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Assessing Rock Mass Permeability Using Discontinuity Properties

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Abstract

Field measurement of rock mass permeability is essential that numerous factors influence its directional magnitude. Lugeon test is a popularly conducted field instrument in order to measure hydraulic conductivity of a rock mass. Discontinuity orientation, spacing and discontinuity surface quality, infill presence and type play essential role in permeability of the rock mass in addition to rock material itself. Geological Strength Index (*GSI*) is a parameter used in Gen. Hoek-Brown failure criterion and supporting empirical equations in order to estimate rock mass strength and deformability parameters. Frequently used Rock Quality Designation (*RQD*) and *GSI* and Lugeon values were combined in order to generate a relation among them. The proposed relationships are produced by interpretation of geotechnical core logging and Lugeon test results.

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Keywords: hydraulic conductivity; rock mass; in situ tests; Lugeon test; rock mass permeability

1. Introduction

Groundwater has great influence on rock engineering structures. Difficulties may include construction operations, rock mass deformation and stability. Hydraulic conductivity, pore water pressure, water pressure acting along the joints are all important as well as water sensitivity of the rock material. Understanding of groundwater condition is crucial for surface structures on rock masses, foundations, slopes [1, 2, 3]. For underground rock structures, information about ground water pressure and water inflow rate is essential [4, 5] since it strongly influences operational issues as well as stability of the structure and supports. Operational issues may include pump selection and infrastructure design for water discharge, foreseeing a need for grouting, water sealing. Permeability character of ground plays important role for also surface structures such as dams and foundations [6, 7].

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2. Hydraulic conductivity

For water flow through a saturated granular material, Darcy's law [8] is widely accepted:

$$Q=A\times K\times i \quad (1)$$

Total flow (Q in m^3/s) is directly proportional to the cross-sectional area of flow (A in m^2), hydraulic conductivity (or called as coefficient of permeability in m/s) and hydraulic gradient i. i is a ratio of pressure difference (Δh) along a particular flow length (l in m) can be represented as:

$$i= \Delta h/l \quad (2)$$

In addition to the intrinsic permeability of the geological material represented by k_i, hydraulic conductivity, K is dependent on the fluid properties which are unit weight γ and viscosity μ:

$$K=k_i\,(\gamma / \mu) \quad (3)$$

Hydraulic conductivity (coefficient of permeability) can be measured in both laboratory scale and field scale and then can be utilized for calculation of total inflow of groundwater in a particular area. For soil material, all pores or voids are accepted to be interconnected [9] and in general, gradation, density, porosity, void ratio, saturation degree, and stratification influence permeability [10]. There are rock formations which may represent soil like permeability behaviour with interconnected voids representing high porosity. Generally intact rock is very well cemented with mineral grains which contain tiny pores. The pores or voids are not interconnected however may represent at least very low permeability if rock is not fractured (Fig. 1).

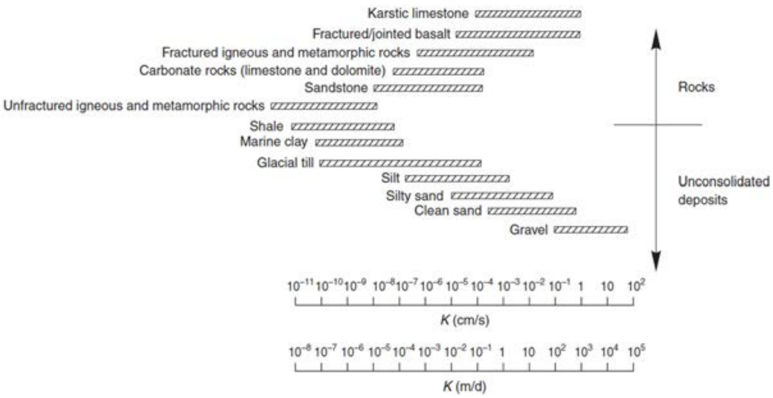

Fig. 1. Hydraulic conductivity of various geological units (after Atkinson [11]).

Permeability of the intact rock and the rock mass alters due to the presence and frequency of discontinuities. Discontinuity condition, namely: persistence, tightness, aperture, roughness, infill type, filling thickness of the discontinuities also govern the water flow rate through a rock mass as well as affecting rock mass strength. In-situ stress also influences water flow. Field scale estimation and measurement of permeability becomes more important when the interest area is a rock mass.