Estimation of Soil Permeability using Soil Index Properties

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Abstract- Permeability is a very important engineering property of soils and finds utility in a number of soil engineering problems such as yield of wells and seepage through and below the earth structures. It controls the hydraulic stability of soil masses. The permeability of soils is also required in the design of filters required to prevent piping in hydraulic structures. However, the determination of soil permeability is a cumbersome and time consuming process, especially in the case of fine grained soils. The permeability of soils depend upon the particle size, structure of soil mass, shape of soil particles, void ratio and properties of permeate. However, the major factors which determines the value of permeability are particle size and void ratio. Several models are available in literature which relate permeability to particle size only. In the present study, an attempt has been made to estimate permeability of soils as a function of soil grain size and void ratio. Soil samples were collected from different Indian hydropower projects. The collected samples were subjected to laboratory investigations for the determination of geotechnical parameters namely specific gravity, maximum dry density, void ratio, grain size distribution and coefficient of permeability. An empirical model was developed for the determination of soil permeability as function of soil grain sizes and void ratios, using regression analysis. The model results were compared with the actual permeability values, as determined by laboratory tests. The results indicate that the present model can predict the soil permeability better than the existing models and the mean absolute percentage errors and root mean square errors are less than the present models.

Keywords – soil permeability, index properties, fine grained soils, gradation curve, Atterberg Limits.

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I. INTRODUCTION

Permeability is a very important engineering property of soils and finds utility in a number of soil engineering problems such as yield of wells and seepage through and below the earth structures. It controls the hydraulic stability of soil masses. The permeability of soils is also required in the design of filters required to prevent piping in hydraulic structures. However, the determination of soil permeability is a cumbersome and time consuming process, especially in the case of fine grained soils. The determination of permeability in the field can be done by pumping out and pumping in tests. Pumping out tests involve a large area and give a better idea about the permeability values of the soil deposit as a whole. Pumping, in tests (which include single and double packer tests etc.), on the other hand, give permeability values of the strata being tested only. Laboratory investigations which are carried out for determination of permeability include constant head and falling head tests which are again cumbersome and time consuming, especially for fine grained soils (Arora, 1987). A need is constantly being felt for simple correlations which express permeability as function of soil index properties such as grain size etc.

The permeability of soils depend upon the particle size, structure of soil mass, shape of soil particles, void ratio and properties of permeate. However, the major factor which determines the value of permeability is particle size and

void ratio. Several models are available in literature which relate permeability to particle size (Masch and Denny, 1966). Allen Hazen's formula was derived using uniform sands and gives permeability as a function of square of average particle size. Shepherd (1989) performed statistical power regression analyses on 19 sets of published data on size and laboratory permeability of unconsolidated sediments. Permeability was found to be related to the soil grain size as shown below:

$k= cd^{1.65 \text{ to } 1.85}$

Here c is a constant and d is average soil grain size. The problem is that most of these models have been developed using sands and hence give erroneous results when they are applied for fine grained soils like clays and silts. In the present study, an attempt has been made to estimate permeability of fine grained soils as a function of soil grain size and void ratio.

II. METHODOLOGY OF THE PRESENT WORK

In the present study, an attempt has been made to estimate permeability of fine grained soils as a function of soil grain size. Soil samples were collected from different Indian hydropower projects. The collected samples were subjected to laboratory investigations for the determination of geotechnical parameters namely specific gravity, maximum dry density, grain size distribution and coefficient of permeability. An empirical model was developed for the determination of soil permeability as function of soil grain sizes, using regression analysis. The proposed model can be written as:

$k= (d10^2)*(e^3)$

where:

k is soil permeability

d10 is average particle size such that 10 percent of the particles are finer than that size.

e is the void ratio which was determined for each of the soil samples.

III. EXPERIMENT AND RESULT

Following results were obtained:

S. No.	Model	Root Mean Square Error	Mean Absolute Error
1.	Hazen's Model	1.51E-05	6.8E-06
2.	Shepherd's Model	5.70E-03	3.2E-05
3.	Proposed Model	6.01314E-07	10E-08

The above table shows clearly that the present model can be used for predicting soil permeability values with a higher degree of accuracy than the existing models.

IV. CONCLUSIONS

Permeability is a very important engineering property of soils and finds utility in a number of soil engineering problems such as yield of wells and seepage through and below the earth structures. It controls the hydraulic stability of soil masses. The permeability of soils is also required in the design of filters required to prevent piping in hydraulic structures. However, the determination of soil permeability is a cumbersome and time consuming process, especially in the case of fine grained soils. The permeability of soils depend upon the particle size, structure of soil mass, shape of soil particles, void ratio and properties of permeate. However, the major factors which determines the value of permeability are particle size and void ratio. Several models are available in literature which relate permeability to particle size only. In the present study, an attempt has been made to estimate permeability of soils as a function of soil grain size and void ratio. Soil samples were collected from different Indian hydropower projects. The collected samples were subjected to laboratory investigations for the determination of geotechnical parameters

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