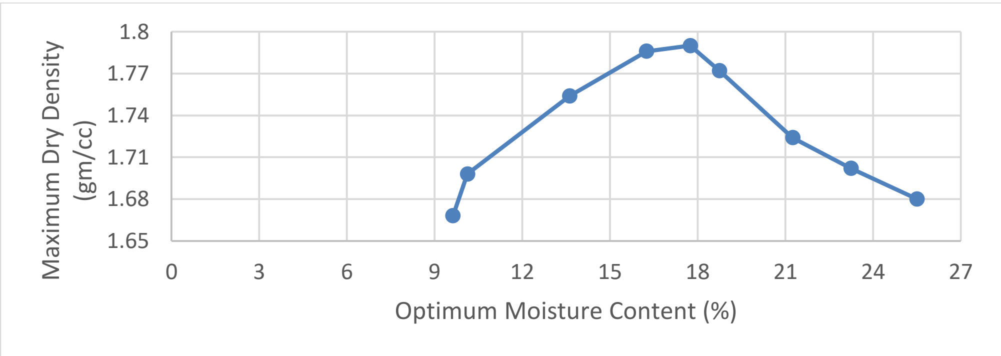
2. Black soil



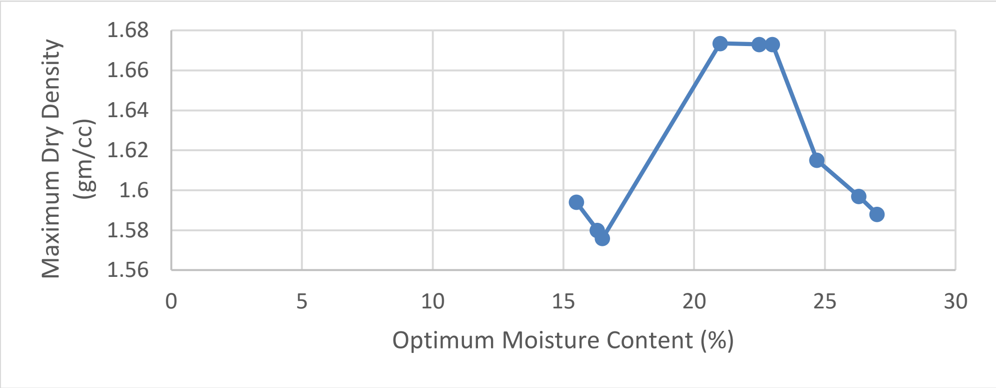
3. Sand



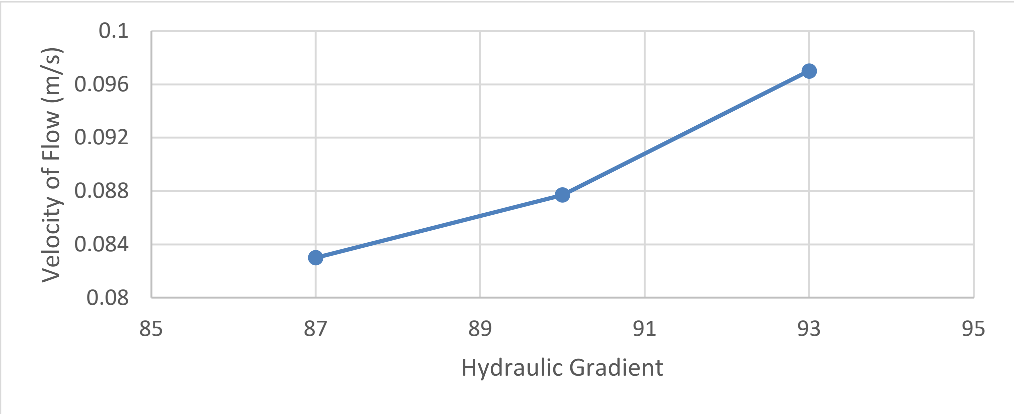
- Relationship between maximum dry density and optimum moisture content for clay



- Relationship between Maximum Dry Density and optimum moisture content of Black soil



- Relationship between hydraulic gradient and velocity of flow for sand.



- Result for permeability analysis

S. No.	Clay and Sand	Black soil and Sand	Clay and Sand and Clay and Sand
1	4.06×10^{-4}	3.94×10^{-4}	3.0529×10^{-4}
2	4.06×10^{-4}	3.94×10^{-4}	3.0529×10^{-4}
3	6.06×10^{-4}	5.88×10^{-4}	3.0529×10^{-4}
4	6.06×10^{-4}	5.88×10^{-4}	3.0529×10^{-4}
5	3.05×10^{-4}	2.972×10^{-4}	3.0529×10^{-4}
6	3.05×10^{-4}	2.972×10^{-4}	3.0529×10^{-4}

V. CONCLUSIONS

A laboratory study was done for two layer and three-layer soil system having different types of soil, type of layer, varying proportion and position for clay, sand and black soil .and it is found that equivalent coefficient of permeability differs from the value calculated from Darcy's law. The permeability of the exit layer controls whether the measured permeability is greater or lesser than the theoretical values for a stratified deposit. The coefficient of permeability of a soil appears to be also a function of the interaction between the soil and the surrounding soil(s) with which it is in contact, in addition to the void ratio, thickness, and the soil type in the case of layered system. And hence the coefficient of permeability of a soil in a layered system has to be considered as dependent upon flow direction, relative position and thickness of layer also this study is purely experimental and it opens up the scope for further work and hence to obtain a mathematical equation for layered soils.

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