THE COOPER UNION FOR THE ADVANCEMENT OF SCIENCE AND ART

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
INTRODUCTION TO GEOTECHNICAL ENGINEERING LABORATORY

EXPERIMENTS 6-7

CONSTANT-HEAD AND VARIABLE-HEAD TESTS

Group 2
Scott Chen Jenna Manfredi
Gila Rosenzweig Jake Sigman
Eliyas Encarnacion

CE-331
4/14/23

Professor Ng

Contents

List of Figures **2**

1 Overview **3**

2 Results **3**

2.1 Constant Head 3

2.2 Variable Head 4

3 Sample Calculations **5**

3.1 Hydraulic Gradient 5

3.2 Velocity 5

3.3 Coefficient of Permeability 5

3.4 Coefficient of Permeability at 20°C 5

3.5 Relative Density 5

3.6 Darcy Coefficient of Permeability 6

3.7 Absolute Permeability 6

4 Appendix **7**

List of Figures

Figure 1: Hydraulic Gradient vs. Velocity at 20°C 3
Figure 2: Time vs. $\ln\left(\frac{h_o}{h_1}\right)$ 4

1 Overview

2 Results

The variable head test indicates, with a $k_p = 2.036 \times 10^{-5}$ at 20°C that the soil has low to very low permeability. The absolute permeability is so small as to be of magnitude on the order 10^{-10} ($\bar{K} = 3.27 \times 10^{-10}$), which indicates a degree of permeability that is so low as to be practically impermeable. The constant head test at all temperatures at which the readings were taken produces a permeability coefficient of $k_T = 0.021 = 2.1 \times 10^{-2}$, which is a medium degree of permeability. At 20°C, the coefficient is $k_{20} = 0.0196 = 1.96 \times 10^{-2}$, indicating a medium degree of permeability as well. The absolute permeability is on the order of magnitude of 10^{-7}, ($\bar{K} = 3.16 \times 10^{-7}$), indicating very low permeability.

2.1 Constant Head

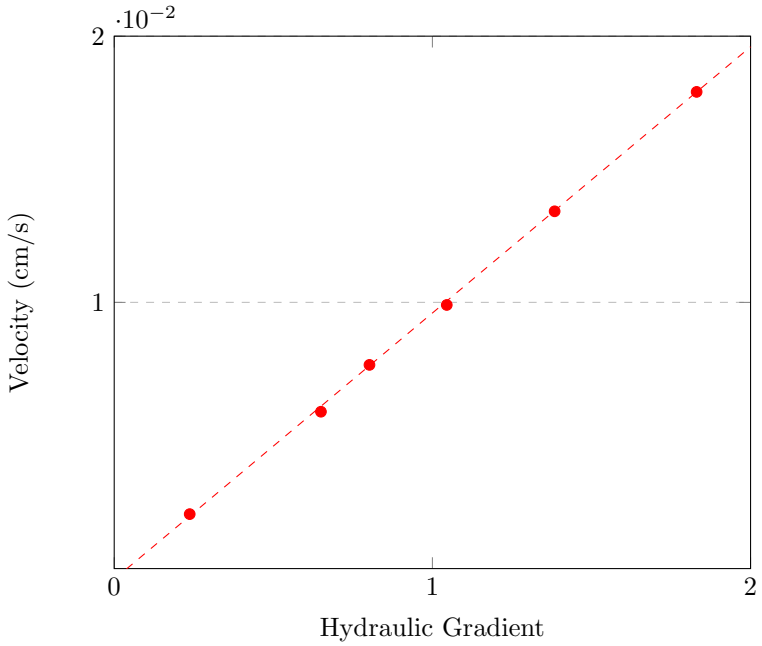

Figure 1: Hydraulic Gradient vs. Velocity at 20° C

2.2 Variable Head

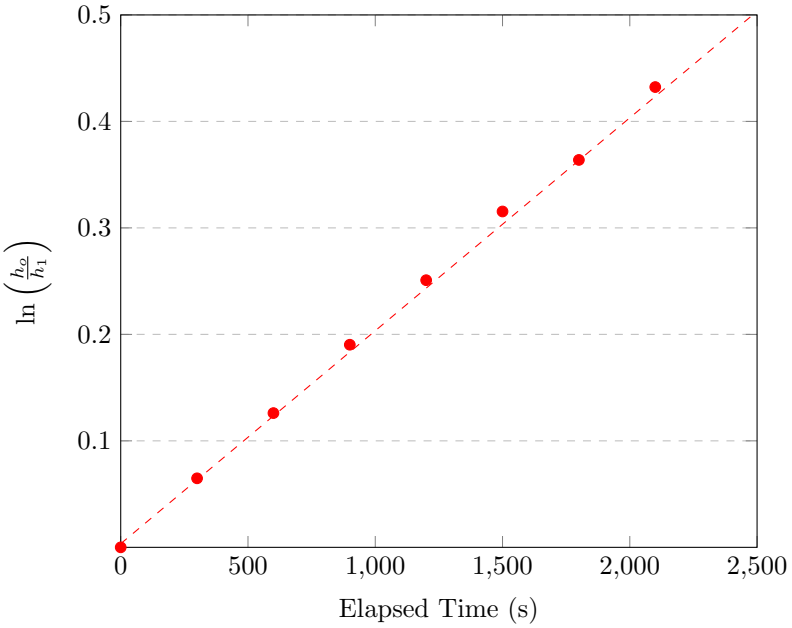

Figure 2: Time vs. $\ln\left(\frac{h_o}{h_1}\right)$

3 Sample Calculations

3.1 Hydraulic Gradient

$$HG = \frac{h}{L}$$

$$HG = \frac{4.199}{37.15} = \boxed{0.237}$$

3.2 Velocity

$$V = \frac{q}{A \times t}$$

$$V = \frac{25}{62.02 \times 180} = \boxed{0.00224 \text{ cm/s}}$$

3.3 Coefficient of Permeability

$$k_T = \frac{q \times L}{h \times A \times t}$$

$$k_T = \frac{25 \times 37.15}{4.199 \times 62.02 \times 180} = \boxed{0.0198}$$

3.4 Coefficient of Permeability at 20°C

$$k_{20} = k_T \left(\frac{\sigma_T}{\sigma_{20}}\right)\left(\frac{\gamma_{20}}{\gamma_T}\right)$$

$$k_{20} = 0.0198 \left(\frac{0.0009159}{0.0010005}\right)\left(\frac{62.3}{62.26}\right) = \boxed{0.018145}$$

3.5 Relative Density

$$D_f r = \frac{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_{dnat}}}{\frac{1}{\gamma_{dmin}} - \frac{1}{\gamma_{dmax}}}$$

$$D_f = \frac{\frac{1}{88.4} - \frac{1}{89}}{\frac{1}{88.4}} - \frac{1}{99.6} = \boxed{6\%}$$

3.6 Darcy Coefficient of Permeability

$$k = 2.303 \left(\frac{a \times L}{A \times t} \right) \log_{10} \left(\frac{h_1}{h_2} \right)$$

$$k = 2.303 \left(\frac{0.063 \times 11.7}{78.54 \times 2100} \right) \log_{10} \left(\frac{1131.2}{734.2} \right) = \boxed{1.9 \times 10^{-6}}$$

3.7 Absolute Permeability

$$\bar{K} = \frac{\eta}{\gamma_w} \left(\frac{\eta_T}{\eta_{20}} \right) k$$

$$\bar{K} = \frac{0.001005}{62.3} \times \left(\frac{0.001005}{0.01056} \right) \times 1.9 \times 10^{-6} = \boxed{3.29 \times 10^{-10}}$$

4 Appendix

Group#: Load File: Load File | View Directory | Compute

THE COOPER UNION
Albert Nerken School of Engineering
Soil Mechanics Laboratory
Experiment No. 6 - Constant Head Permeability Test

Name: Date: 4/4/1224/4/122
Group No.:
Members:

Location: Depth: Horizon:
Boring: Elevation: Agronomic Name:
Geological Region: Sample:
Description:

Formulae:

1) $k_T = ql/hAt$ **2)** $k_{20} = k_T(\sigma_T/\sigma_{20})(\gamma_{20}/\gamma_t)$ **3)** $D_r = ((1/\gamma_{d\ min} - 1/\gamma_{d\ nat})/(1/\gamma_{d\ min} - 1/\gamma_{d\ max}))*100\%$

k_T = coefficient of permeability, cm/s, as observed temperature
m_T = absolute viscosity of liquid at T °C, in g-s/cm^2
q = quantity of water collected, in cc
h = head loss, in cm
A = cross-sectional area of sample, in cm^2
$\gamma_{d\ max}$ = maximum dry unit weight, in pcf
$\gamma_{d\ nat}$ = natural, or compacted dry unit weight, in pcf
γ_t = unit weight of liquid at T:C, in g/cm^3

k_{20} = coefficient of permeability corrected to 20°C
m_{20} = absolute viscosity of liquid at 20°C, in g-s/cm^2
L = distance the head loss h occurs in, or distance between piezometer outlets, in cm
D_r = relative density, in %
$\gamma_{d\ min}$ = minimum dry unit weight, in pcf
γ_{20} = unit weight of liquid at 20°C, in g/cm^3
t = time to collect the water, q, in sec

Table 1 ***[Data Sheet (A)]*****: Sample Preparation Data**

Determination Number:	1	2	3
Area of Sample, A (cm^2):	62.02		
Length of Sample, L' (cm):	37.15		
Distance Between Piezometers, L (cm):	17.70		
Total Volume of Sample, V_t (cc):	2304	----------	----------
Weight of Container & Soil Before (g):	9201		
Weight of Container & Soil After (g):	5930		
Weight of Dry Soil Sample (g):	3271	----------	----------
Specific Gravity, G_s:	2.66		
Dry Unit Weight of Sample (pcf):	89	----------	----------
Max. Dry Unit Weight of Soil (pcf):	99.60		
Min. Dry Unit Weight of Soil (pcf):	88.40		
Relative Density, D_r (%):	6	----------	----------
Void Ratio of Sample, e:	0.864988764044	----------	----------
Porosity of Sample, n (%):	46.38037401195	----------	----------

Table 2 ***[Data Sheet (B)]*****: Run Data**

Determination Number: 1

Run Number	Piezometer Readings		Loss in Head, h (cm)	Hydraulic Gradient, i = h/L	Time, t (sec)	Quantity, q (cm^3)	Temperature, T (:C)	V=q/At @ T, :C (cm/sec)	V=q/At @ 20 :C (cm/sec)
	h_1 (cm)	h_2 (cm)							
1	107.6	103.4	4.199999999	0.237288135	180	25	23.7	0.0022394209	0.0020459623
2	104.5	93.0	11.5	0.649717514	180	72	23.7	0.0064495324	0.0058923716
3	103.2	89.0	14.20000000	0.802259887	180	93.5	23.7	0.0083754344	0.0076518992
4	101.5	83.0	18.5	1.045197740	180	119	23.0	0.0106596438	0.0099030079
5	98.4	73.9	24.5	1.384180790	180	157	21.9	0.0140635637	0.0134211038
6	95.5	63.1	32.4	1.830508474	180	206	21.2	0.0184528288	0.0179069395
7			NaN	NaN				NaN	NaN
8			NaN	NaN				NaN	NaN
9			NaN	NaN				NaN	NaN
10			NaN	NaN				NaN	NaN
11			NaN	NaN				NaN	NaN
12			NaN	NaN				NaN	NaN
13			NaN	NaN				NaN	NaN
14			NaN	NaN				NaN	NaN
15			NaN	NaN				NaN	NaN

Compute Reset

Enter Group Number:

Enter Filename to Save:

Save File

View Directory

Group#: Load File: Load File | View Directory | Compute

THE COOPER UNION
Albert Nerken School of Engineering
SOIL MECHANICS LABORATORY
Experiment No. 7 - Variable Head Permeability Test

Name: Date: 4/4/1224/4/122
Group No.:
Members:

Location: Depth: Horizon:
Boring: Elevation: Agronomic Name:
Geological Region: Sample:
Description:

Table 1 *[Data Sheet (A)]*: Sample Preparation Data

Determination Number:	1	2	3
Area of Permeameter, A (cm^2):	78.54		
Length of Sample, L (cm):	11.70		
Total Volume of Sample, V_t (cm^3):	918.918	----------	----------
Weight of Permeameter & Sample (g):	4636		
Weight of Permeameter (g):	2739		
Weight of Soil Sample, W_t (g):	1897	----------	----------
Water Content, w (%):	21.4		
Specific Gravity, G_s:	2.75		
Dry Unit Weight (pcf):	106.1100392430	----------	----------
Void Ratio, e:	0.617189110701	----------	----------
Porosity, n (%):	38.16431279539	----------	----------

Table 2 *[Data Sheet (B)]*: Run Data

Determination Number:	1	Diameter of Standpipe, d, (cm):	0.283	Area of Standpipe, a, (cm^2):	0.062901753		
Run Number	Initial Standpipe Reading, h_0 (cm)	Final Standpipe Reading, h_1 (cm)	h_0/h_1	Elapsed Time, t_T (sec)	Temperature, T (:C)	Elapsed Time, t_{20} (sec)	$\ln(h_0/h_1)$
1	1131.2	1131.2	1	0	18.4	0	0
2	1131.2	1060.2	1.066968496	300	18.5	289.1971870	0.064821446
3	1131.2	997.2	1.134376253	600	18.5	578.3943740	0.126082943
4	1131.2	935.2	1.209580838	900	18.5	867.5915611	0.190273884
5	1131.2	880.2	1.285162463	1200	18.5	1156.788748	0.250885140
6	1131.2	825.2	1.370819195	1500	18.5	1445.985935	0.315408513
7	1131.2	786.2	1.438819638	1800	18.55	1737.323749	0.363823082
8	1131.2	734.2	1.540724598	2100	18.55	2026.877707	0.432252824

Table 6-1 Properties of distilled water (η = absolute)

Temp., °C	Unit weight of water, g/cm³	Viscosity of water, poise*
4	1.00000	0.01567
16	0.99897	0.01111
17	0.99880	0.01083
18	0.99862	0.01056
19	0.99844	0.01030
20	0.99823	0.01005
21	0.99802	0.00981
22	0.99780	0.00958
23	0.99757	0.00936
24	0.99733	0.00914
25	0.99708	0.00894
26	0.99682	0.00874
27	0.99655	0.00855
28	0.99627	0.00836
29	0.99598	0.00818
30	0.99568	0.00801