Permeability of Alluvium

- 1. Constant Head Test
- Variable head Test
- Pumping Test (below W/T)

Constant Head Test

  K=q/F.H

K =coefficient of permeability m/sec or cm/sec

Q =Inflow per time m^3/sec
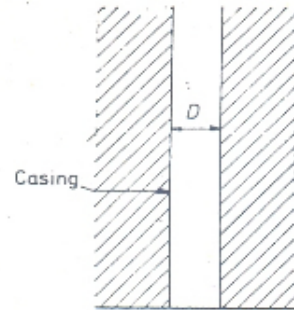
H= head causing flow in 'm'

F= Intake Factor (see figure)

Variable Head Test

K= A/{F(t_2-t_1)} x ln(h1/h2)
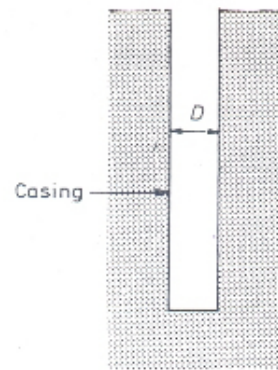
A=x-sectional area, t_2 & t_1 = final and initial time

h1 & h2=initial and final head

Intake Factor

(a) Soil flush with bottom at impervious boundary — $F = 2D$

(b) Soil flush with bottom in uniform soil — $F = 2.75D$
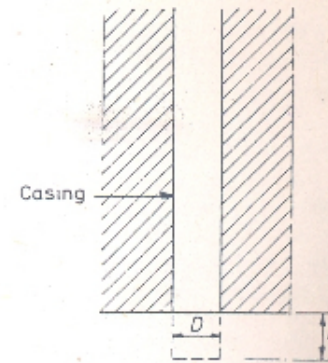
(c) Well point or hole extended at impervious boundary — $F = \dfrac{2\pi L}{\log_e \left[(2L/D) + \sqrt{(1 + ((2L)^2/D))} \right]}$
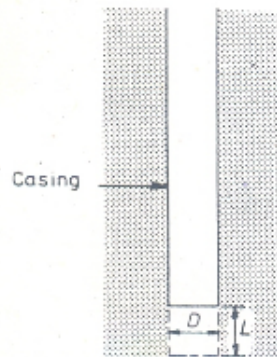
(d) Well point or hole extended in uniform soil — $F = \dfrac{2\pi L}{\log_e \left[(L/D) + \sqrt{(1 + (L/D)^2)} \right]}$
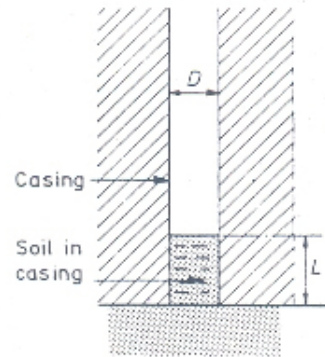
(e) Soil in casing with bottom at impervious boundary — $F = \dfrac{2D}{1 + (8/\pi)\,(L/D)}$
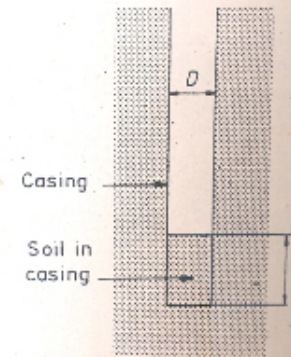
(f) Soil in casing with bottom in uniform soil — $F = \dfrac{2.75D}{1 + (11/\pi)\,(L/D)}$

Pumping Test

Case 2 Unconfined conditions

Phreatic surface

Seepage face and well losses

Original phreatic surface

Permeable

Impermeable
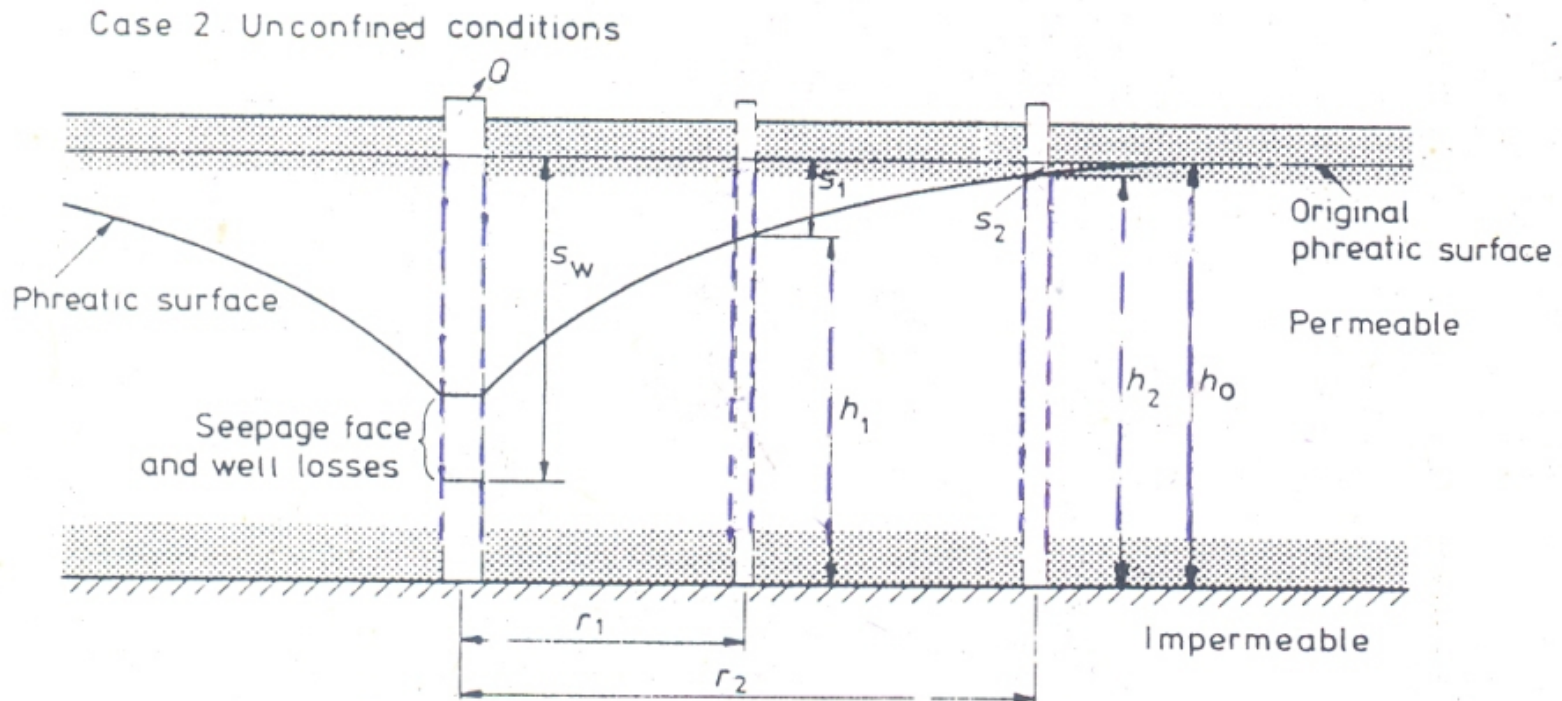
Permeability is given by

$$k = \frac{2.3Q}{\pi(h_2{}^2 - h_1{}^2)} \times \log_{10}\frac{r_2}{r_1}$$

where

k is the permeability in m/s
Q is the rate of flow of pump in m^3/s
s_1, h_1, r_1 etc. are distances as shown in m

Un-confined Aquifer

Pumping Test
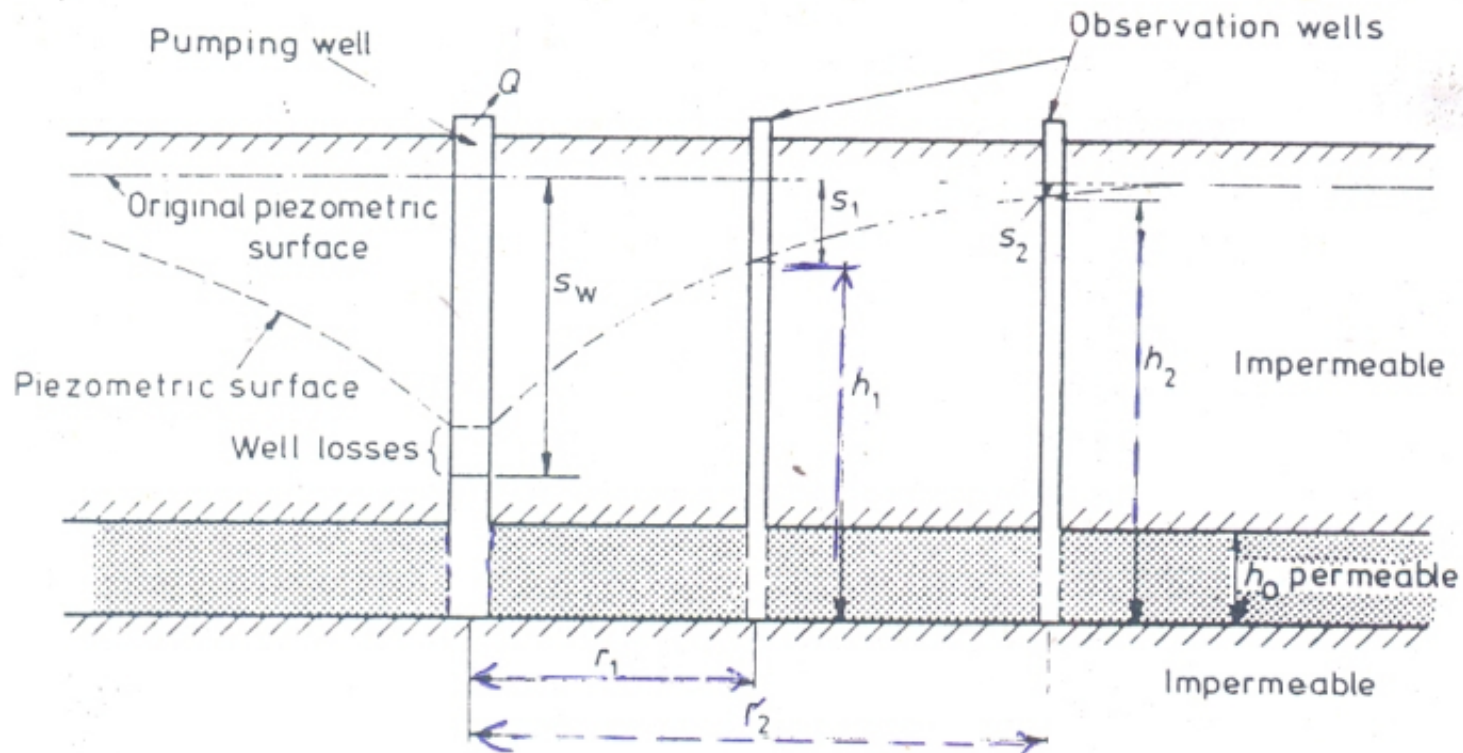
Permeability is given by

$$k = \frac{2.3Q}{2\pi h_0 (s_1 - s_2)} \times \log_{10}\frac{r_2}{r_1}$$

Confined Aquifer

Water Pressure or Packer or Lugeon Test

Test is conducted in borehole drilled in rock to provide an acceptable standard for permeability of dam foundation. It measures the quantity of water that escapes from an uncased section of borehole in a given time under a given pressure. Flow is confined between two depths by means of packers, test is named as packer's test

Water Pressure or Packer or Lugeon Test

Two types of tests

- 1. Single Packer test
- 2. Double Packer test

Three Main Purposes

- To estimate the amount of grout that rock will accept during grouting process
- To estimate the degree of Rock Fracturing
- To determine the coefficient of permeability of rock

WATER PRESSURE TEST
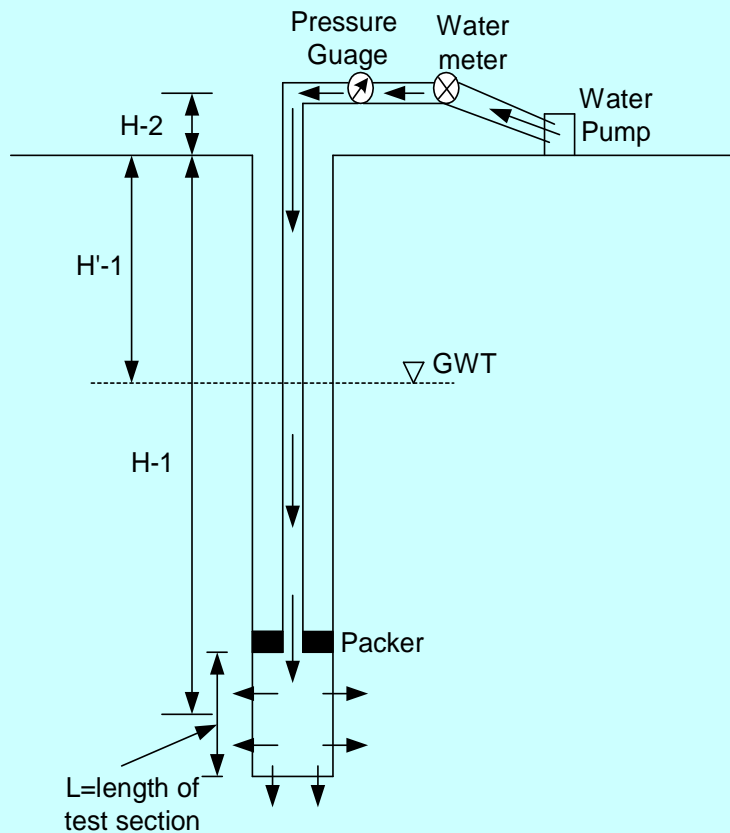
Single Packer
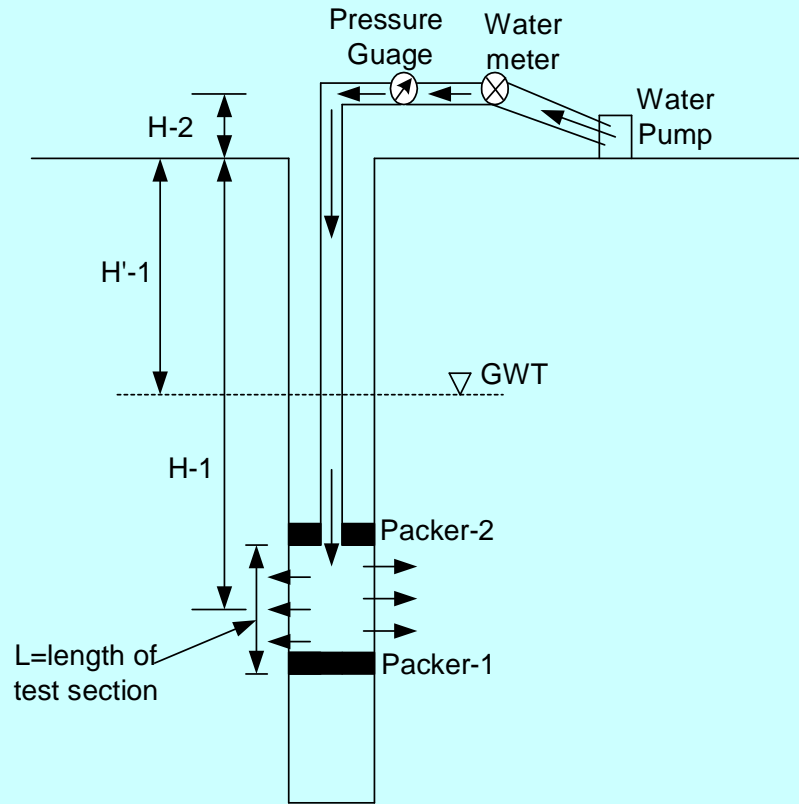
Double Packer

$H = H_g + H\text{-}2 + H\text{-}1$ or $H'\text{-}1$ (if water table exists above test level)

$H =$ total head of water causing flow of water into rock mass

<u>Water Pressure or Packer or Lugeon Test</u>

Permeability of rock is usually measured in Lugeon unit

- Lugeon: A rock is said to have a permeability of one Lugeon (1 L) if under a water head of 100 m (10 bar, 1000 kPa), above GWL, a 1 m length of borehole accepts 1 litre of water in one minute

Degree of rock Fracturing based on Lugeon Value

Lugeon Value	Permeability Range	Condition of rock fracturing
<1	Low	Joints Tight
1-5	Medium	small joint opening
5-50	Med-High	some open joint
>50	High	many open joint

Water Pressure or Packer or Lugeon Test

- $K = C \cdot Q/H \cdot L$

C= a constant, 100 if q in litre/min, L & H in meter

C=a constant, 4890 if Q in gal/min, L & H in feet

L= length of test section in m or ft

H= total head causing flow in rock

Q= flow into rock mass in litre/min or gal/min

H= Hg −H_f + H-2 + H-1 or H'-1 (if water table exists above test level)

Typical water pressure test sheet

Packer Test

Project: Kohala HydroPower Project

Depths below ground level to:	m	Date:	14-05-08	Location:	Siran-Dam Site
a. Top of test section:	105	Elevation(m):	958	Bore Hole #	2
b. Bottom of test section:	110	Weather:	Sun shine	Sheet :	18 of 19
c. Centre of test section:	107.5	Pressure:	400 (psi)	Operator:	Mr. Maqbool
d. Initial ground water level:	-	Packer Type:	Pnumatic	Test No.	18
Gauge height above GL:	0.18	Rock Type:	Sand Stone	Dia. Of hole:	75.7 mm (NQ)

Test Record

1st Period	Time	min	0	5	10	15	Average Flow q
Gauge Pressure	Flowmeter	m^3	1.4004	1.4048	1.407	1.4102	
Bar	Water Take	m^3		0.0044	0.0022	0.0032	liter/min
3							0.65
2nd Period	Time	min	0	5	10	15	Average Flow q
Gauge Pressure	Flowmeter	m^3	1.4116	1.4212	1.431	1.4421	
Bar	Water Take	m^3		0.0096	0.0098	0.0111	liter/min
6							2.03
3rd Period	Time	min	0	5	10	15	Average Flow q
Gauge Pressure	Flowmeter	m^3	1.4443	1.4628	1.4809	1.498	
Bar	Water Take	m^3		0.0185	0.0181	0.0171	liter/min
10							3.58
4th Period	Time	min	0	5	10	15	Average Flow q
Gauge Pressure	Flowmeter	m^3	1.4981	1.5072	1.5161	1.5252	
Bar	Water Take	m^3		0.0091	0.0089	0.0091	liter/min
6							1.81
5th Period	Time	min	0	5	10	15	Average Flow q
Gauge Pressure	Flowmeter	m^3	1.5252	1.5292	1.534	1.539	
Bar	Water Take	m^3		0.004	0.0048	0.005	liter/min
3							0.92

Typical water pressure test sheet

Period	Q Flow Liter/min	Gauge Pressure		Friction Head Loss (m)		Total Head (m)
		Gauge Pressure (Bar)	Head (m)	Pipework	Extra Pipe	
						0.92
1st	0.65	3	30	-	-	137.68
2nd	2.03	6	60	-	-	167.68
3rd	3.58	10	100	-	-	207.68
4th	1.81	6	60	-	-	167.68
5th	0.92	3	30	-	-	137.68

Graph Between Head & Flow
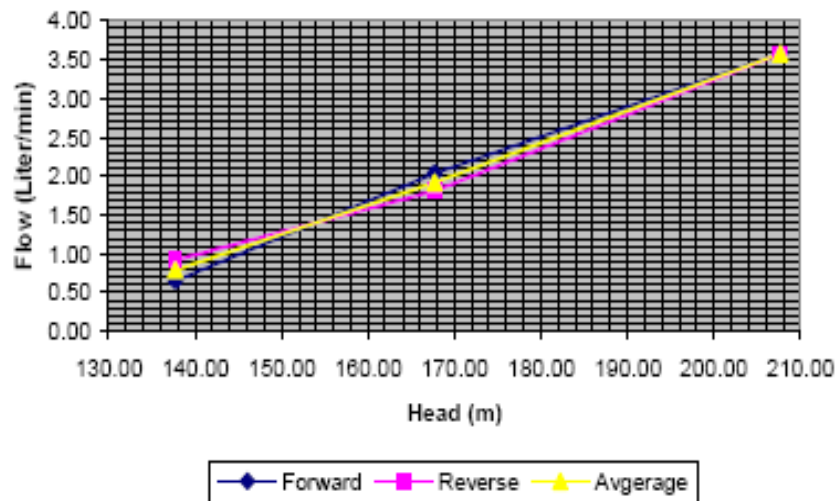
Result:	Slope	Lugeon
Forwad Lugeon Unit	0.04	0.83
Reverse Lugeon Unit	0.04	0.77
Average Lugeon Unit	0.040	0.800

Problem: Calculate Lugeon value for following Data:
i. Top of test section =100m below NSL
ii. Bottom of test section =105 m
iii. Guage height above NSL = 0.18m

1st Period	Time	min	0	5	10	15	Average Flow q liter/min
Gauge Pressurer	Flowmeter	m³	1.2	1.2042	1.2087	1.2114	
	Water Take	m³					
3 Bar							
2nd Period	Time	min	0	5	10	15	Average Flow q liter/min
Gauge Pressure	Flowmeter	m³	1.217	1.2247	1.2326	1.2401	
	Water Take	m³					
6 Bar							
3rd Period	Time	min	0	5	10	15	Average Flow q liter/min
Gauge Pressure	Flowmeter	m³	1.25	1.2756	1.3016	1.3282	
	Water Take	m³					
10 Bar							
4th Period	Time	min	0	5	10	15	Average Flow q liter/min
Gauge Pressure	Flowmeter	m³	1.3286	1.3423	1.3516	1.3608	
	Water Take	m³					
6 Bar							
5th Period	Time	min	0	5	10	15	Average Flow q liter/min
Gauge Pressure	Flowmeter	m³	1.362	1.3735	1.3826	1.3901	
	Water Take	m³					
3 Bar							