Soil and foundation engineering

Measurement of Permeability

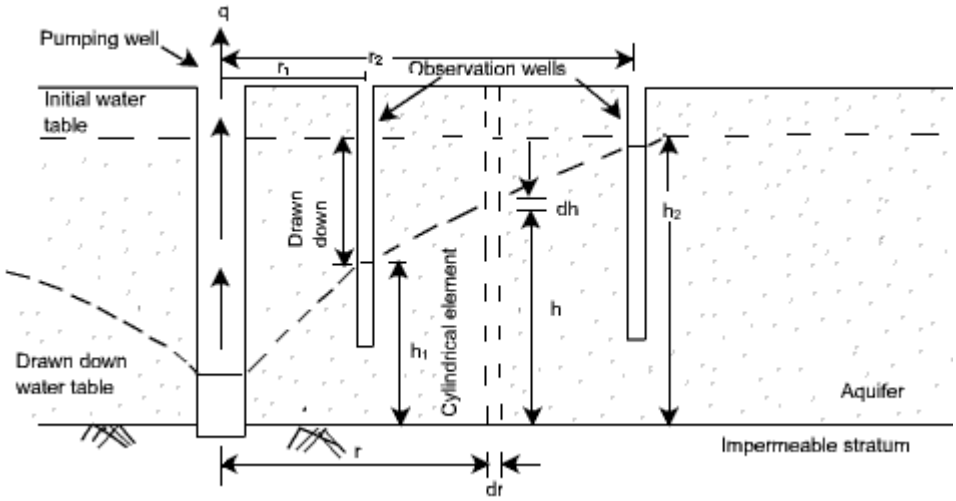
Field or *in-situ* measurement of permeability provides information about bulk permeability

Two important field tests for determining permeability are:

Unconfined flow pumping test

confined flow pumping test.

Unconfined Flow Pumping Test



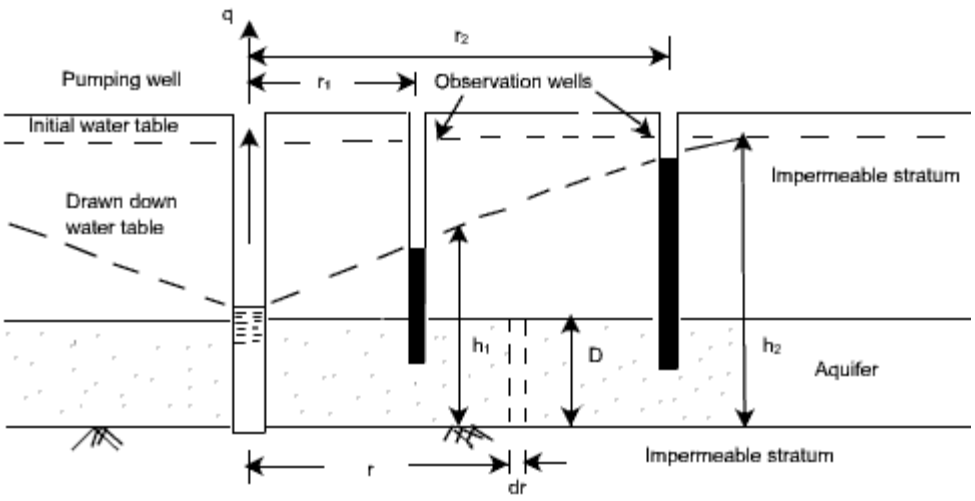
In this test, the pumping causes a drawdown in an unconfined (i.e. open surface) soil stratum, and generates a radial flow of water towards the pumping well. The steady-state heads $\mathbf{h_1}$ and $\mathbf{h_2}$ in observation wells at radii $\mathbf{r_1}$ and $\mathbf{r_2}$ are monitored till the flow rate **q** becomes steady.

The rate of radial flow through any **cylindrical surface** around the pumping well is equal to the amount of water pumped out. Consider such a surface having radius **r**, thickness **dr** and height **h.** The hydraulic gradient is

$$i = \frac{dh}{dr}$$

Confined Flow Pumping Test

Artesian conditions can exist in a aquifer of thickness **D** confined both above and below by impermeable strata. In this, the drawdown water table is above the upper surface of the



aquifer.

For a **cylindrical surface** at radius **r**,

$$q = k.\frac{dh}{dr}.2\pi rD$$

Integrating, $\int_{r_1}^{r_2}\frac{dr}{r} = \int_{h_1}^{h_2}\frac{2rDk}{q}dh$

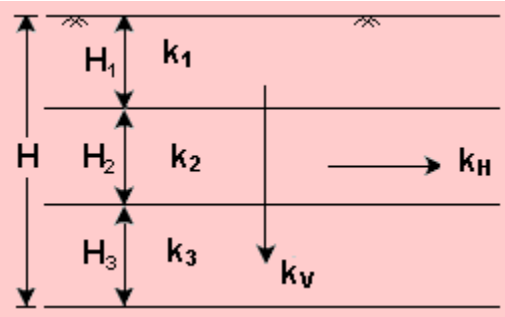
$$\log_e\left(\frac{r_2}{r_1}\right) = \frac{2\pi Dk}{q}\left(h_2 - h_1\right)$$

$$k = \frac{q.\log_e\left(\frac{r_2}{r_1}\right)}{2\pi rD(h_2 - h_1)}$$

Permeability of Stratified Deposits

if a soil deposit consists of a number of horizontal layers having different permeabilities, the average value of permeability can be obtained separately for both vertical flow and horizontal flow,

Consider a stratified soil having three horizontal layer h1,h2,h3 and permeability k1,k2,k3 respectively.



For vertical flow

$$k_v.\frac{h}{H} = k_1.\frac{h_1}{H_1} = k_2.\frac{h_2}{H_2} = \ldots\ldots\ldots\ldots\ldots$$

The total head drop **h** across the layers is

$$h = h_1 + h_2 + \ldots\ldots\ldots\ldots$$

$$h = \frac{k_v.h}{H}.\frac{H_1}{k_1} + \frac{k_v.h}{H}.\frac{H_2}{k_2} + \ldots\ldots\ldots$$

$$k_v = \frac{H}{\frac{H_1}{k_1} + \frac{H_2}{k_2} + \ldots\ldots\ldots\ldots\ldots\ldots}$$

Horizontal flow

$$k_H = \frac{1}{H}(k_1.H_1 + k_2H_2 + \ldots\ldots\ldots\ldots)$$

Determine the following:

(a) Equivalent coefficient of vertical permeability of the three layers
(b) The rate of flow per m^2 of plan area
(c) The total head loss in the three layers