Hydraulic Conductivity of Soil Using Guelph Permeameter

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Abstract – In this the research work on measuring the In situ hydraulic conductivity by different techniques, measuring Ks at various depths by using various instruments, effect of land use land cover, hill slope etc., and estimation of Ks by using texture based equation.

The hydraulic conductivity (KS) of soils is an important soil parameter that is essentially required for various fields of civil engineering where there is interaction between the soil and water such as estimation of seepage, drainage of fluid through the soil media, for groundwater supplies, settlement behaviour of structure, percolation and lateral flow of contaminants, checking the efficiency of compacted landfill liners, simulation of fluid flow through soil for modelling purpose, water and mass transport models and irrigation and drainage studies ,efficiency of domestic wastewater treatment system , reservoir characterization, leaching of pesticides from agricultural lands, and migration of pollutants from contaminated sites to the ground water. Stability of slopes in hilly areas will depend on the drainage of water through such soils which in turn depends on the hydraulic conductivity of soil. Soil saturated hydraulic conductivity (Ks) is a key variable in the water cycle. It co-determines how rainfall is partitioned into different water flow paths, such as groundwater recharge, lateral subsurface runoff and overland flow.

Keywords: Hydraulic Conductivity, Permeability, Guelph Permeameter.

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1. INTRODUCTION

The hydraulic conductivity (Ks) of soils is an important soil parameter that is essentially required for various fields of civil engineering where there is interaction between the soil and water. Its accurate determination is important in order to address various issues related with soil and water interaction in various fields of Civil engineering. It can be resoluted either by direct method (In situ or laboratory method) or by indirect method in which it is estimated by using some other properties of soil. Both field and laboratory procedures are difficult, cumbersome, time-consuming and expensive. In addition, the results may not be accurate due to spatial and temporal variability in soil physical and hydraulic properties. This has led to the development and general use of indirect methods that estimated K from more easily, widely available, routinely measured basic soil properties. The objective of this study is to develop empirical relation between saturated hydraulic conductivity and particle size distribution data by using regression analysis.

2. REVIEW OF LITERATURE

This section gives the overview of the study conducted on hydraulic conductivity by other researchers.

Boadu (2000) Developed a regression model to estimate saturated hydraulic conductivity of compacted soil by using grain size distribution data wherein author has considered fractal dimensions and lack of predictability of the distributions, as well as porosity, soil density, and fines content the predictive capability of the model is in worthy agreement with the measured value of hydraulic conductivity.

Holden and Burt (2003) have carried out experimental work to assess the variability of hydraulic conductivity of peat and they found that compressibility of soil generally decline with depth and also vary significantly between sampling sites.

Chen et al. (2009) performed study of various factors on hydraulic conductivity such as land use land cover, hill slope, etc at a site in China's Guizhou province which is heterogeneous with respect to all these factors and they found that with increase in depth bulk density was increased and hydraulic conductivity decreased i.e. 2.9cm/min in upper 15 cm to 0.8cm/min in the 30 cm below in the Dongija (DJ) mountains. Forest soils were found to have the lowest average bulk density; pasture and cultivated soils as expected have higher densities average root volume in case of forest area is 29.5% and that in bare land is 5.1% measured value of K_S at depth of 30 cm are 0.01, 0.6 and 0.8cm/min in the bare soil, agricultural and forest areas respectively.

Wei Hu et al. (2009) carried out the study for understanding the effect of land usage and land cover on hydraulic conductivity and they found transformations in the magnitude of diminution in hydraulic conductivity existed for the four land uses.

The numerical value of K_S cannot be the largest or smallest for all the measurement sets. This may also reflect that the land use effect was time-dependent.

Xi Chen et al. (2010) investigated the effect of vegetation cover on hydraulic permeability and found that the saturated hydraulic conductivity for the surface soil are very large as compared to those of deep soil for the soil under consideration saturated hydraulic conductivity depend on type of vegetation , age of vegetation and soil density. i.e. for forest its value is quite large due to large amount of roots and humus. To understand the effect of sloping terrain on the hydraulic conductivity.

Majeedraoof et al. (2011) carried out study in the Gonbad research station, Hamadan, Iran. For study purpose four different slope from flat to 40^0 were selected and they found that there is diminution in the hydraulic conductivity with slope gradient

Duan et al. (2012) carried out investigation to check the trustworthiness of the models proposed by Campbell, Smetten and Bristow and Sexton et al. compute saturated hydraulic conductivity in Texas soil with grass. They found that these models failed to predict the true representative value of saturated hydraulic conductivity if the constants and coefficients proposed by them were used directly without doing any modification to account for type of vegetation. The Saxton et al. and Campbell models were found to be more robust than the Smetten and Bristow model because the former two models contain two independent variables rather than the one included in the Smetten and Bristow model.

Kameníčková et al. (2012) studied the impact of different cultivation treatment on hydraulic conductivity of loamy soil in Horqin. The K_S value increased approximately six times for reduced cultivation and more than three times for conventional cultivation.

Emmanouil Steiakakis et al. (2012) have investigated the trustworthiness of Kozenycarman equation for estimating saturated hydraulic conductivity of compacted clayey soil**.** They found that Kozenycarman equation can envisage the hydraulic conductivity of compressed clayey soil very close to the actual value of hydraulic conductivity.

3. OBJECTIVES OF THE STUDY

1. In situ hydraulic conductivity by using Guelph Permeameter and to study its spatial variation,

2. Devise a model to determine hydraulic conductivity from simple index properties of soil.

3.1 Practical Relevance

These results are useful for soil and water management and conservation planning in the low precipitation zone. Understanding soil hydraulic properties is crucial for planning effective soil and water management practices

In agriculture, ecology, hydrology, global change, and related sciences, there is a pressing need for improved instrumentation to augment the general understanding of water flow, nutrient/chemical transport, and heat transport processes in rooting zones, the vadose zone, and ground water

Seasonal transitions in arid climates control the form and mobility of nitrogen and can in turn impact terrestrial and aquatic ecology. Soil hydraulic properties are key to quantitatively describing soil water flow and chemical transport. The hydraulic conductivity K_S of soils is of great importance in relation to some geotechnical problems, including the determination of seepage losses, settlement computations, and stability analyses. The development, management, and protection of ground-water resources also demand reliable estimates of hydraulic conductivity. Accurate estimation of streambed vertical hydraulic conductivity (K_S) is of great importance in the analysis of water quantity exchange and solute transfer between a stream and its sediments. Modelling of water transport and waste contaminant migration through soil, management of soil organic matter and management of water resources.

3.2 Agency which can utilize

The Results of the Research

Following agencies will get benefitted from this

- Agriculture

- Waste management
- Irrigation
- Environment and ecology
- Water resource management etc.

4. METHODOLOGIES

Saturated hydraulic conductivity of soil were measured in the field by using Guelph Permeameter at a depth of 15cm, 30cm, and 45cm; and soil samples were collected from the site at these depth. Index properties of the soil samples collected from field were determined in the laboratory. Empirical relation between the saturated hydraulic conductivity and index properties measured in the laboratory were developed by using regression analysis.

5. FIELD TEST

5.1 Hydraulic Conductivity by Guelph Permeameter

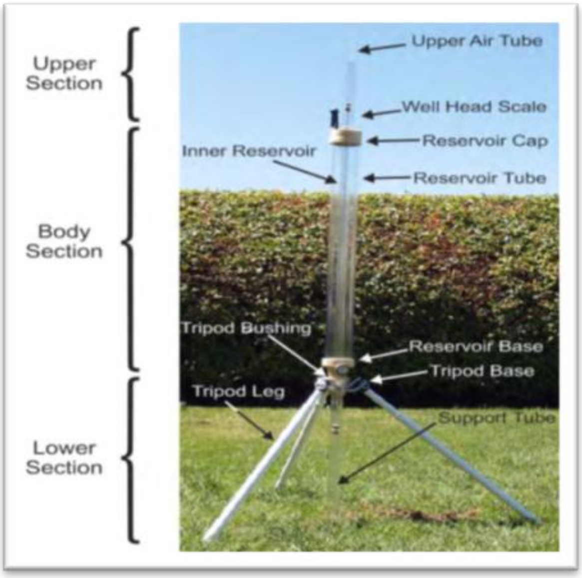

Figure 5.1 Guelph Permeameter

Depth operation may rise by 80 cm. The maximum practical operating depth is 315 cm.

5.2 Determination of Field Hydraulic Conductivity of Soil

Field hydraulic conductivity (permeability) of soil (K_s) can be determined by any of following method

1) One Head method
2) Two Head Method

1) One-Head Method

Saturated hydraulic conductivity by using one head method can be found by using an equation as given below

$$K_S = \left(\frac{C_1 Q1}{2\pi H_1{}^2 + \pi a^2 C_1 + 2\pi \left({}^{H_1}/_{\alpha^*}\right)}\right)$$

$$Q_1 = XR_1 \text{ Or } Q_1 = YR_1$$

Where,

H_1, H_2 = Well height for first and second measurements respectively, in cm.

a = Well radius, in cm.

K_S = Field-saturated Hydraulic conductivity (entrapped air present), in cm/sec

R_1, R_2= Steady State rate of fill corresponding to H_1 and H_2, respectively, and converted to cm/sec.

$$C_1 = \left(\frac{{}^{H}/_{a}}{2.074 + 0.093 * ({}^{H}/_{a})}\right)^{0.754}$$

$$C_2 = \left(\frac{{}^{H}/_{a}}{1.992 + 0.091 * ({}^{H}/_{a})}\right)^{0.683}$$

NOTE: $Q_1 = XR_1$ or $Q_1 = YR_1$, depending on whether the combine reservoir was used (X) or inner reservoir was used (Y)

2) Two-Head Method

Saturated hydraulic conductivity by using two head method can be found by using an equation as given below.

$$K_S = (G_2 Q_2 - G_1 Q_1)$$

Where,

$$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$$

$$G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$$

NOTE: $Q_1 = XR_1$ or YR_1 and $Q_2 = XR_2$ or YR_2 depending on whether the combine reservoir was used (X) or inner reservoir was used (Y)

6. EXPERIMENTAL WORKS

In this project, the in-situ hydraulic conductivity is estimated by using Guelph Permeameter and the soil sample is collected from field to carry out laboratory tests such as Grain Size Analysis, Liquid Limit, Plastic Limit, and Shrinkage Limit.

7. CONCULSION

In this we projected the in-situ hydraulic conductivity of soil by using Guelph Permeameter and the soil is collected from field and laboratory test are carried out such as Grain Size Analysis, Liquid Limit, Plastic Limit, Shrinkage Limit. In this study described equations to estimate Ks, saturated hydraulic conductivity, from D_{10}, D_{20}, D_{30}, D_{40}, D_{50}, and D_{60} data. The results showed approximately success in predicting hydraulic conductivity from particle diameters data.

8. FUTURE SCOPES

In this project only grain size record were used to correlate permeability with the various % finer sizes such as D_{10}, D_{20}, D_{30}, D_{40}, D_{50}, and D_{60}. Other index properties can be correlated with the permeability such as liquid limit, plastic limit, shrinkage limit, mineralogical composition of soil, organic content, cation exchange capacity, density of soil etc.

9. REFERENCES

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