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An Experimental Study for Effect of Permeability of Individual Layers on Equivalent Permeability in Stratified Soils

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Abstract: The permeability of soil is of great significance as it helps us with draining of fluids which would otherwise pose a threat to constructions of various kinds and also in some cases the permeability encourages seepage flows which pose a threat to heavy water retaining structures such as RCC Gravity Dams, Check Dams, etc**.** If the soil is placed in multiple layers with each layer having its different permeability; we may achieve desired equivalent permeability.

Darcy's law has been used to calculate the permeability of various materials since long but many scholars have found that the theoretical values of permeability of a multilayered soil system obtained by equation given by Darcy deviates from the practically obtained values in the laboratory. The cause of this deviation remains unknown till the date but, different hypotheses exist.

In this research, an attempt was made to unravel the practical possibility of the change of equivalent permeability by introduction of sand layer as a component in multilayered soil system. In this study we have used black csoil, silt and sand in layered form with equal depths; switching the sand layer at different positions to obtain various values of equivalent permeability both theoretically and practically.

***Index Terms* – Permeability, Sand Layer, Lab Experiment, Darcy's Law**

I. Introduction

Permeability of soil is of great significance in engineering context as it affects other properties of fine-grained soils, e.g.- shear strength, compressibility etc. (Bowles 1976). Darcy's law has been used to calculate the permeability(k) of a material and is in use till date. However, during ground explorations, we come across soil systems which are multilayered (one layer stratified between other two) rather than a single soil mass extending to the total depth. The equivalent permeability(k_{eq}) of such soil systems is calculated by extending the Darcy's approach to multilayered system.

The equivalent permeability of a multilayered soil system with the flow normal to the bedding plane is calculated by the below equation by Darcy. As per Darcy,

$$(k_{eq})_n = \sum_{i=1}^{n}[\, T_i/(T_i/k_i)] \qquad \text{.........(1)}$$

Where, T_i = Thickness of the ith soil layer in the multilayered soil system.

k_i = Permeability of the ith soil layer in the multilayered soil system.

k_{eq} = Equivalent permeability of the multilayered soil system.

However, some researchers (Hansbo,1960; Olsen,1985; Doubin and Moulin,1986 and few more) had noticed that the validity of Darcy's law is not justified in every case and practical results differed from that obtained using the formula for equivalent permeability for stratified soil masses .

Since then the deviation of theoretical values of permeability obtained from Darcy's law from the practical values obtained in the lab are unexplained. A hypothesis made by Prakash and Sridharan, 2002, suggests that the equivalent permeability of the stratified soil mass is dependent upon the permeability of the exit layer. Ranjan and Rao,2007, also suggested that the permeability of a multilayered soil system depends upon the interactions between the adjoining soil layers.

In light of different studies made by research scholars, we have tried to experiment upon the effect of position of sand layer on the equivalent permeability of the multilayered (stratified) soil system.

II. Experimental Setup and Calculations Involved

To conduct this experiment soil samples from different places were gathered and experimented upon. The sand was locally available natural sand gathered from the banks of River Kuwano, Basti, Uttar Pradesh; Silt was gathered from an excavated location near Bade ban, Basti, Uttar Pradesh and Black Soil was gathered from Dewas, Madhya Pradesh.

All the soil samples were oven dried for 24 hours at a temperature of 108 ºC. After drying, the samples were subjected to particle size distribution analysis and Hydrometer analysis (Fig. 1,2 &3). The specific gravity was then calculated using the density bottle method as per IS:2720(Part III/Sec1)-1980 and the values were found as 2.58, 2.54 and 2.57 respectively for sand, silt and black soil.

Constant head permeameter was used for calculating permeability of sand and Falling head permeameter was used for silt and black soil.

A stand pipe was connected to the mould and the drop in heads at regular time intervals was recorded and the individual permeability values were found for silt and black soil.

A mould was prepared and the soils were compacted up to maximum dry density and layered inside with a filter placed at the bottom to avoid loss of soil particles during the test. Water was supplied to the mould at a very slow rate so as to saturate the layered soil system in the mould.

Calculations of permeability were done using equations –

(A)For constant head permeability test

$$k = qL/Ah \quad \text{……….(2)}$$

(B) For falling head permeability test

$$k = 2.303\ (aL/At)\ \log(h_1/h_2) \quad \text{……….(3)}$$

where q = discharge,
L = length of sample,
h = head under which the flow occurs
A = Area of Cross section of sample
t = time interval for head to reach final head h_2 from initial head h_1.

III. Results and Discussions

A total of 6 cases were studies with sand layer at top, bottom and middle positions also switching the positions of silt and black soil.

Case 1 – In this case the sand layer was placed on top accompanied by the silt layer in middle and then black soil was placed as the bottom most layer.

Case 2 – In this case the sand layer was placed on top accompanied by black soil in middle and then silt was placed as the bottom most layer.

Case 3 – In this case the silt layer was at the top accompanied by sand layer in middle and then black soil was placed as the bottom most layer.

Case 4 – In this case the black soil layer is at top accompanied by sand layer in middle and then silt was placed as the bottom most layer.

Case 5 – In this layer the black soil is placed on top accompanied by silt layer in middle and then sand was placed as the bottom most layer.

Case 6 – In this layer the silt layer is placed on top accompanied by black soil layer in middle and then sand was placed as the bottom most layer.

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Top Layer	Sand	Sand	Silt	Black soil	Black soil	Silt
Middle Layer	Silt	Black soil	Sand	Sand	Silt	Black soil
Bottom Layer	Black soil	silt	Black soil	Silt	Sand	Sand

The plot of particle size distribution is given as follows –

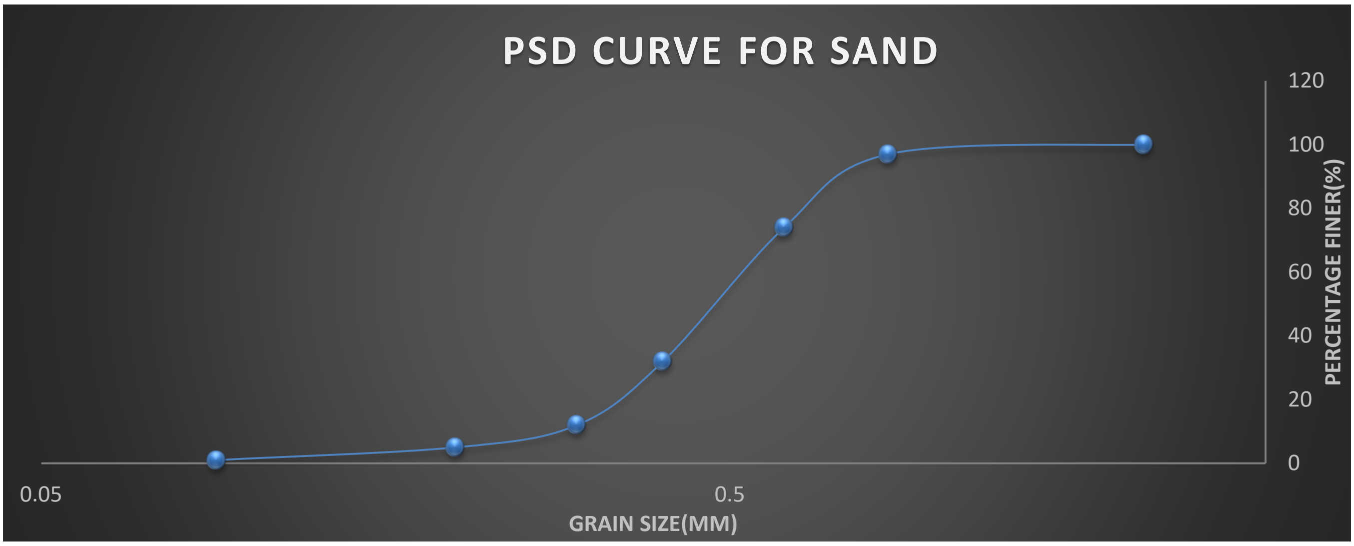

FIG 1. PARTICLE SIZE DISTRIBUTION PLOT FOR SAND

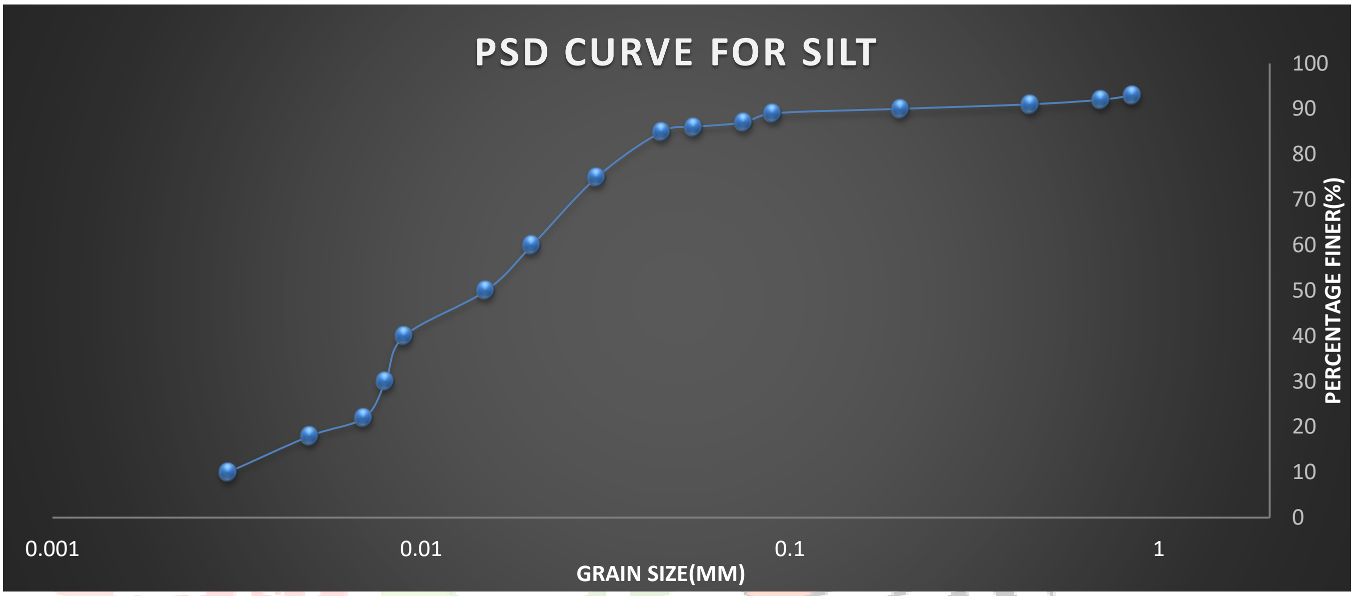

FIG 2. PARTICLE SIZE DISTRIBUTION PLOT FOR SILT

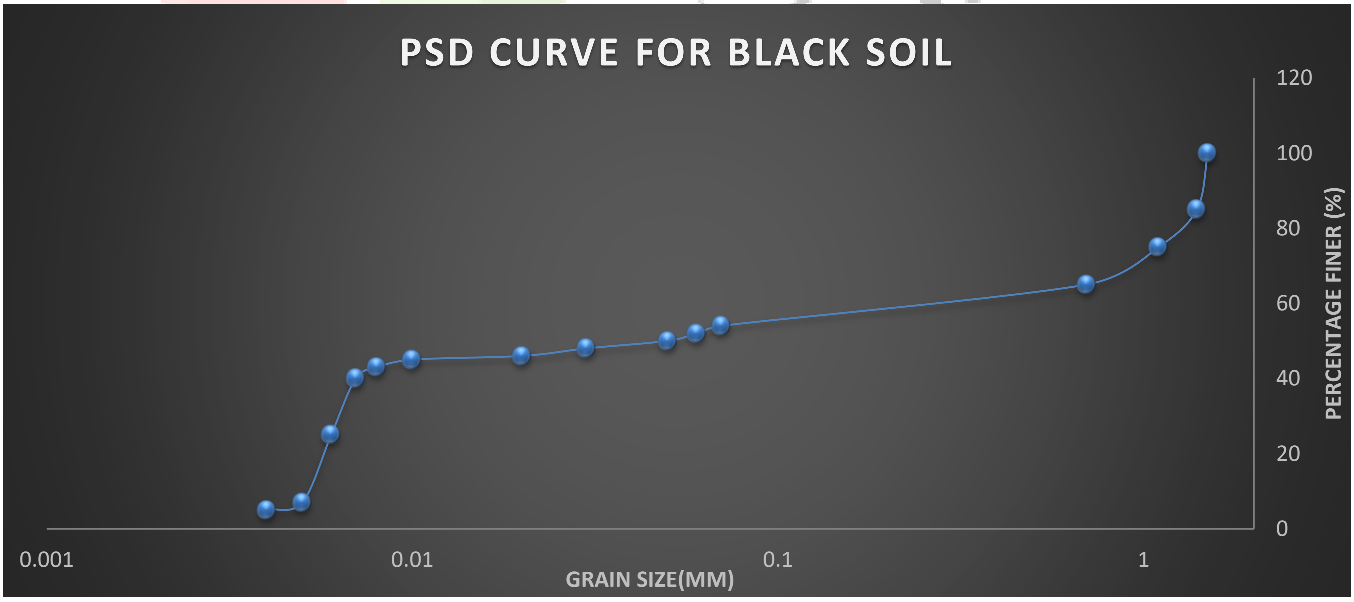

FIG 3. PARTICLE SIZE DISTRIBUTION PLOT FOR BLACK SOIL

The values of permeability both individual and also for each case of layering is mentioned below and a comparison is also made for better understanding.

CASE NO.	SEQUENCE OF LAYERING		INDIVIDUAL MEASURED PERMEABILITY VALUES (k) (m/s)	K_{eq} (m/s)		$\frac{Keq\ measured}{Keq\ calculated}$
				Calculated	Measured	
1	FLOW ↓	SAND	5.110×10^{-7}	5.290×10^{-7}	5.611×10^{-7}	1.060
		SILT	1.690×10^{-8}			
		BLACK SOIL	1.090×10^{-9}			
2	FLOW ↓	SAND	5.000×10^{-7}	5.198×10^{-7}	5.587×10^{-7}	1.074
		BLACK SOIL	1.310×10^{-9}			
		SILT	1.850×10^{-8}			
3	FLOW ↓	SILT	1.890×10^{-8}	5.432×10^{-7}	5.958×10^{-7}	1.096
		SAND	5.230×10^{-7}			
		BLACK SOIL	1.310×10^{-9}			
4	FLOW ↓	BLACK SOIL	1.180×10^{-9}	5.180×10^{-7}	5.499×10^{-7}	1.061
		SAND	4.980×10^{-7}			
		SILT	1.880×10^{-8}			
5	FLOW ↓	BLACK SOIL	1.240×10^{-9}	5.401×10^{-7}	5.845×10^{-7}	1.082
		SILT	1.890×10^{-8}			
		SAND	5.200×10^{-7}			
6	FLOW ↓	SILT	1.970×10^{-8}	5.219×10^{-7}	5.532×10^{-7}	1.060
		BLACK SOIL	1.190×10^{-9}			
		SAND	5.010×10^{-7}			

From the above table we can clearly see that the sand layer placement as well as placement of black cotton soil affects the equivalent permeability of the multilayered soil system. The case in which the least permeability was obtained both experimentally and by calculation is Case-4 where, Sand is the middle layer, Black Soil is the top most layer and Silt is the bottom most layer.

The result also shows that highly permeable soil present at the bottom layer contributes to more seepage that was observed in the experiment.

IV. CONCLUSIONS

After discussing the results, Author is of conclusion that both entry and exit layers tend to control the seepage by and large only when they are less permeable than the middle layer. Also, the research work partially supports the hypothesis of exit layer controlling the seepage but, further research work with different soil layers is also needed to come to any conclusion.

The deviation of the experimental values from the calculated values can not be explained with the help of current work but future work with more layers and different type of soil layers with advanced method may prove helpful in explaining the deviation witnessed during the experiment.

Concluding the results of this work we can conclude that the soil with most permeability should not be placed in the bottom most layer to avoid an increase in equivalent permeability of the system.

V. REFERENCES

1. Sridharan & Prakash,1999, Simplified seepage consolidation test for soft sediments. Geotech Test J, ASTM 22(3):235–244
2. Hansbo ,1960, Consolidation of clays with special reference to influence of vertical sand drains. Swed Geo-tech Ins Proc, Stockholm 18:41–61
3. Doubin & Moulin ,1986, Influence of a critical gradient on the consolidation of clays. Consd. soil: Test Eval, ASTM, STP 892:354–377
4. Sridharan & Prakash ,2002, Permeability of two-layer soils. Geotech Test J, ASTM 25(4):443–448
5. Ranjan, G., & Rao, A. S. R. ,2007, Basic and applied soil mechanics. New Age International.
6. Hamidon, A.,1994, Some laboratory studies of anisotropy of permeability of kaolin (Doctoral dissertation),University of Glasgow.
7. Swartzendruber D,1962, Modification of Darcy's law for the flow of water in soils. Soil Sci 93:22–29