

2006-08 Catalog Data: ENCE 3340 Geotechnical Engineering, 3 Cr.

Prerequisites: Geology 1001/EES 1001, ENCE 2351 and ENCE 3318; registration in ENCE 3341.

Properties and behavior of soils as engineering materials; the origin and classification of soils; permeability of soils; compressibility and strength characteristics of soils; elementary treatment of consolidation, earth pressure, and bearing capacity; determination of engineering properties of soil in the laboratory. Two and half hours of lecture.

Time: 11.00 –12.15 pm M W; Room Engr: TBA

Textbook: Principles of Geotechnical Engineering
By Braja M. Das, CENGAGE Learning, 7th Edition, 2010.

Instructor: M.S. Nataraj; Office: Room 825 Engineering Building; Tel: 280-7044
E –Mail: mnataraj@uno.edu ; Office hrs: M,T 1-2 pm

Goals: To impart the basic principles of soil mechanics and its application in civil engineering Practice.

Prerequisites by Topic: 1. Stress and strain 2. Stress-strain relationships 3. Three dimensional state of stress 4. Generalized Hooke's law 5. Mohr's Circle 6. Fluid statics

Topics:

Introduction and (Chp. 1)

1. Soil composition, index properties, and soil classification (Chps.2-5)
2. Compaction of soils (Chp. 6)
3. Flow of water through soils (Chps.7-8)
4. Effective stress and stress distribution in soils (Chp.9-10)
5. Compressibility and consolidation of soils (Chps. 11)
6. Shear strength of soils (Chp. 12)
7. Introduction to stability of slopes (Chp.15)
8. Geo-environmental Engineering (Chp. 17)
- Brief introduction to the following topics
9. Lateral earth pressure (Chp. 13)
10. Bearing capacity of shallow foundations (Chp. 16)
11. Subsoil exploration (Chp.18)

GRADING SYSTEM

Quizzes and / or home assignments:	20%
Class exams (3) @ 20 %	60%
Final exam	20%

GRADING SCALE

90 and above	: A
> 80 and less than 90	: B
> 70 and less than 80	: C
> 60 and less than 70	: D

PRACTICE PROBLEMS

CHP 2: 3, 5,7,10

CHP 3: 1,5,6,7,11,18

CHP 4: 3,4

CHP 5: 2(1,4,8),3(1,3,6)

CHP 6: 4,6,7,8

CHP 7: 2,4,7,10,15

CHP 8: TO BE ASSIGNED

CHP 9: 2,4,7,8 and other problems to be assigned

CHP 10: 2,3,7,9,19,20

CHP 11: 3,6,9,17,18,20

CHP 12: 3,11,12,15,23,

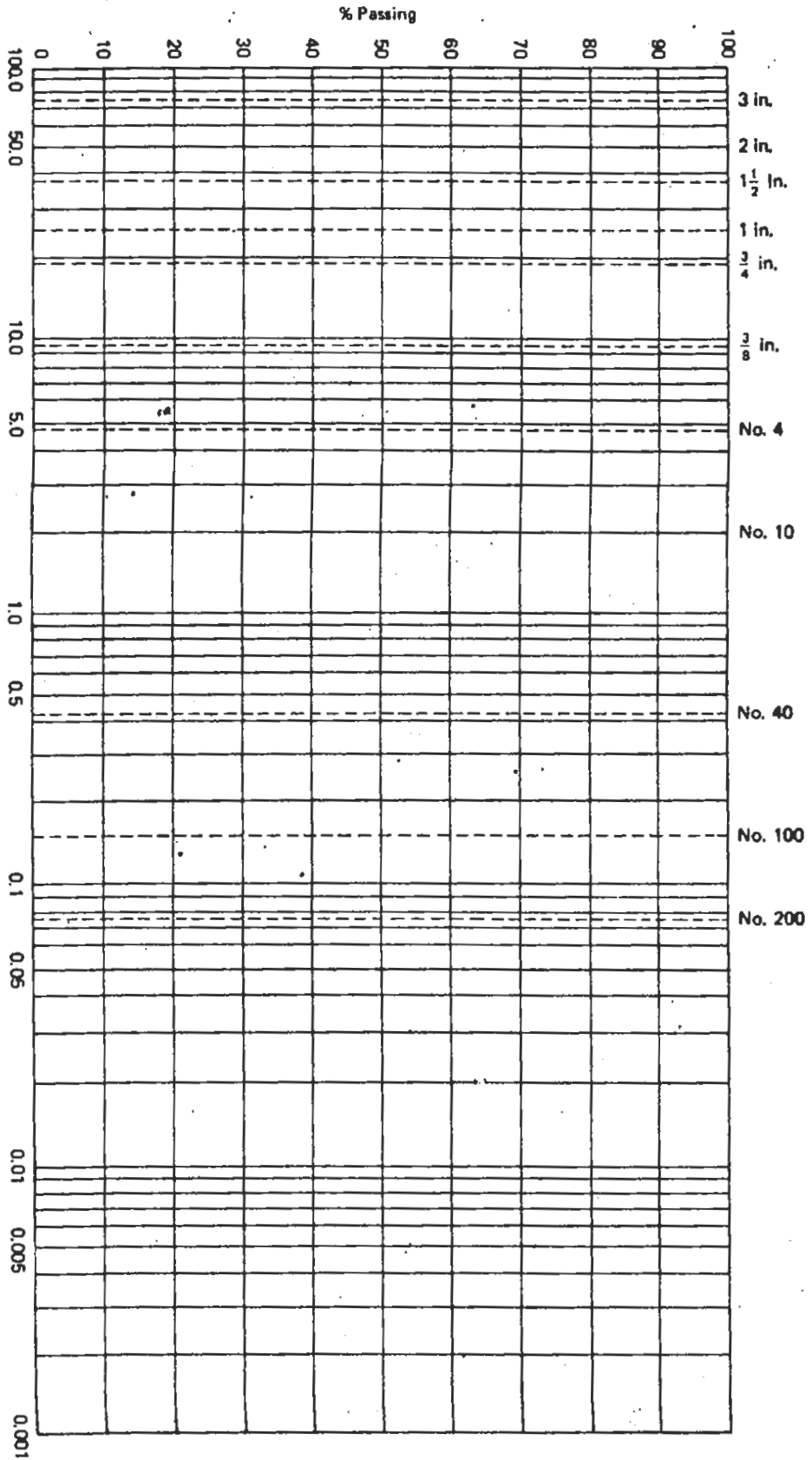
CHP 13: to be assigned

CHP 15: to be assigned

CHP 16: to be assigned

CHP 18: to be assigned

It is your responsibility that you diligently solve the practice problems as the class progresses and understand the concepts and the computational procedures involved. QUIZZES WILL BE GIVEN IN EVERY CLASS (UNLESS INFORMED OTHERWISE) SIMILAR TO OR INVOLVING THE CONCEPTS LEARNED IN PRACTICE PROBLEMS; IT MAY LAST FROM 10 TO 20 MINUTES DEPENDING ON THE PROBLEM. I SUGGEST THAT ALL OF YOU PLEASE READ THE APPROPRIATE MATERIAL IN THE TEXT BEFORE YOU COME TO THE CLASS. THEN YOU WILL LEARN THE MATERIAL WELL AND EASILY. IF YOU HAVE ANY DIFFICULTIES WITH THE TEXT BOOK MATERIAL YOU ARE WELCOME TO MY OFFICE. PLEASE DO NOT WAIT TILL THE END OF THE SEMESTER OR ONE DAY BEFORE AN EXAMINATION.



Project No. SUL
 Plotted by _____

Sample No. 2
 Date _____

Grain-size distribution curve

316)

$$S = 50\%$$

$$\gamma = 105.73$$

$$S = \frac{w G_s}{c}$$

$$.5 = \frac{e}{e+1} \rightarrow 0.5 = \frac{1}{1+e} \quad 1+e = \frac{1}{0.5} - 1 = 1$$

$$\boxed{e=1} \quad \gamma = 105.73 =$$

$$G_s = \frac{\gamma}{w}$$

$$.5 = \frac{w G_s}{1}$$

$$.5 = \frac{V_w}{V_v} = \frac{w G_s}{c}$$

$$105.73 = \frac{w}{V}$$

$$C_u = \frac{D_{60}}{D_{10}}$$

$$C_c = \frac{D_{30}^2}{D_{60} D_{10}}$$

$$\rho = 1705 \frac{\text{kg}}{\text{m}^3}$$

$$\gamma_d = \frac{\gamma}{1+w} = \frac{16.7 \frac{\text{KN}}{\text{m}^3}}{1+0.105}$$

$$\gamma = \rho \cdot g = 9.81 \left(\frac{\text{m}}{\text{s}^2} \right) \left(1705 \frac{\text{kg}}{\text{m}^3} \right) = 16726.05 \frac{\text{N}}{\text{m}^3} \rightarrow \frac{16.7}{1000} \frac{\text{KN}}{\text{m}^3}$$

$$\gamma_{\text{field}} = 15.14 \frac{\text{KN}}{\text{m}^3}$$

$$R = \frac{\gamma_{\text{field}}}{\gamma_{\text{max lab}}} = \frac{15.14}{16.7}$$

descrip of test

Standard Proctor Compaction Test

Determination of Dry Unit Weight

Description of soil CLAYEY SILT Sample No. 3

Location UNO LAB

Volume of mold 1/30 ft³ Weight of hammer 5.5 lb Number of blows/layer 25 Number of layers 3

Tested by _____ Date 02.24.2010

Test	1	2	3	4	5	6
1. Weight of mold, W_1 (lb)	10.35	10.35	10.35	10.35	10.35	10.35
2. Weight of mold + moist soil, W_2 (lb)	14.19	14.41	14.53	14.63	14.51	14.47
3. Weight of moist soil, $W_2 - W_1$ (lb)						
4. Moist unit weight, $\gamma = \frac{W_2 - W_1}{1/30} \text{ (lb / ft}^3\text{)}$						
5. Moisture can number	1	2	3	4	5	6
6. Mass of moisture can, W_3 (g)	54.0	53.3	53.3	54.0	54.8	40.8
7. Mass of can + moist soil, W_4 (g)	253.0	354.0	439.0	490.0	422.8	243.0
8. Mass of can + dry soil, W_5 (g)	237.0	326.0	401.0	441.5	374.7	211.1
9. Moisture content, $w (\%) = \frac{W_4 - W_5}{W_5 - W_3} \times 100$						
10. Dry unit weight of compaction $\gamma_d \text{ (lb / ft}^3\text{)} = \frac{\gamma}{1 + \frac{w (\%)}{100}}$						

ASSUME $G_s = 2.7$ and PLOT

ZERO AIR VOID CURVE. SHOW COMPUTATIONS.

Hydrometer Analysis

Description of soil Silty clay Sample No. 2
 Location Wisner bridge
 G_s 2.70 Hydrometer type ASTM 152-H
 Dry weight of soil, W_s 50 g Temperature of test, T 26 °C
 Meniscus correction, F_m +1 Zero correction, F_s 5 Temperature correction, F_T _____
 [Eq. (5.6)]
 Tested by XYZ Date 10/6/11

Time (min)	Hydrometer reading, R	R_{cp}	Percent finer, $\frac{a \cdot R_{cp}}{50} \times 100$	R_{cd}	L^\dagger (cm)	A^\ddagger	D (mm)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.25	35						
1	37						
2	35						
4	28						
8	24						
15	20						
30	16						
45	14						
60	13						
180	12						
1290	10						
1320	10						
1460	9.5						

* Table 5.3; † Table 5.1; ‡ Table 5.2

Donald Jerolleman

ENCE 3341 Spring 2010

Lab 1: Particle Size Distribution (Sieve Analysis)

January 19, 2010

? curve?

10

Objective: (a) Use sieve analysis to determine particle sizes in the soil sample.
(b) Draw a distribution curve.
(c) Create a computational table.

Equipment: (a) Mechanical sieve shaker.
(b) Set of ASTM sieves, numbers 10, 20, 40, 60, 100, & 200
(c) Electronic balance.
(d) China dish (measurement container [122.81g])

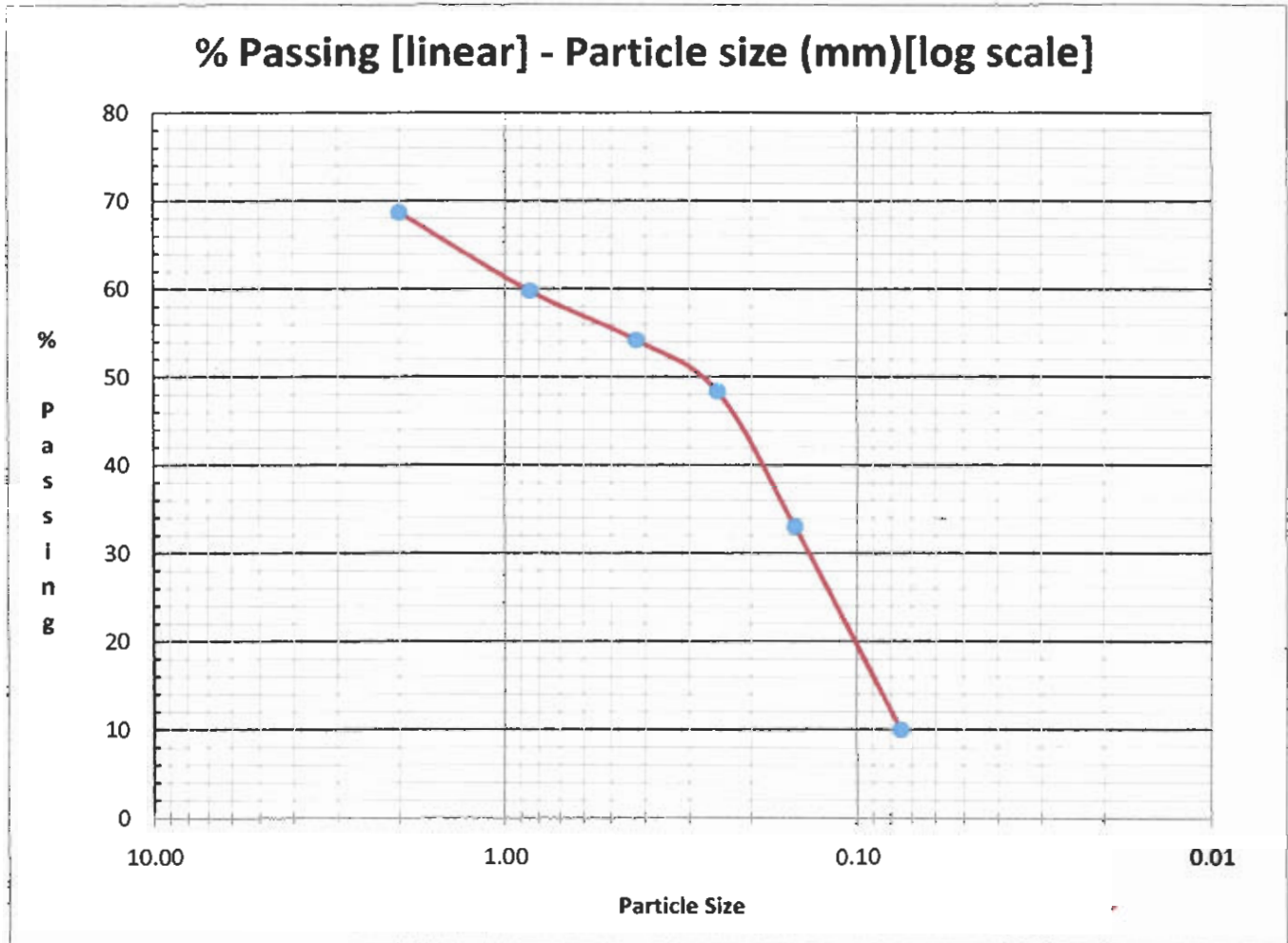
Procedure: (a) Weigh and record the soil sample
(b) Place sample into top sieve of the stack and electronically shake for 4-5 min.
(c) Record the weight of soil retained in each sieve.
(d) Make calculation (see attached tables, chart, and formulas)

Data: See attached tables.

Analysis: See attached chart and formula calculations.

Conclusion: The soil sample seems to have a "well graded" particle distribution curve.

US Standard Sieve Sizes Openings (mm)							
Sieve No.	Opening	Sieve No.	Opening	Sieve No.	Opening	Sieve No.	Opening
4	4.75	14	1.40	40	0.425	140	0.106
5	4.00	16	1.18	50	0.355	170	0.090
6	3.35	18	1.00	60	0.250	200	0.075
7	2.80	20	0.85	70	0.212	270	0.053
8	2.36	25	0.71	80	0.180		
10	2.00	30	0.60	100	0.150		
12	1.70	35	0.50	120	0.125		



Approx Values

D10 = 0.075	D30 = 0.145	D60 = 0.85
D50 = 0.27	D25 = 0.115	D75 = 2

Uniformity coefficient ($C_u = D_{60}/D_{10}$):

11.333333

Coefficient of Gradation ($C_c = D_{30}^2 / (D_{60} * D_{10})$):

0.3298039

5.4 p.113 (a) percent passing 200 sieve is $< 35\%$

\therefore soil is granular material

$$PI = 4$$

by AASHTO = $\boxed{A-2-7}$ (0)

$$GI = (13 - 35) [0.2 + 0.005(23 - 40)] + 0.01(13 - 15)(4 - 10)$$

$$= \boxed{\phi}$$

(b) $< 50\%$ on #200 \therefore coarse-grained

$< 50\%$ on #4 \therefore Sands

Sands w/ Fines w/ superscript d applies

\therefore $\boxed{SC - SM}$

Sand clay - sand silt

Flow Net

I. Pick point

A) Note elevation (vertical distance from datum) [= elevation head]

B) Calc. $\Delta h = \frac{h}{N_d}$, $N_d = \text{drops (total)}$, $h = \text{total head}$
(driving force) - ^{initial height} final height

C) Total head at point

i) Elev. head - Δh

D) Calc. pressure head

i) = total head eqt. - Elev. head at point

E) water pressure

i) $\gamma_{H_2O} (62.4 \text{ lb/ft}^3)$ (Pressure head) at point

F) Calc. q

$q = k \left(\frac{N_F}{N_d} \right) h$ [~~constant~~ k usually given, $h = \text{total head}$]
- gives flow per unit length

G) Calc. Hydraulic Gradient in a square

$i = \frac{\Delta h}{L}$, $L = \text{height of square}$

$q = k i$

Donald Terolleman

ENCE 3340

GEOTECHNICAL ENGINEERING

SPRING 2010

PLEASE READ THESE INSTRUCTIONS CAREFULLY:

EXAM IS CLOSED BOOK AND NOTES.

1. YOU NEED TO WRITE YOUR ANSWER IN THE SPACE PROVIDED OR IF YOU NEED ADDITIONAL SPACE YOU CAN WRITE ON THE REVERSE OF THE PAPER. DO NOT USE YOUR OWN PAPERS FOR ANY PURPOSE. KINDLY DO NOT DETACH PAPERS FROM THE SET.

2. READ THE QUESTIONS CAREFULLY. YOU NEED TO SHOW ALL YOUR COMPUTATIONAL STEPS. WRITE THE FORMULA YOU USE AND THE VALUES THAT YOU SUBSTITUTE TO OBTAIN AN ANSWER. YOU WILL NOT RECEIVE CREDIT IF YOU WRITE ONLY THE ANSWER.

3. WRITE APPROPRIATE UNITS. ANSWERS WRITTEN WITHOUT UNITS WILL COST YOU POINTS.

4. ALL QUESTIONS ASK FOR SPECIFIC ANSWERS AND HENCE DO NOT WASTE YOUR TIME IN WRITING EXTRA INFORMATION OR SKETCHES.

5. THE NECESSARY TABLE FOR COMPUTATION IS ATTACHED WITH THE QUESTION PAPER.

6. IF YOU HAVE ANY QUESTION DURING THE EXAMINATION KINDLY WRITE IT ON A SHEET OF PAPER AND BRING IT TO ME. I WILL TRY TO CLARIFY IT THOUGH I CANNOT HELP ANY ONE IN THE EXAMINATION.

7. CONTROL YOUR PEREPHERIAL VISION AND CONCENTRATE ON YOUR WORK.

TOTAL NUMBER OF POINTS FOR THE EXAM = 50 POINTS.

WISH YOU ALL THE BEST

NAME: Donald Scrolleman

35
/ 50

ENCE 3340 : SPRING 2010 GEOTECHNICAL ENGINEERING

Q 1. Answer the following questions:

a) With respect to flow of water through soils, what is the difference between the discharge velocity and seepage velocity? What is their inter-relationship?

- discharge velocity is calculated using the total cross-sectional area of the sample
- seepage velocity is calculated using the void cross-sectional area

$$v = q A_{total} \quad v_s = q A_v$$

b) There are two samples of the same sand ~~are~~ tested in a permeameter; sample A has a degree of saturation 98% and sample B has a degree of saturation of 61%; which sample gives a reliable value of coefficient of hydraulic conductivity?

Sample A ✓

c) Fill in the blank space appropriately.

a. Soil having a coefficient of permeability less than 1×10^{-6} cm/sec is generally known as clay material.

b. The permeability of coarse-grained soils is determined in the laboratory using a Constant Head test.

c. The effective size of a sample of sand is 0.2 mm. Its coefficient of permeability is approximately ∞ cm/sec.

d. The flow net is the graphical solution to Hydrostatic Flow equation.
(differential)

d) State whether the following statements are true or false. If it is false write the correct statement under the given statement.

a. In all seepage problems, the velocity head is disregarded.

TRUE ✓

b. In general the coefficient of permeability of a layered soil system is more in the vertical direction than in the horizontal direction.

False ✓ (more in the horizontal)

c. An equipotential line is a line on which all the points have same pressure head.

TRUE ✓

d. The soil mass is assumed to be an elastic, isotropic and homogeneous material in the stress – distribution theory.

TRUE ✓

(10 points)

Q 2. For a clay soil, the following values are given:

Void ratio	k (cm / sec)
0.75	1.2×10^{-6}
1.2	2.8×10^{-6}

Compute the hydraulic conductivity at a void ratio of 0.60 using the equation $k = c \left(\frac{e^n}{1+e} \right)$

(10 points)

$$\frac{1.2 \times 10^{-6}}{2.8 \times 10^{-6}} = \frac{\frac{0.75^n}{1+0.75}}{\frac{1.2^n}{1+1.2}} \quad \Rightarrow \quad 0.42857 = \left(\frac{0.75^n}{1.2^n} \right) (1.257)$$

$$\Rightarrow 0.34095 = (0.625)^n \Rightarrow \ln(0.34095) = n \ln(0.625)$$

$$\Rightarrow n = \frac{-1.07602}{-0.47} = 2.289$$

$$1.2 \times 10^{-6} = c \left(\frac{0.75^{2.289}}{1.75} \right) = c (0.29579) \Rightarrow c = 4.0569 \times 10^{-6}$$

$$k = 4.0569 \times 10^{-6} \left(\frac{0.6^{2.289}}{1.6} \right) = 7.875 \times 10^{-7} \text{ units?}$$

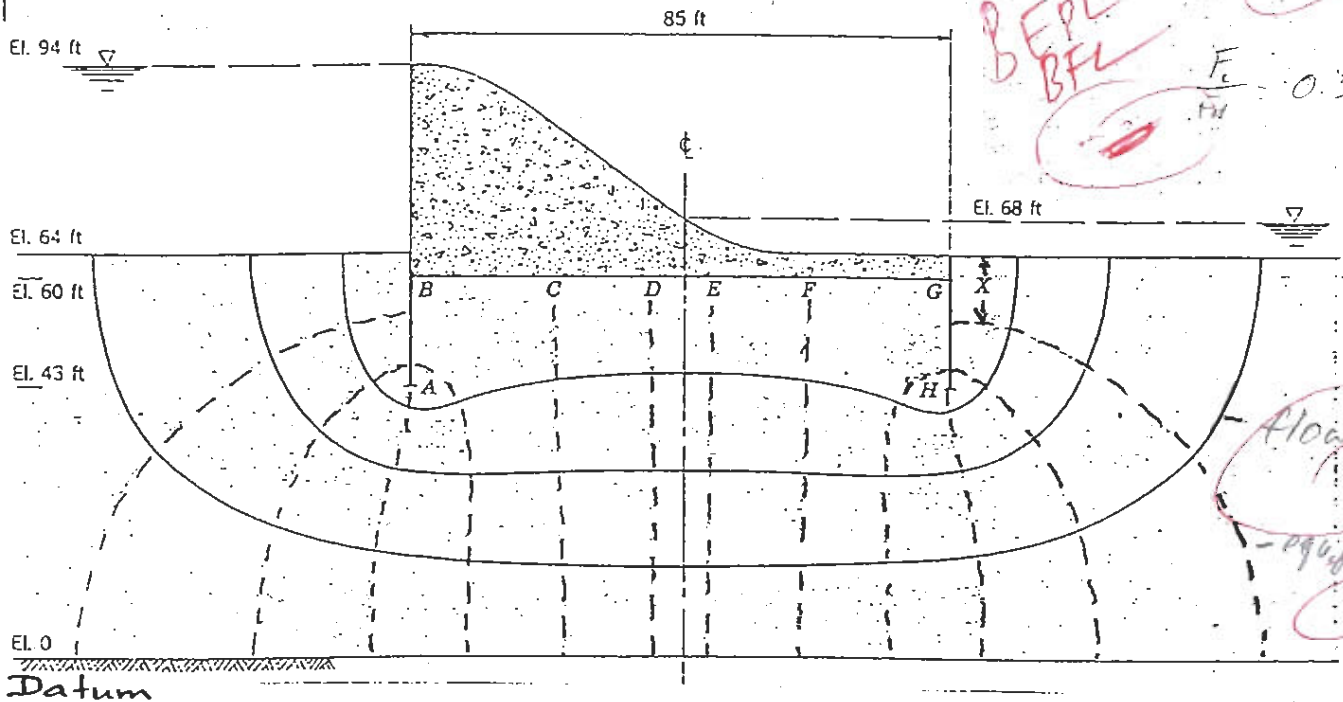
12

Q 3. Consider the flow net for a dam shown below. **i) Identify and label the boundary flow lines and boundary equipotential lines on the sketch.** ii) Compute the quantity of seepage in cubic feet per minute per foot of the dam if the coefficient of permeability for the soil is 0.1 ft. per minute. iii) Find the pressure head at points A, C, F, H shown in the figure. iv) Hydraulic gradient in square marked X if the length of the path is 11 ft. (10 points)

$$q = k \left(\frac{E}{E_2} \right) A = 0.1 \frac{\text{ft}}{\text{min}} (0.333) (85 \text{ ft}) (1 \text{ ft}) = 2.83 \frac{\text{ft}^3}{\text{min}}$$

$E = 4$
 $E_2 = 12$
 $\frac{E}{E_2} = 0.333$

BEPL & BFL



$$\Delta H = \frac{(94 - 68)}{E} = 2.167$$

Point	Elev head (ft)	total head (ft)	pressure head (ft)	water pressure (psf)
A	51	44.5		2776.8
C	34	23.17		1445.8
F	34	16.66		1039.6
H	51	29.33		1830

Square X

$$i = \frac{\Delta H}{L} = \frac{2.167}{11 \text{ ft}} = 0.197$$

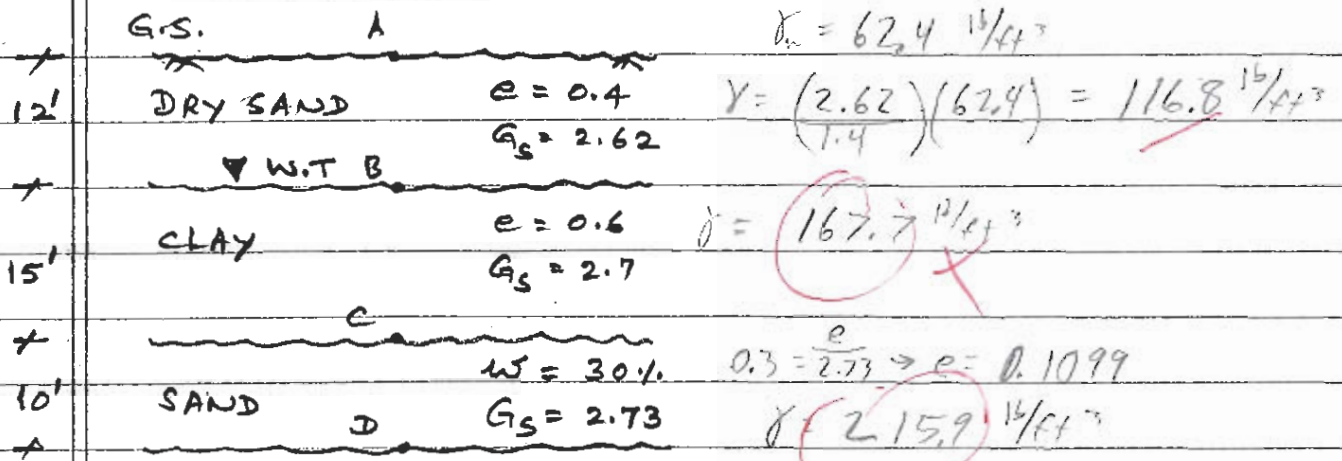
$$z = i \left(k \left(\frac{E}{E_2} \right) \right) = 0.00656 \frac{\text{ft}}{\text{min}}$$

5

$$\gamma = \frac{(G_s + Se)\gamma_w}{1+e}$$

$$w = \frac{Se}{G_s}$$

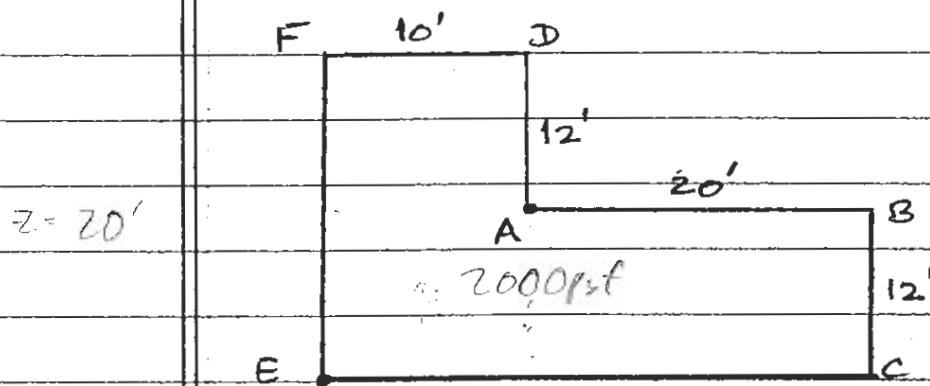
Q.4. A soil profile is shown below. compute and plot total stress, pore pressure and effective stress at A through D. (10 points)



Point	σ (psf)	u (psf)	σ' (psf)
A	\emptyset	\emptyset	\emptyset
B	$12(116.8) = 1401$	\emptyset	1401
C	$1401 + 15(167.7) = 3916.8$	$15(62.4) = 936$	2980.8
D	$3916.8 + 10(215.9) = 6076$	$25(62.4) = 1560$	4516

6

Q.5 A foundation plan is as shown below with an intensity of loading of 2000 psf. Determine the induced stress at a depth of 20 ft. under the points A and E. Influence coefficients are given (to points) in the attached table.



Point A $n_1 = \frac{10}{20} = 0.5$, $m_1 = \frac{12-0.6}{20}$, $n_2 = \frac{10}{20}$, $m_2 = \frac{12}{20}$, $n_3 = \frac{20-1}{20}$, $m_3 = \frac{12}{20} = 0.6$

$$\sigma = 2(I_1)(q) + I_3(q)$$

$$= 2(2000)(0.095) + (2000)(0.136)$$

$$= \boxed{652 \text{ psf}}$$

Point E $n_1 = \frac{10}{20} = 0.5$, $m_1 = \frac{24}{20} = 1.2$, $n_2 = \frac{30}{20} = 1.5$, $m_2 = \frac{12}{20} = 0.6$, $n_3 = \frac{10}{20}$, $m_3 = \frac{12}{20}$

$$\sigma = q(I_1) + q(I_2) - q(I_3)$$

$$= 2000(0.126 + 0.149 - 0.095) = 2000(0.18)$$

$$= \boxed{360 \text{ psf}}$$

TABLE 6-2
Influence Coefficients for Points under Uniformly Loaded Rectangular Areas

$m = \frac{B}{z}$ or $\frac{L}{z}$	$n = \frac{B}{z}$ or $m = \frac{L}{z}$																	
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	5.0	10.0	∞
0.1	0.005	0.009	0.013	0.017	0.020	0.022	0.024	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.032	0.032	0.032
0.2	0.009	0.018	0.026	0.033	0.039	0.043	0.047	0.050	0.053	0.055	0.057	0.059	0.061	0.062	0.062	0.062	0.062	0.062
0.3	0.013	0.026	0.037	0.047	0.056	0.063	0.069	0.073	0.077	0.079	0.083	0.086	0.089	0.090	0.090	0.090	0.090	0.090
0.4	0.017	0.033	0.047	0.060	0.071	0.080	0.087	0.093	0.098	0.101	0.106	0.110	0.113	0.115	0.115	0.115	0.115	0.115
0.5	0.020	0.039	0.056	0.071	0.084	0.095	0.103	0.110	0.116	0.120	0.126	0.131	0.135	0.137	0.137	0.137	0.137	0.137
0.6	0.022	0.043	0.063	0.080	0.095	0.107	0.117	0.125	0.131	0.136	0.143	0.149	0.153	0.155	0.156	0.156	0.156	0.156
0.7	0.024	0.047	0.069	0.087	0.103	0.117	0.128	0.137	0.144	0.149	0.157	0.164	0.169	0.170	0.171	0.172	0.172	0.172
0.8	0.026	0.050	0.073	0.093	0.110	0.125	0.137	0.146	0.154	0.160	0.168	0.176	0.181	0.183	0.184	0.185	0.185	0.185
0.9	0.027	0.053	0.077	0.098	0.116	0.131	0.144	0.154	0.162	0.168	0.178	0.186	0.192	0.194	0.195	0.196	0.196	0.196
1.0	0.028	0.055	0.079	0.101	0.120	0.136	0.149	0.160	0.168	0.175	0.185	0.193	0.200	0.202	0.203	0.204	0.205	0.205
1.2	0.029	0.057	0.083	0.106	0.126	0.143	0.157	0.168	0.178	0.185	0.196	0.205	0.212	0.215	0.216	0.217	0.218	0.218
1.5	0.030	0.059	0.086	0.110	0.131	0.149	0.164	0.176	0.186	0.193	0.205	0.215	0.223	0.226	0.228	0.229	0.230	0.230
2.0	0.031	0.061	0.089	0.113	0.135	0.153	0.169	0.181	0.192	0.200	0.212	0.223	0.232	0.236	0.238	0.239	0.240	0.240
2.5	0.031	0.062	0.090	0.115	0.137	0.155	0.170	0.183	0.194	0.202	0.215	0.226	0.236	0.240	0.242	0.244	0.244	0.244
3.0	0.032	0.062	0.090	0.115	0.137	0.156	0.171	0.184	0.195	0.203	0.216	0.228	0.238	0.242	0.244	0.246	0.247	0.247
5.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.204	0.217	0.229	0.239	0.244	0.246	0.249	0.249	0.249
10.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250
∞	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250

Source: N. M. Newmark, *Simplified Computation of Vertical Pressures in Elastic Foundations*, Circ. No. 24, Eng. Exp. Sta., University of Illinois, 1935.

NAME: Donald Terolleman

Q 1. A sample of inorganic soil has the following grain size characteristics: Percent passing no. 10 sieve is 95 and percent passing no. 200 sieve is 75; the liquid limit is 56 percent and plastic limit is 31 percent. Classify the soil according to the AASHTO and Unified Soil Classification System. (10 points)

#10 = 95% pass #200 = 75% pass
LL = 56% PL = 31%

9

$$PI = LL - PL = 25 \quad LL - 30 = 26\%$$

A-7-5(20) ← GI silt-clay materials 73.5% # passing 200

Clayey soils
Fair to poor subgrade rating

Unified Soil Class. Sys.

CH (clay - high plasticity)

Comp
name?

Outcome: (c) An ability to design a system, component, or process to meet desired needs

Course: ENCE 4358

Instructor: M. Folse

Date: spr2010

Design Problem Description: Design of Steel Framed Office Building- ASD and LRFD-Individual Project, Unique Dimensions

- Assessment Elements:
- (a) Project Introduction and Design Criteria
 - (b) Design Drawings Complete, Neat, Accurate
 - (c) Calculations Complete and Accurate
 - (d) Computer Analysis Complete and Accurate
 - (e) Effectively Organized and Neat
 - (f) All Required Elements Completed

Evaluation Scale			
Excellent	Good	Average	Poor
4	3	2	1

Target Score: 2.5

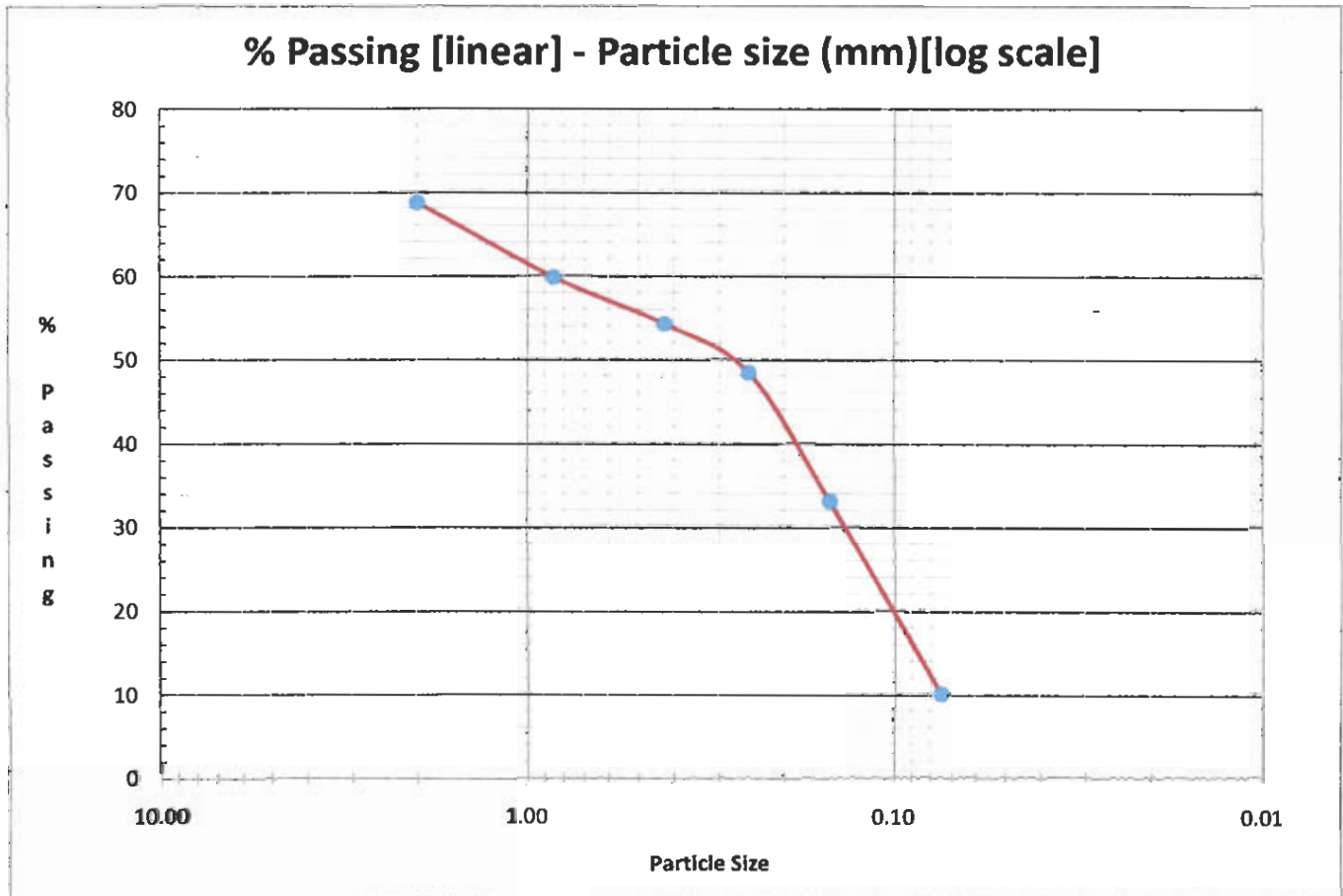
Student Name	(a)	(b)	(c)	(d)	(e)	(f)	Avg. Score
Aghakasiri							
Battaglia							
Christensen							
Dammon							
Harris							
Heath							
Holmes							
Jerolleman	3.5	3.8	4	3.8	3	4	3.68
Johnson							
Juarez							
Julien D.							
Julien R.							
Julien							
Larkins							
McInnis							
Meladine							
Mirambell							
Nguyen H.							
Posadas							
Richards							
Rockwell							
Ruiz							
Schenck							
Shalabi							
Smith							
Titus							
Tran							
Williams, Keiron							
Zeringue							
Guerra							
McGovern							
Stones							
Williams, Kristen							

96

PROJECT Grade = $26.0 \times \text{Avg. Score}$, Minimum of 65 required for ABET Accreditation

Description of Soil					Sample No		
Location							
Sieve Type	Mechanical Sieve Shaker	Sieve Shake Time (min)	4-5	Initial Wt. of Sample (g)	703		
Hydrometer type					Gs		
Temperature of test, T		(°C)	Dry weight of soil, Ws			(g)	
Zero correction, Fs		Meniscus correction, Fm					
Balance Type		Electronic	Temp. correction, Ft [Eq. (5.6)]				
Initial Wt. - Sum Mass		4.64	(g)	Measurement container's weight	122.81	(g)	
% error		0.66002845	%	Repeat Sieve Test (% error >= 10%):	NO		
Sieve No. ASTM	Opening Size (mm)	Wt. with container	Mass soil Retained (g)	% Retained	Cum. Mass Retained	Cum. % Retained (Rn)	% Finer (100-Rn)
10	2.00	341.34	218.53	31.29	218.53	31.292	68.708
20	0.85	185.03	62.22	8.91	280.75	40.201	59.799
40	0.425	161.69	38.88	5.57	319.63	45.769	54.231
60	0.250	163.46	40.65	5.82	360.28	51.589	48.411
100	0.150	229.98	107.17	15.35	467.45	66.935	33.065
200	0.075	283.92	161.11	23.07	628.56	90.005	9.995
Pan		192.61	69.80	9.99	698.36	100.000	0.000
Sum Mass		698.36					

US Standard Sieve Sizes Openings (mm)							
Sieve No.	Opening	Sieve No.	Opening	Sieve No.	Opening	Sieve No.	Opening
4	4.75	14	1.40	40	0.425	140	0.106
5	4.00	16	1.18	50	0.355	170	0.090
6	3.35	18	1.00	60	0.250	200	0.075
7	2.80	20	0.85	70	0.212	270	0.053
8	2.36	25	0.71	80	0.180		
10	2.00	30	0.60	100	0.150		
12	1.70	35	0.50	120	0.125		



Approx Values

D10 = 0.075	D30 = 0.145	D60 = 0.85
-------------	-------------	------------

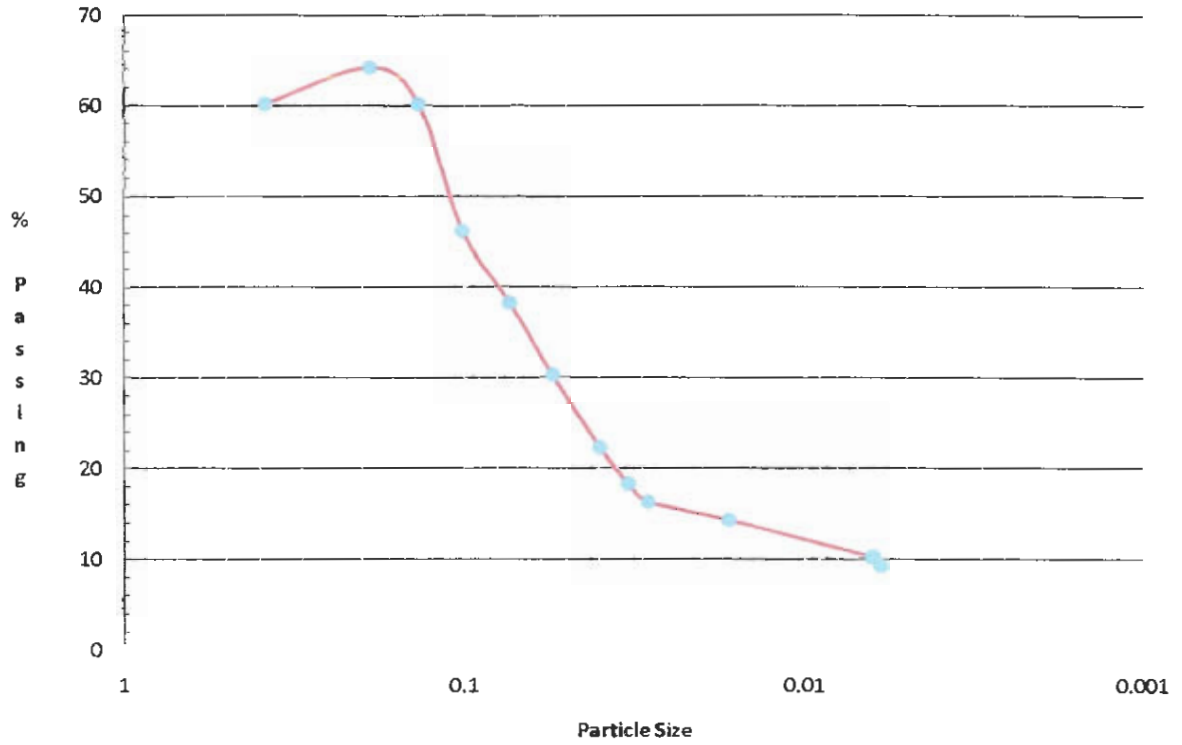
Uniformity coefficient ($C_u = D_{60}/D_{10}$):

11.333333

Coefficient of Gradation ($C_c = D_{30}^2 / (D_{60} * D_{10})$):

0.3298039

Hydrometer Analysis



Objective : Demonstrate dry-density / moisture content relationship. Create a dry-density vs. water content and zero air void curve.
 Calculate maximum dry unit weight and optimum moisture content.

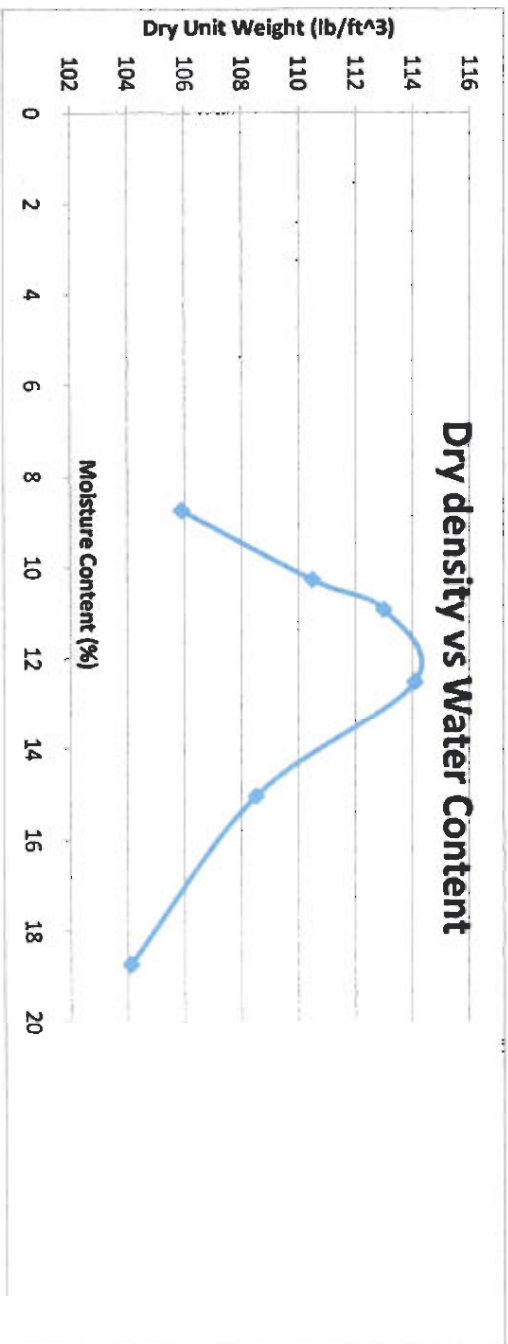
Equipment: Standard proctor mold (Volume = 1/30 ft³), standard rammer (5.5 lbs), oven.

Procedure: Coat the mold with a thin layer of vasaline. Fill 1/3 of mold with sample, and drop rammer twenty-five times from a height of twelve inches. Add another 1/3 of sample and repeat 25 blows. Add last 1/3, attach collar, and repeat blows. Take the weight of sample with the mold, remove the soil sample, take weight of sample then place in oven to dry. Add two percent water to sample and repeat the process twenty-five times.

Assumption given: Specific Gravity of sample = 2.7

Test	Weight of Mold (lb)	Mold + moist sample (lb)	W2-W1 (lb)	Moist unit weight (lb/ft ³)	Can Number	W3 (g)	W4 (g)	W5 (g)	w (%)	unit weight (lb/ft ³)
1	10.35	14.19	3.84	115.2	1	54	253	237	8.74	105.9
2	10.35	14.41	4.06	121.8	2	53.3	354	326	10.27	110.5
3	10.35	14.53	4.18	125.4	3	53.3	439	401	10.93	113
4	10.35	14.63	4.28	128.4	4	54	490	441.5	12.52	114.1
5	10.35	14.51	4.16	124.8	5	54.8	422.8	374.7	15.04	108.5
6	10.35	14.47	4.12	123.6	6	40.8	243	211.1	18.73	104.1

Maximum dry unit weight = 114.1 lb/ft³



$$\gamma_d = \frac{\gamma}{1 + \frac{w}{G_s}} = \frac{G_s \gamma_w}{1 + \frac{G_s w}{G_s}} = \frac{G_s \gamma_w}{1 + w}$$

- Q 1) Consider the soil profile shown in figure (a). A sample of clay was obtained from the center of clay layer and consolidation test was conducted in the laboratory. The result from this test is given in the accompanying table. A structure is to be constructed at this site and a mat foundation is selected to transfer the loads from the structure to the soil mass below. The plan of the foundation is as shown in figure (b), and transmits a intensity of stress of 1000 psf. For these conditions:
- determine whether the clay is normally consolidated or preconsolidated
 - construct the field consolidation line
 - compute the compression index for this clay
 - compute the settlement of the foundation due to consolidation of clay
(assume the entire clay stratum as a single layer) (30 pts.)

void ratio	pressure in T/sq.ft
1.72	0.25
1.70	0.50
1.64	1.0
1.51	2.0
1.34	4.0
1.15	8.0
0.95	16.0

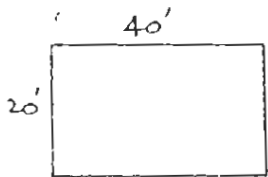


figure (b)

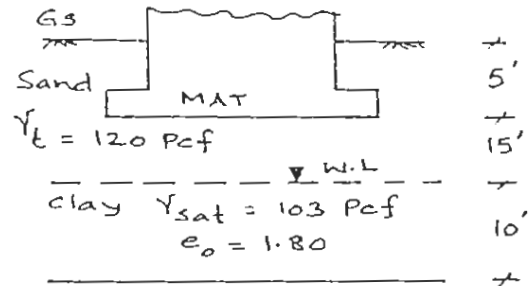


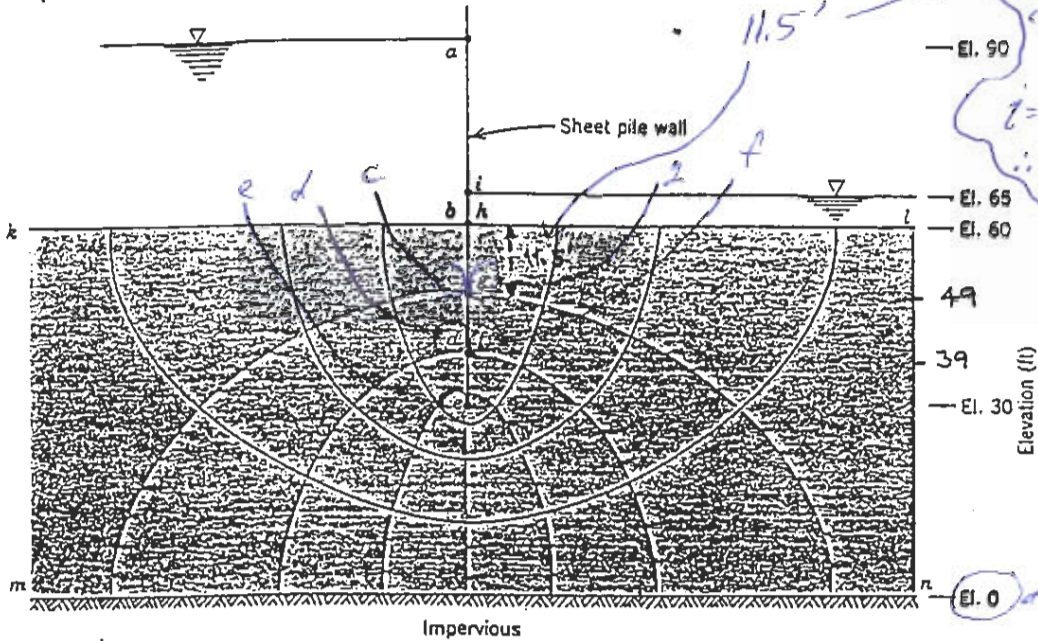
figure (a)

$$\Delta H_c = \frac{c_c}{1+e_o} \cdot H \cdot \log \frac{P_1}{P_o}$$

$$k = 1 \times 10^{-6} \text{ ft/min}$$

$$q = 12.5 \times 10^{-6} \frac{\text{ft}^3}{\text{min}} \frac{\text{ft}}{\text{ft}}$$

$$q_{100} = 0.001547 \frac{\text{ft}^3}{\text{min}}$$



$$\Delta h = \frac{h}{N_l} = \frac{25}{8} = 3.12 \frac{\text{ft}}{\text{sq}}$$

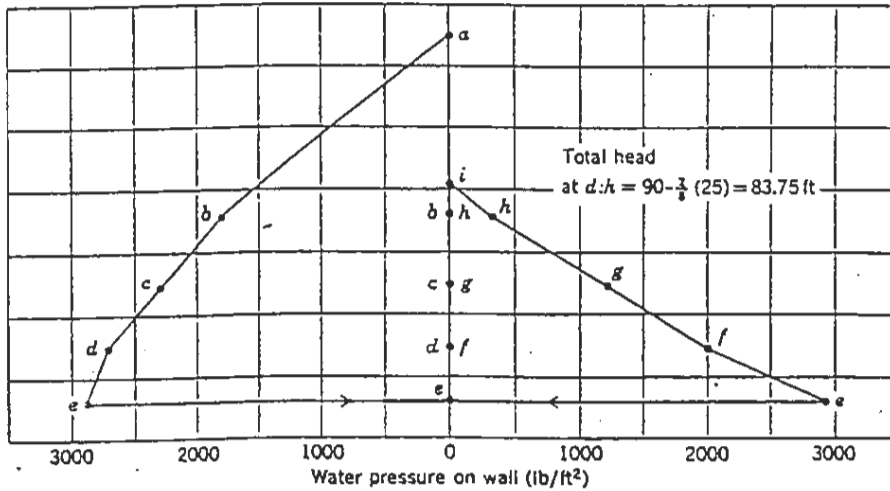


Fig. E18.1 Flow under sheet pile wall.

$$x_{100} = 62.4 \frac{\text{lb}}{\text{ft}^3}$$

Point	Elev. Head (ft)	Total Head (ft)	Pressure Head (ft)	Water Pressure (PSF) (Pressure head × γ)
a	90	90	0	0
b	60	90	30	1872
1 drop c	49	90 - 3.12 = 86.88	37.88	2364
2 drops d	39	90 - 6.24 = 83.76	44.76	2792
4 drops e	30	90 - (100.0) = 77.52	47.52	2964
6 drops f	39	71.28	32.28	2014
7 drops g	49	68.16	19.16	1193
8 drops h	60	65.04	5.04	312
i	65	65	0	0

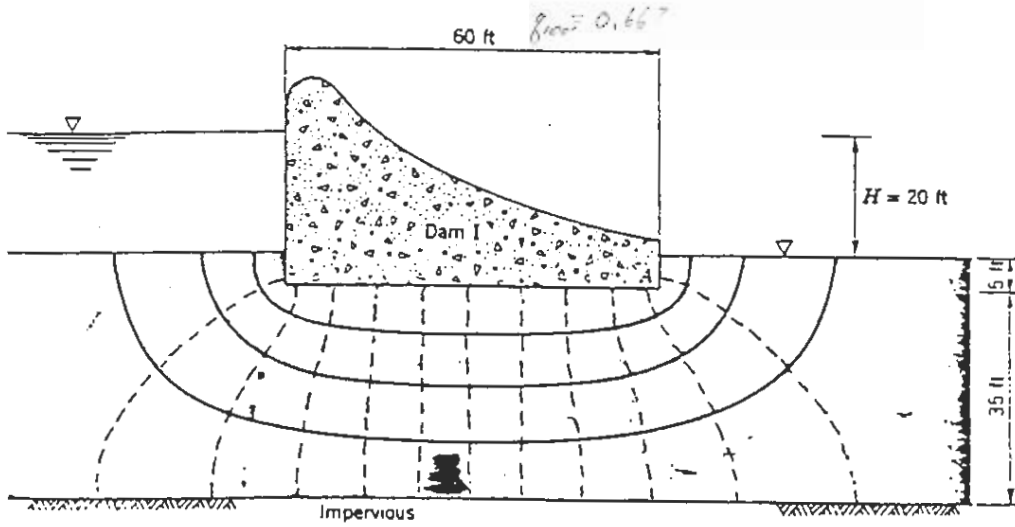
Some examples

calc. q for 100' of dam (z-axis)

$$q = k \frac{H}{N_x} \left[\frac{N_z}{L} \right]$$

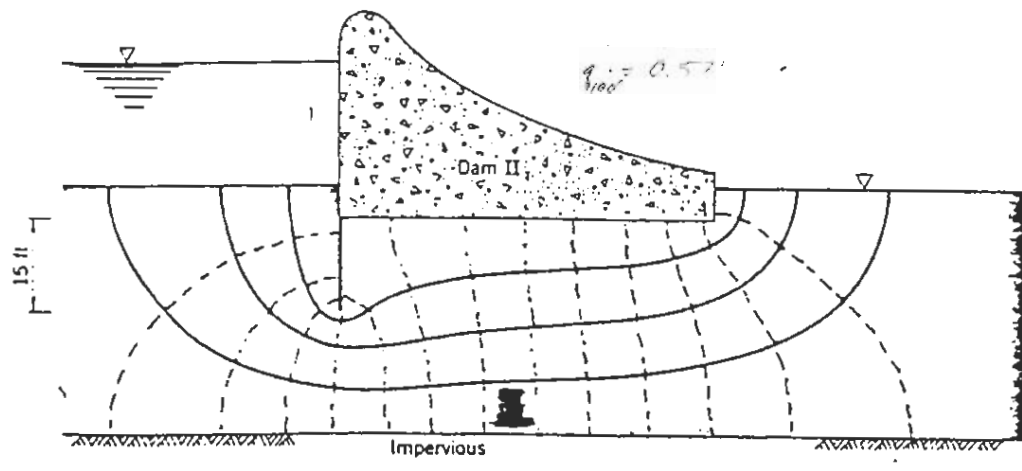
$k = 1 \times 10^{-3} \text{ ft/min}$

A)



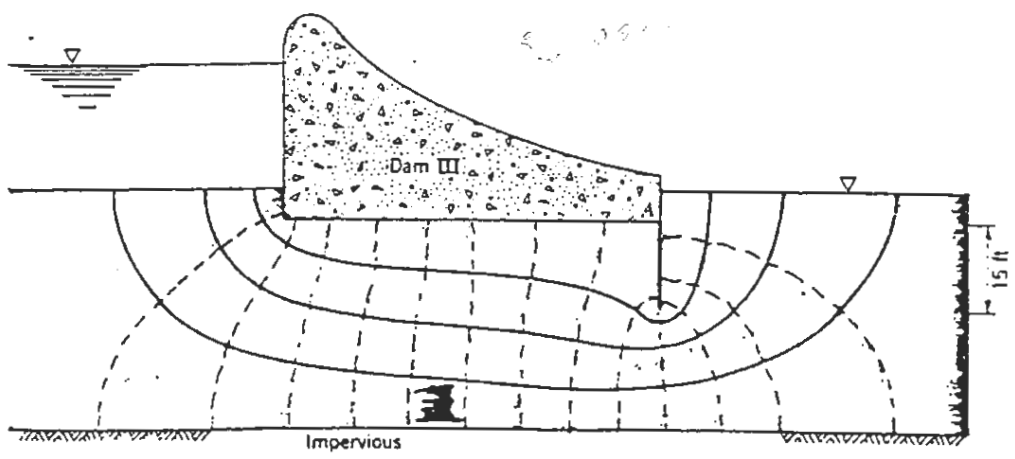
$N_z = 4$
 $N_x = 12$

B)



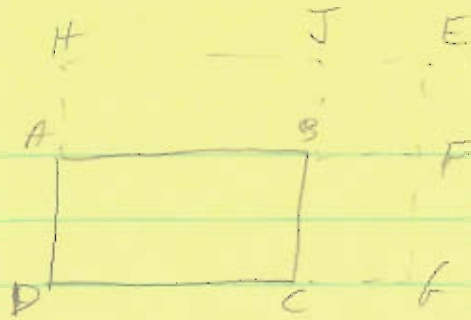
$N_z = 4$
 $N_x = 14$

C)



$N_z = 4$
 $N_x = 14$

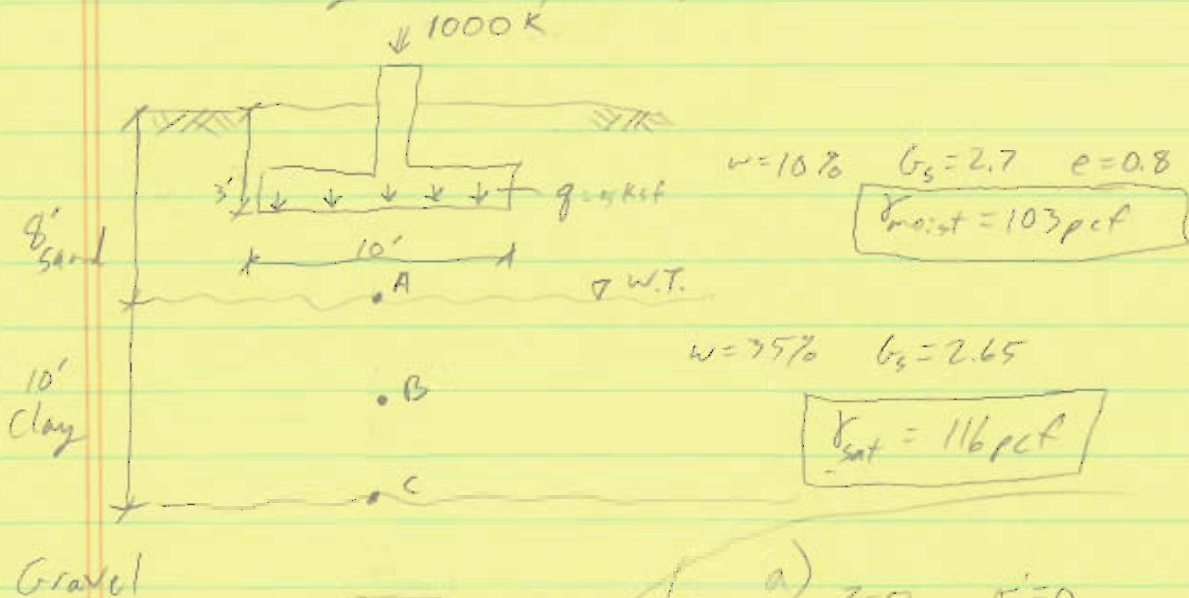
Flow under three dams.



$$\Delta\sigma_z = \Delta\sigma_z_{HDFH} - \Delta\sigma_z_{HEAF} - \Delta\sigma_z_{JECL} + \Delta\sigma_z_{BFJF}$$

Given soil profile & structure loading on a rectangular footing

- Find total stresses, pore pressure, & effective stress at depths of 8', 13', 18' ;
- Find introduced stress (due to applied load) under the center of footing at Pt A, B & C shown



a)

$z=0$	$\sigma' = 0$
$= 8'$	$= 824 \text{ pcf}$
$= 13'$	$= 1092 \text{ pcf}$
$= 18'$	$= 1360 \text{ pcf}$

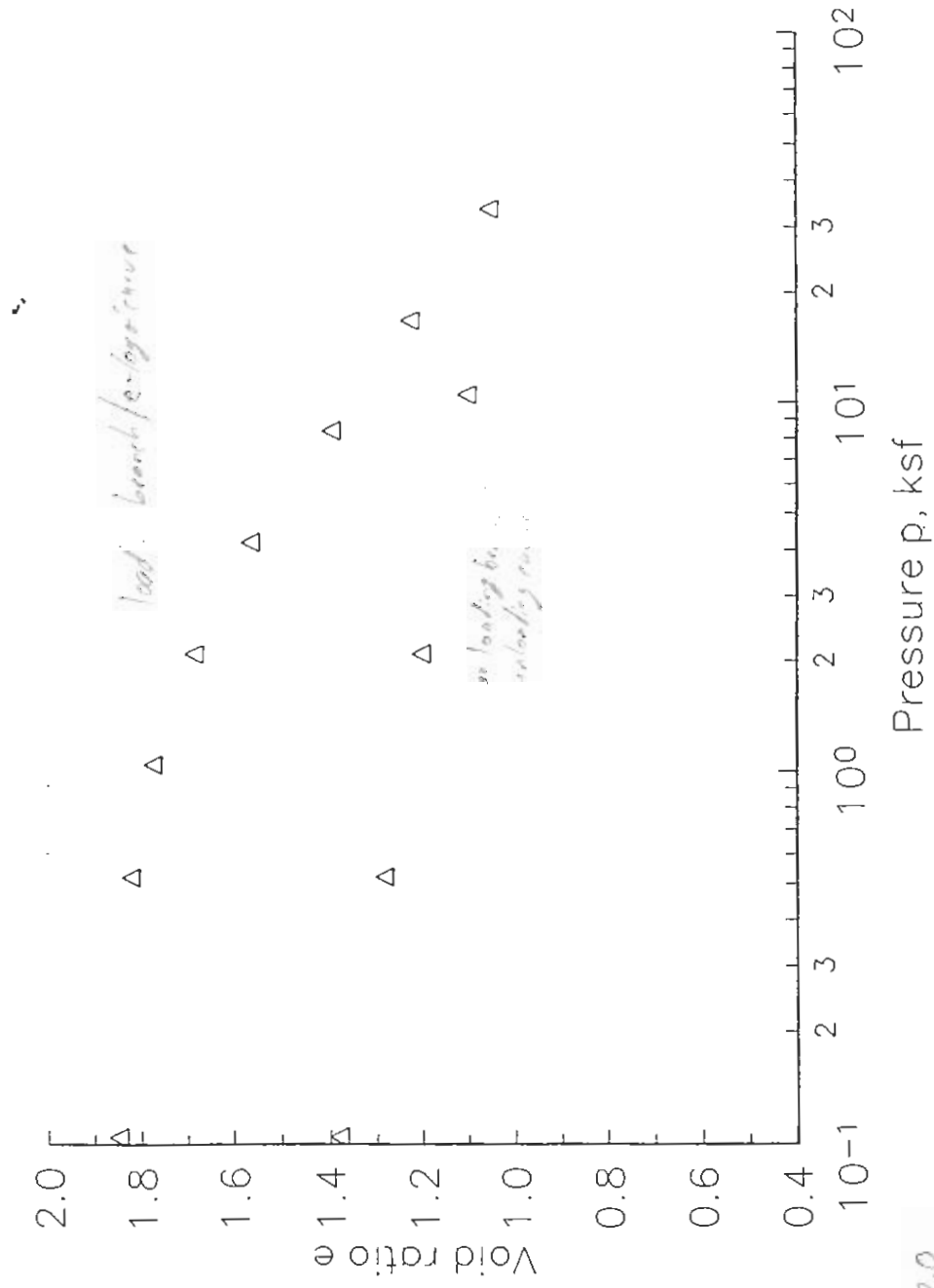
Point A: $z=5'$ $m=1$ $n=2$ $I=0.2$
 $\Delta\sigma_z = (0.2)(5)(4) = 4 \text{ ksf}$

Point B: $z=10'$ $m=0.5$ $n=1$ $I=0.12$
 $\Delta\sigma_z = 0.12(5)(4) = 2.4 \text{ ksf}$

Point C: $z=15'$ $m=0.33$ $n=0.67$ $I=0.07$
 $\Delta\sigma_z = 0.07(5)(4) = 1.4 \text{ ksf}$

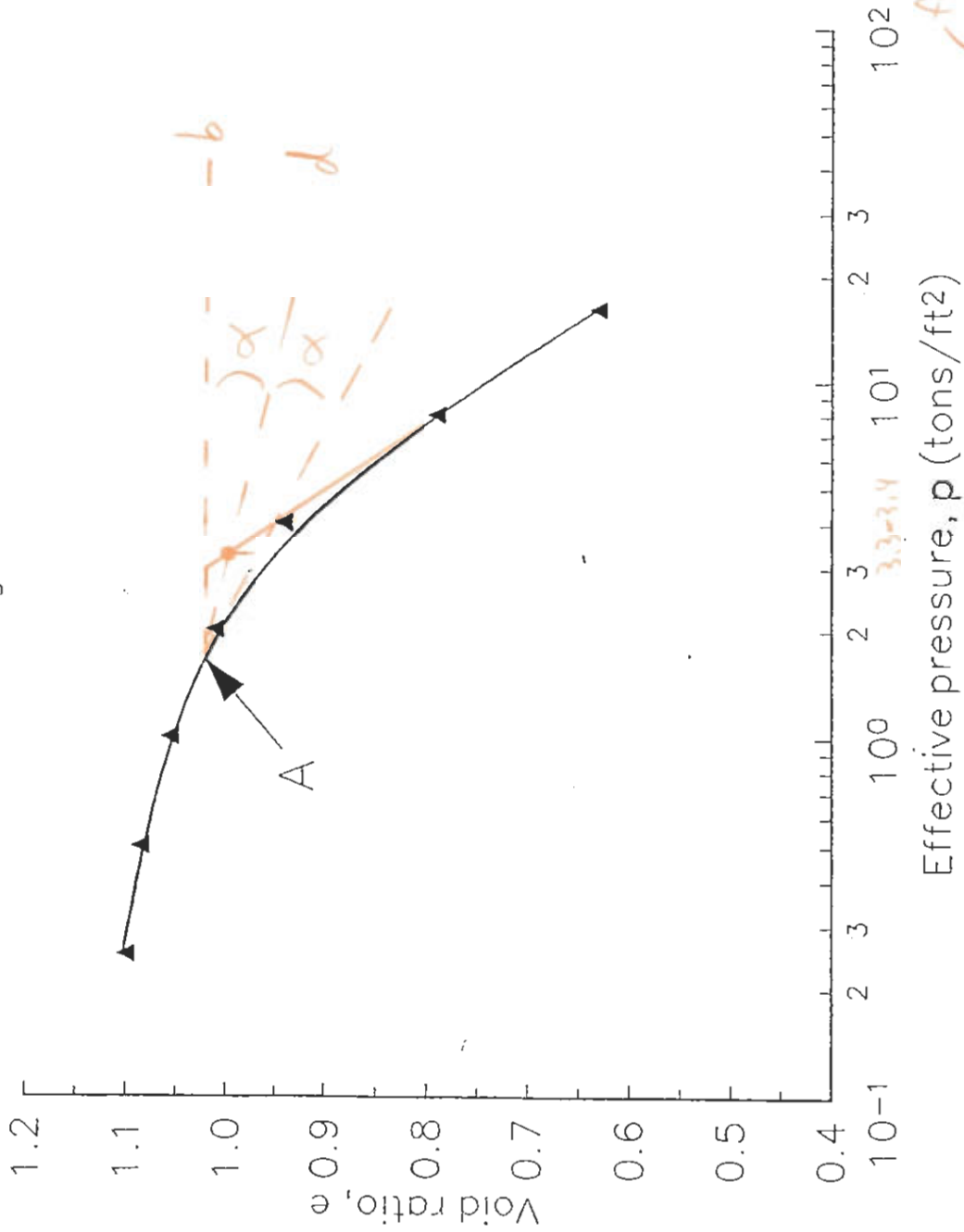
b) intensity of loading $= q = \frac{1000}{10(200)} = 5 \text{ ksf}$

Example with rebound



$C_c = 2.0$
 $C_r = 1.0$

Results from a consolidation test
Figure 1



The sample was from a depth of 10 ft. The existing overburden pressure was 1076 psf = 1.076 Ksf = 0.5475 Tsf
The clay is overconsolidated $\sigma'_{vc} = 3.375$

OCR = overconsolidation ratio = $\frac{\sigma'_c}{\sigma'_v} = \frac{3.3}{0.51} = 6$

$$G_s = \frac{\gamma_s}{\gamma_w} = \frac{W_s}{V_s \gamma_w} = \frac{W_s}{(A_s)(H_s) \gamma_w} \rightarrow H_s = \frac{W_s}{G_s (A) \gamma_w}$$

EXAMPLE ON CONSOLIDATION TEST

Pressure p (tsf)	Final dial reading (in)	Change in sample height ΔH (in)	Final sample height (in) (H)	Height of voids H_v (in) (H - H _s)	Final void ratio (e) = (H _v /H _s)
0	0.0200		1.000	0.4610	0.855
	$\uparrow \rightarrow$	0.0083 \leftarrow			
0.5	0.0283		.9917	.4527	.840
		0.0073			
1.0	0.0356		.9844	.4454	.826
		.0282			
2.0	0.0638		.9562	.4172	.774
		.0421			
4.0	0.1059		.9141	.3751	.696
		.0455			
8.0	0.1514		.8686	.3296	.612

SAMPLE TEST DATA

Sample diameter : 2.5 in
 Initial sample height: 1.0 in
 Weight of dry sample: 116.74 grams
 Specific gravity: 2.72
 Height of solids: 0.539 in

$$H_s = \frac{W_s}{A G_s \gamma_w}$$

$$= \frac{116.74}{\dots}$$

$$\left\{ \left(\frac{\pi}{4} \right) (2.5 \times 2.54)^2 \right\} (2.72) (1)$$

$$H_s = 1.36 \text{ cms} = 0.539 \text{ in}$$

$$\frac{V_v}{V_s} = \frac{A H_v}{A H_s} = \frac{H_v}{H_s}$$

CONSOLIDATION TEST

(Time vs. vertical dial reading)

Description of soil light brown clay
 Pressure on specimen 4 ton/ft² (at the end of 4 ref)
 Clock time of load application 8:35 am

Time after load application, t (min)	\sqrt{t} (min ^{0.5})	Vertical dial reading (in)
0	0	0.0638
0.25	0.5	0.0654
1.0	1.0	0.0691
2.25	1.5	0.0739
4	2	0.0795
6.25	2.5	0.0833
9.0	3.0	0.0868
12.25	3.5	0.0898
16	4	0.0922
20.25	4.5	0.0941
25	5	0.0954
36	6	0.0979
60	7.75	0.1004
120	10.95	0.1019
240	15.49	0.1029
480	21.91	0.1048
1440	37.95	0.1059

Table 16-1

GEO LAB FEB 10 S10 ①

Permeability or Hydraulic Conductivity

Methods to Find Coefficient of Perm. (K)

Laboratory Methods

- 1) Constant Head TEST P.166
- 2) Variable Head TEST (Falling Head TEST)

Field Methods

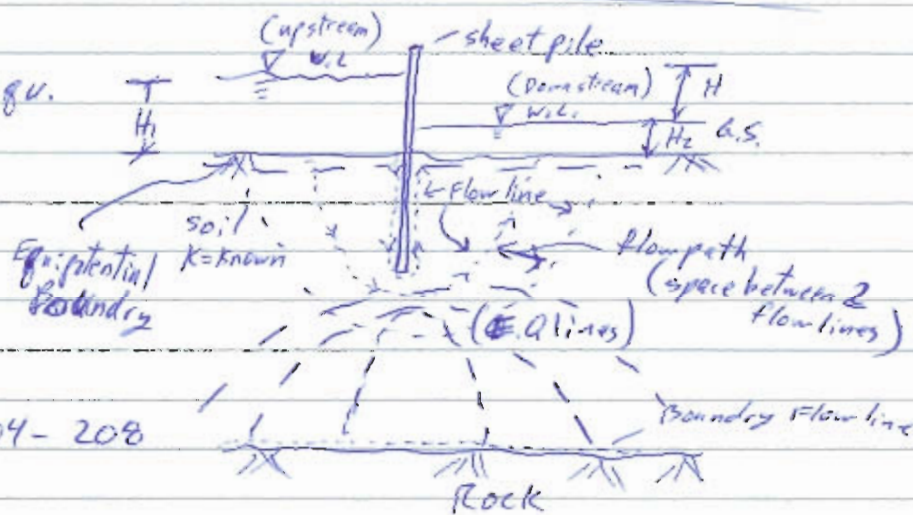
- 1) Pumping Tests
- 2) Bouwvell 2-stage Perm. Test

Feb 15

method for solving Diff. equ.

★★ Flow Net:

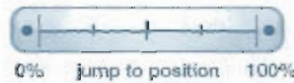
is the graphical solution for Laplace equ. for a given set of boundary conditions



see p. 204-208

N_f = # of flow paths

N_d = # of Equipotential drops (space between ~~E.P.~~ lines)



$g = 0.0022046 \text{ lb}$

$\gamma_w = 9.81 \frac{\text{KN}}{\text{m}^3} = 62.4 \frac{\text{lb}}{\text{ft}^3} \quad \rho = \frac{\gamma}{g}$

study notes

test 2 old test

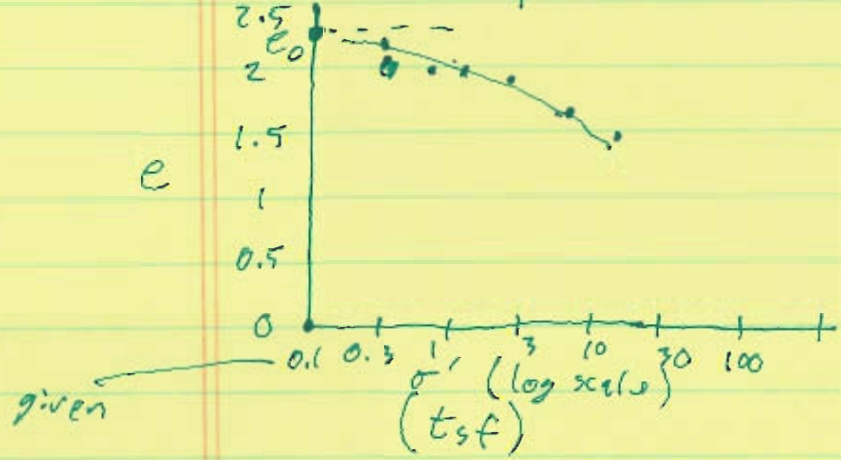
$e_w = 9.81 \frac{\text{KN}}{\text{m}^3} \left(\frac{1 \text{ m}}{5 \text{ s}} \right) = 191 \frac{\text{Kg}}{\text{m}^3} \left(\frac{1000 \text{ g}}{\text{Kg}} \right) \left(\frac{1 \text{ m}}{100 \text{ cm}} \right)^3 = 1.91 \frac{\text{g}}{\text{cm}^3}$

Height of solids: $H_s = \frac{W_s}{A G_s \gamma_w} = \frac{M_s}{A G_s \rho_w} = \frac{75.91 \text{ g}}{9.11 \text{ in}^2 (2.72) (1.91) \frac{\text{g}}{\text{cm}^3}} = 0.244 \text{ in}$

$A = \pi \left(\frac{D}{2} \right)^2 = \frac{\pi D^2}{4} = 4.91 \text{ in}^2$

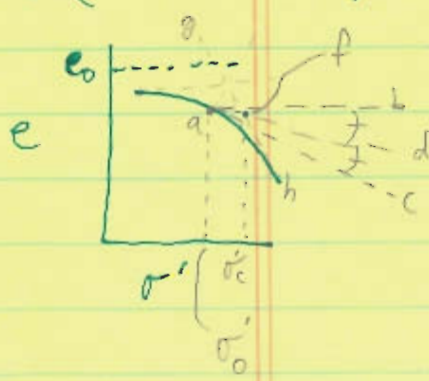
$\rho_w = 62.4 \frac{\text{slugs}}{\text{ft}^3} \left(\frac{1}{32.2 \frac{\text{ft}}{\text{s}^2}} \right) = 1.94 \frac{\text{lb}}{\text{ft}^3}$

σ'_v (psf)	$H_v = H - H_s$ (in)	$e = \frac{H_v}{H_s}$
7	$0.7900 - 0.244 = 0.536$	$0.536 / 0.244 = 2.197 = e_0$
4	$0.7642 - 0.244 = 0.5202$	$0.5202 / 0.244 = 2.132$
3	0.508	2.082
2	0.487	2
1	0.45	1.89
0.5	0.421	1.73
0.25	0.378	1.55



e vs. log σ'_v curve

σ'_c (pre-consolidation pressure)



a (point of least curvature); ab = horizontal; ac = tangent
 ad = bisects b, c; gh = tangent to h, f = intersection of gh & ad; the abscissa of f = σ'_c

Right +
 If line gh intersects e_0 to e_0 of point a, the clay is overconsolidated

fine take clay layer into parts



Compute excess pore pressure @ a, b, c, d, e after 2 yrs.

$T_v = 0.2$ $u_z = (1 - U_z) u_0$ $u_0 = \Delta \sigma' = 1000 \text{ psf}$

Using Fig 11.23

point a: $U_z = 0$
 point b: $\frac{z}{H_{dr}} = \frac{2.5}{10} = 0.25$

$\rightarrow U_z = 0.71$

So $u_z = (1 - 0.71)(1000) = 290 \text{ psf}$

point c: $\frac{z}{H_{dr}} = \frac{5}{10} = 0.5$

U_z From 11.23 = 0.47

$u_z = 530 \text{ psf}$

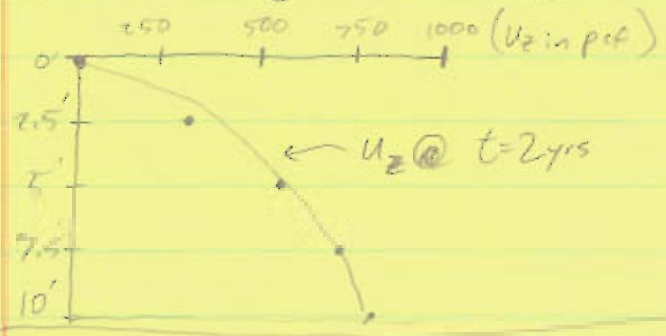
point d: $\frac{z}{H_{dr}} = \frac{7.5}{10} = 0.75$

$U_z = 0.3$

$u_z = (1 - 0.3)(1000) = 700 \text{ psf}$

point e: $U_z = 0.24$ $u_z = 760 \text{ psf}$

$T_v = \frac{c_v t}{H_{dr}^2}$



Compute u_z @ point c after 9 yrs (excess pore pressure)

$T_v = \frac{c_v t}{H_{dr}^2} = \frac{10(9)}{10^2} = 0.9$

$\frac{z}{H_{dr}} = 0.5$ From 11.23 $\rightarrow U_z = 0.92$

$u_z = (1 - 0.92)(1000) = 80 \text{ psf}$

Consider double drainage, find u_z @ pt. c after 2 yrs.

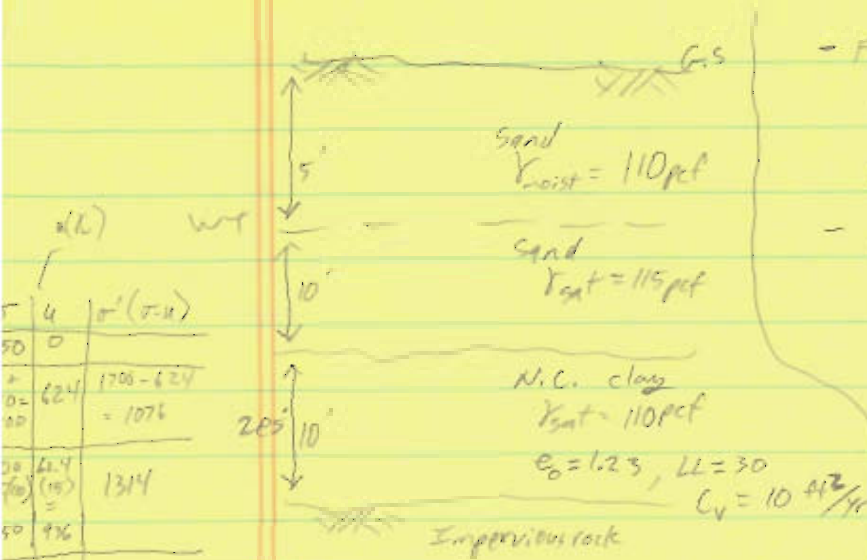
$T_v = \frac{10(2)}{(5)^2} = 0.8$ $\frac{z}{H_{dr}} = \frac{5}{5} = 1$ $U_z = 0.85$

$u_z = (1 - 0.85)1000 = 150 \text{ psf}$

$$\gamma_w = 62.4 \text{ pcf}$$

$$S_c = \frac{C_c}{1+e_0} H \log \left(\frac{\sigma'_0 + \Delta\sigma'}{\sigma'_0} \right)$$

← existing @ mid height of clay layer



- Find settlement of the clay layer due to a 10' high fill to be placed over the G.S. $\gamma_{sat} = 100 \text{ pcf}$
- Find the time for 50% & 90% settlement
- existing cap @ mid height of clay layer

$$\sigma'_0 = 1314 \text{ pcf}$$

$$\Delta\sigma' \text{ (induced stress @ the mid-height of clay layer due to 10' high fill material)}$$

$$\Delta\sigma' = 10' (100 \text{ pcf}) = 1000 \text{ pcf}$$

$$C_c = 0.009 (LL - 10) = 0.18$$

$$\therefore S_c = 0.2' = \boxed{2.4''}$$

- Time for 50%

$$T_v = \frac{C_v t}{H_{dr}^2}$$

$$T_v^{50\%} = 0.197$$

From table 11.8

$$H_{dr} = 10'$$

$$t_{50} = \frac{T_v \cdot H_{dr}^2}{C_v} = \frac{0.197 (10^2)}{10 \text{ ft}^2/\text{yr}} = 1.97 \text{ yrs} = \boxed{2 \text{ yrs}}$$

$$t_{90} = 8.48 \text{ yrs} = \boxed{8.5 \text{ yrs}} \text{ (for } 2.2' \text{)}$$

(double drainage)

It instead gravel @ bottom

$$H_{dr} = \frac{10'}{2} \text{ (4 times as fast)}$$

- What is avg degree of consolidation after 8.5 yrs? (U%)

$$T_v = \frac{C_v (t)}{H_{dr}^2} = \frac{10 (8.5)}{10^2} = 0.85 \text{ go to table 11.8}$$

$$U = 90\%$$

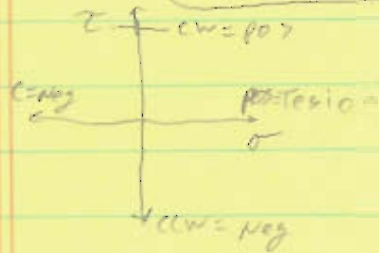
- what is it for after 2 yrs. $U = 50\%$

- " " " " 6 yrs $U =$

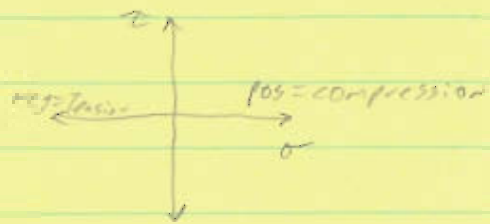
① 4-5-10 Geotech

chp 12

Mohr's Circle
mechanics of material



Geotech



state of stress on the element

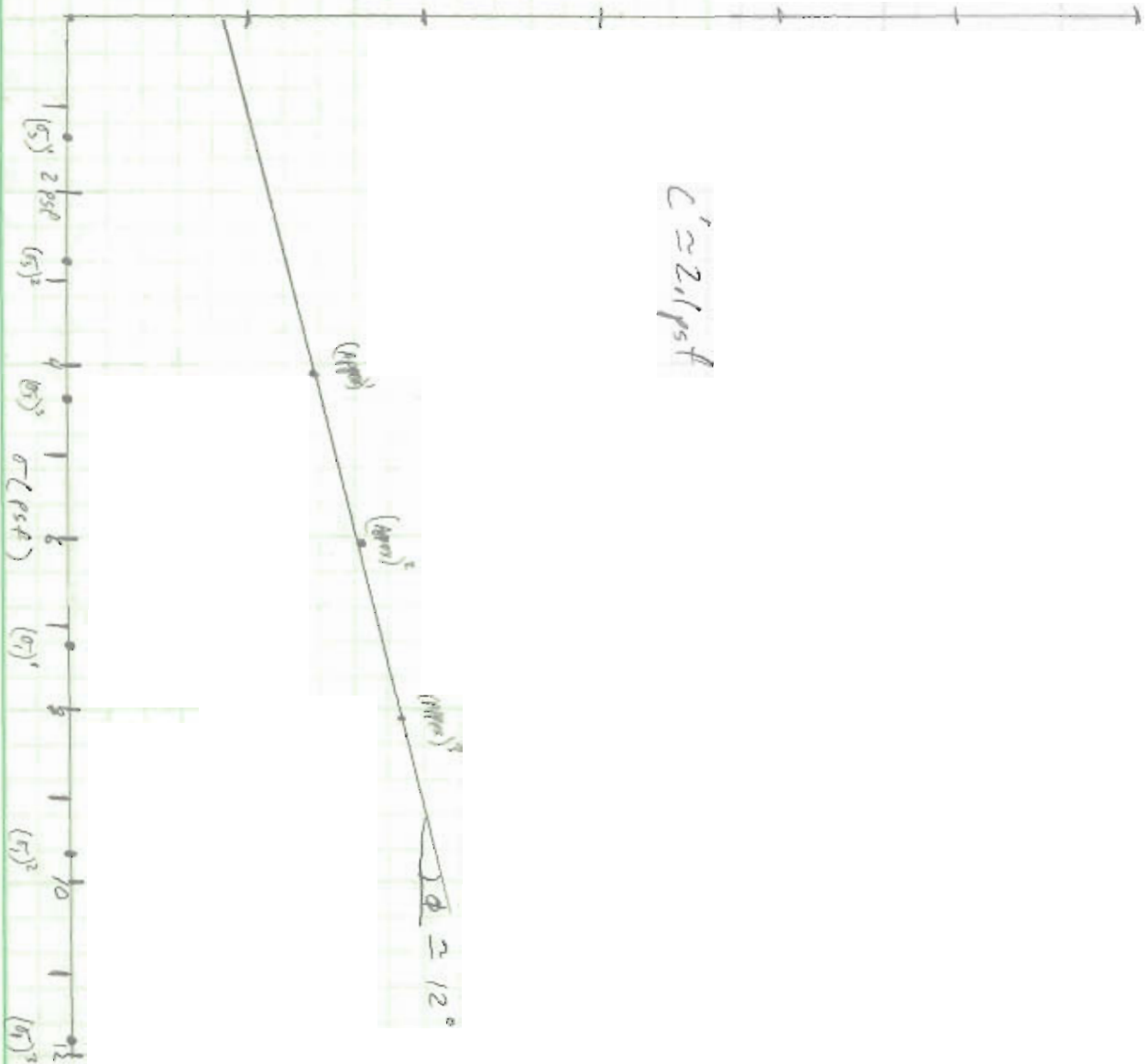


DUSTIN RICHARDS dtrichar@umt.edu
985 502 1669

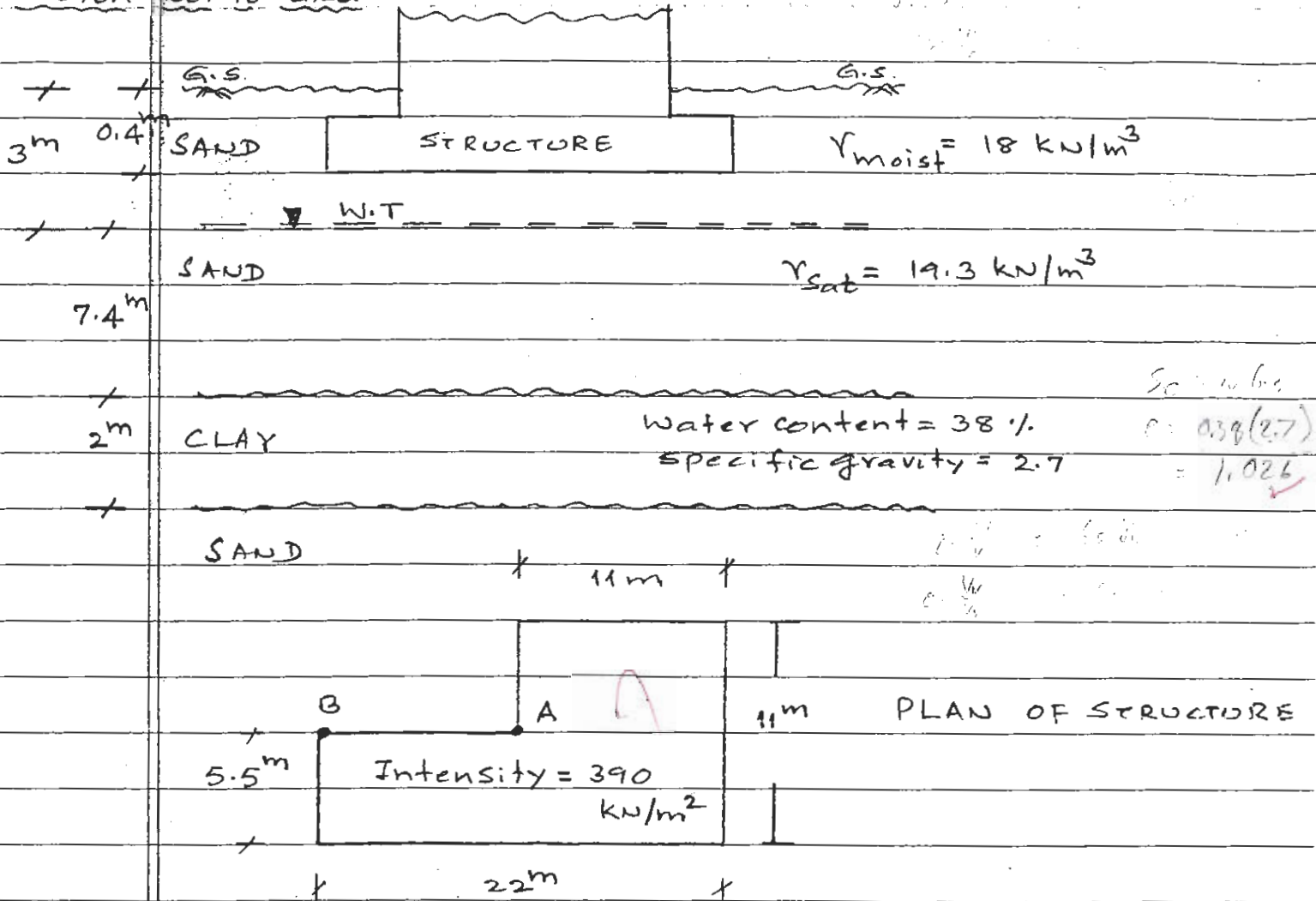
Example chap. 12.8 CD TEST
Find Shear parameters

Scale
1" = 216/ft²

Sample	σ_3 (psf)	$\Delta\sigma_1$ (psf)	σ_1 (psf)
1	1.44	5.76	7.2
2	2.88	6.65	9.73
3	4.32	7.50	11.82



Sketch NOT TO SCALE.



- (a) compute the settlement at (A) & (B) assuming the clay is normally consolidated. Given compression index = 0.3 what do you conclude from your results?
- (b) if the coefficient of consolidation is $8000 \times 10^{-6} \text{ m}^2/\text{day}$ determine the time for 90% consolidation.
- (c) what is the settlement at (A) if the clay is over-consolidated with an overconsolidation ratio of 2.5 and swell index equal to 0.05? All other conditions are same as in part (a).
- (d) what is the settlement at (A), if the overconsolidation ratio is 1.5 and swell index is 0.05?
- (e) what do you conclude from results of parts c and d?
- (30 Points)

Time Factor U
for 90% cons = 0.848

$$T_v = \frac{C_v t}{H^2}$$

$$r_{us} = 9.81 \text{ kN/m}^3$$

$$OCR = \frac{\sigma_c'}{\sigma_o'}$$

$$S_c = \frac{C_c}{1+e_o} H \log \left(\frac{\sigma_o' + \Delta \sigma'}{\sigma_o'} \right) \text{ for N.E. clays.}$$

For o.e. clays:

$$a) S_c = \frac{C_s H}{1+e_o} \log \left(\frac{\sigma_o' + \Delta \sigma'}{\sigma_o'} \right)$$

$$b) S_c = \frac{C_s H}{1+e_o} \log \frac{\sigma_c'}{\sigma_o'} + \frac{C_c H}{1+e_o} \log \left(\frac{\sigma_o' + \Delta \sigma'}{\sigma_o'} \right)$$

TABLE 6-2
Influence Coefficients for Points under Uniformly Loaded Rectangular Areas

or $m = \frac{A}{L^2}$	$n = B/z$ or $m = \frac{A}{L^2}$																	
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	5.0	10.0	∞
0.1	0.005	0.009	0.013	0.017	0.020	0.022	0.024	0.026	0.027	0.028	0.029	0.030	0.031	0.031	0.032	0.032	0.032	0.032
0.2	0.009	0.018	0.026	0.033	0.039	0.043	0.047	0.050	0.053	0.055	0.057	0.059	0.061	0.062	0.062	0.062	0.062	0.062
0.3	0.013	0.026	0.037	0.047	0.056	0.063	0.069	0.073	0.077	0.079	0.083	0.086	0.089	0.090	0.090	0.090	0.090	0.090
0.4	0.017	0.033	0.047	0.060	0.071	0.080	0.087	0.093	0.098	0.101	0.106	0.110	0.113	0.115	0.115	0.115	0.115	0.115
0.5	0.020	0.039	0.056	0.071	0.084	0.095	0.103	0.110	0.116	0.120	0.126	0.131	0.135	0.137	0.137	0.137	0.137	0.137
0.6	0.022	0.043	0.063	0.080	0.095	0.107	0.117	0.125	0.131	0.136	0.143	0.149	0.153	0.155	0.156	0.156	0.156	0.156
0.7	0.024	0.047	0.069	0.087	0.103	0.117	0.128	0.137	0.144	0.149	0.157	0.164	0.169	0.171	0.171	0.172	0.172	0.172
0.8	0.026	0.050	0.073	0.093	0.110	0.125	0.137	0.146	0.154	0.160	0.168	0.176	0.181	0.183	0.184	0.185	0.185	0.185
0.9	0.027	0.053	0.077	0.098	0.116	0.131	0.144	0.154	0.162	0.168	0.178	0.186	0.192	0.194	0.195	0.196	0.196	0.196
1.0	0.028	0.055	0.079	0.101	0.120	0.136	0.149	0.160	0.168	0.175	0.185	0.193	0.200	0.202	0.203	0.204	0.205	0.205
1.2	0.029	0.057	0.083	0.106	0.126	0.143	0.157	0.168	0.178	0.185	0.196	0.205	0.212	0.215	0.216	0.217	0.218	0.218
1.5	0.030	0.059	0.086	0.110	0.131	0.149	0.164	0.176	0.186	0.193	0.205	0.215	0.223	0.226	0.228	0.229	0.230	0.230
2.0	0.031	0.061	0.089	0.113	0.135	0.153	0.169	0.181	0.192	0.200	0.212	0.223	0.232	0.236	0.239	0.240	0.240	0.240
2.5	0.031	0.062	0.090	0.115	0.137	0.155	0.170	0.183	0.194	0.202	0.215	0.226	0.236	0.240	0.242	0.244	0.244	0.244
3.0	0.032	0.062	0.090	0.115	0.137	0.156	0.171	0.184	0.195	0.203	0.216	0.228	0.238	0.242	0.244	0.246	0.247	0.247
5.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.204	0.217	0.229	0.239	0.244	0.246	0.249	0.249	0.249
10.0	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250
∞	0.032	0.062	0.090	0.115	0.137	0.156	0.172	0.185	0.196	0.205	0.218	0.230	0.240	0.244	0.247	0.249	0.250	0.250

Source: N. M. Newmark, Simplified Computation of Vertical Pressures in Elastic Foundations, Circ. No. 24, Eng. Exp. Sta., University of Illinois, 1935.

NOTE: SHOW ALL COMPUTATIONS,
FORMULAS USED & UNITS.

$$B = \frac{2}{5} (11 \times 22) = (11 \times 5.5)$$

$$A = 3 (11 \times 5.5)$$

$$\frac{5.5}{11.4} = 0.49$$

$$\frac{22}{11.4} = 1.93$$

$$\frac{11}{11.4} = 0.965$$

Donald J. Frolleman

$C_c = 0.3$

$\alpha_c = 7.81 \text{ kN/m}^3$

z (m)	σ (kN/m ²)	u	σ' (kN/m ²)	z	σ	u	σ'
3	$390 + (3.09 \times 18) = 436.8$	\emptyset	436.8	3	46.8	\emptyset	46.8
10.4	$7.9(19.7) + 436.8 = 580$	$7.81(7.4) = 73$	$580 - 73 = 507$	10.4	$193 + 46.8 = 190$	73	117
11.4	606.5	82.4	524	11.4	217	82.4	135

90-1
19
135

Where are time steps

Where $\gamma_{sat} = ?$

(a) $\sigma_{zA} = \gamma z = 3(390)(0.12) = 140.4 \text{ units}$

(b) $\sigma_{zB} = (2)(390)(0.135) - (390)(0.12) = 58.5 \text{ units}$

(c) $S_c = \frac{0.3}{2.026} (11.4) \log \left(\frac{135 + 140.4}{135} \right) = 0.5227 \text{ m}$

$S_{cB} = \frac{0.3}{2.026} (11.4) \log \left(\frac{135 + 58.5}{135} \right) = 0.264 \text{ m}$

- The structure will have a slight tilt

(b) $0.848 = \frac{8000 \times 10^{-6} \frac{\text{m}^2}{\text{s}} (t)}{\left(\frac{11.4 \text{ m}}{2} \right)^2} \rightarrow t_{90} = 3444 \text{ days}$

(c) $\sigma_c > \sigma'_0 + \Delta\sigma'$; $\sigma'_c = ?$

$S_c = \frac{0.05 (11.4)}{2.026} \log \left(\frac{135 + 140.4}{135} \right) = 0.087 \text{ m}$

(d) $\sigma_c < \sigma'_0 + \Delta\sigma'$; $\sigma'_c = ?$

$S_c = \frac{0.05 (11.4)}{2.026} \log \left(\frac{2025}{135} \right) + \frac{0.3 (11.4)}{2.026} \log \left(\frac{135 + 140.4}{2025} \right) = 0.275 \text{ m}$

(e) Structure will settle less than part (A) & as expected part (d) will settle more than part (c)

Consolidation Test

95 dia
 Example
 11.7
 .8
 .9
 .11

OD' = 1.15 OB'
 Join AD

$\sqrt{t_{90}} = 4.75 \text{ min}$
 $t_{90} = 22.56 \text{ min}$
 $= 1354 \text{ Sec.}$

$$T = \frac{C_v t}{H^2 \Delta v}$$

$T_{90} = 0.848$

$H = 0.8914 \text{ in.}$

$$C_v = \frac{(0.848)(0.445)^2}{1354}$$

$C_v = 1.24 \times 10^{-4} \text{ in}^2/\text{sec}$

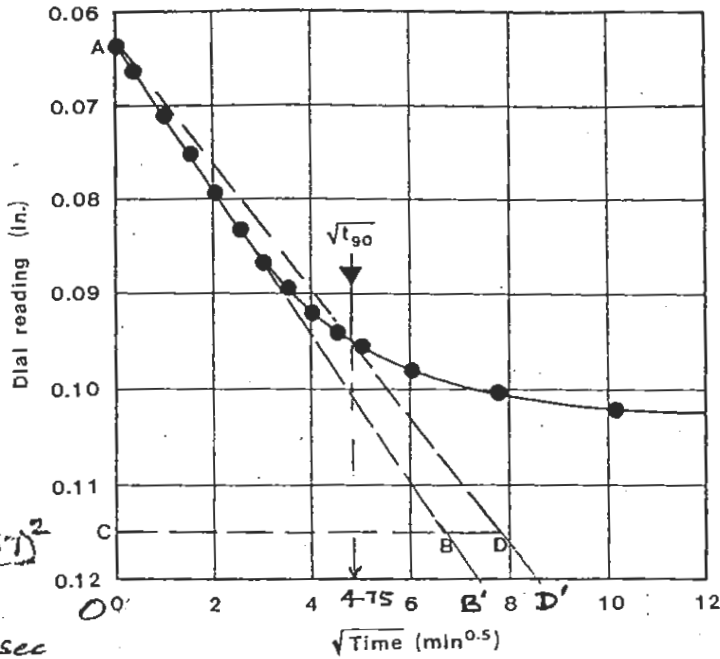


Figure 16-4. Plot of dial reading vs. $\sqrt{\text{time}}$ for the test results given in Table 16-1. Determination of t_{90} by square-root-of-time method.

$$d_{50} = (d_0 + d_{100})/2$$

$H = 0.8914 \text{ in.}$
 $\Delta v = 0.4457$

$t_{50} = 4 \text{ min}$
 $= 240 \text{ sec}$

$T_{50} = 0.197$

$$T = \frac{C_v t}{H^2 \Delta v}$$

$$C_v = \frac{0.197 \times (0.4457)^2}{240}$$

$C_v = 1.68 \times 10^{-4} \text{ in}^2/\text{sec}$

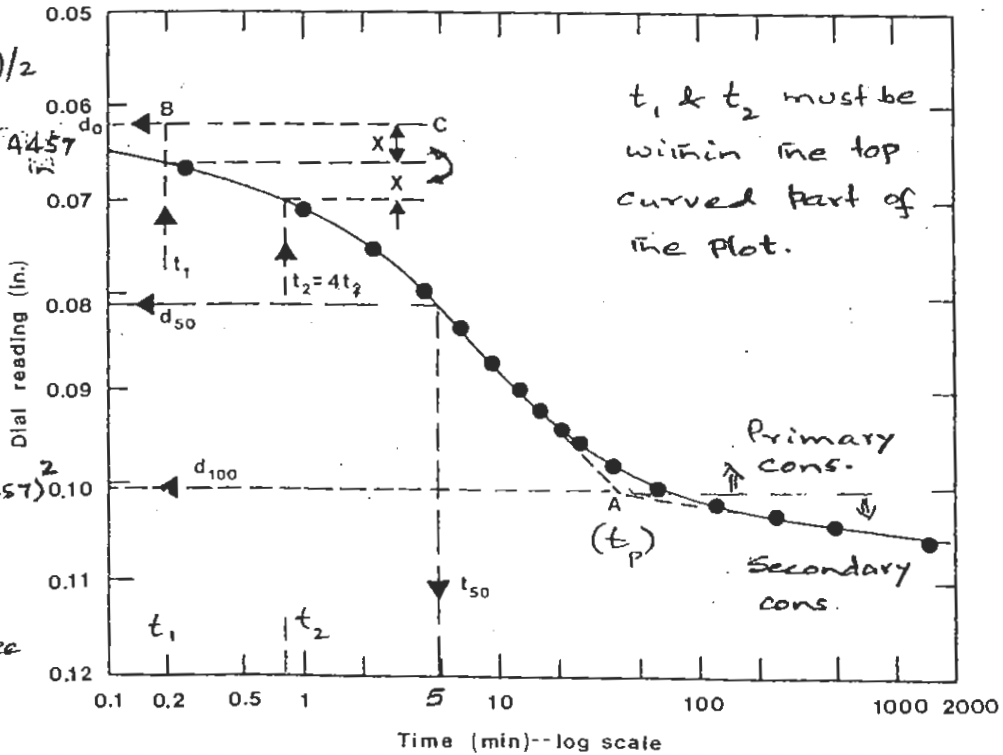


Figure 16-5. Logarithm-of-time curve fitting method for the laboratory results given in Table 16-1.

$\sigma = 7.81 \cdot \frac{e_2}{m^2} = 2.4 \frac{lb}{in^2}$
 $\rho = \frac{\sigma}{2}$

NAME: _____

SHOW ALL COMPUTATIONS; LIST ANY ASSUMPTIONS YOU MAKE; PLOTS MUST BE ON APPROPRIATE GRAPH PAPER; BE NEAT; STAPLE YOUR ANSWER SHEET

(1) Consider the soil profile shown in Figure. A sample of a clay was obtained from the mid-height of a compressible clay layer consolidation test was conducted on a part of this sample. Sample test results are given below:

The sample diameter is 2.5 in; initial sample height is 0.78 in; weight of dry sample is 75.91 gms.; specific gravity for solids is 2.72;

pressure (tsf) height of sample at the end of consolidation (in) $e = \frac{H_v}{H_s}$

weight solids
 $\rho_s = \frac{W_s}{V_s} = \frac{M_s}{V_s}$
 $\rho = \frac{W}{V} = \frac{M}{V}$

expt. H_v

0	0.7800
0.4	0.7642
0.8	0.7516
1.6	0.7310
3.2	0.7039
6.4	0.6655
12.8	0.6220

$H = H_v - H_s$

Note: 1 ton = 2 kips

Make necessary calculations to obtain the e-log σ curve and plot the e-log σ curve. Determine whether the clay is normally consolidated or preconsolidated. Draw the field consolidation line and determine the compression index.

The following are part of the results of the consolidation test on the sample for a load increment from 1.6 to 3.2 tsf:

Time (min)	Dial reading (in)	Time (min)	Dial reading (in)
0	0	15	0.0120
0.1	0.0067	30	0.0132
0.25	0.0069	60	0.0144
0.5	0.0071	120	0.0152
1.0	0.0077	240	0.0158
2.0	0.0084	480	0.0160
4.0	0.0095	1380	0.0162
8.0	0.0107	1560	0.0162

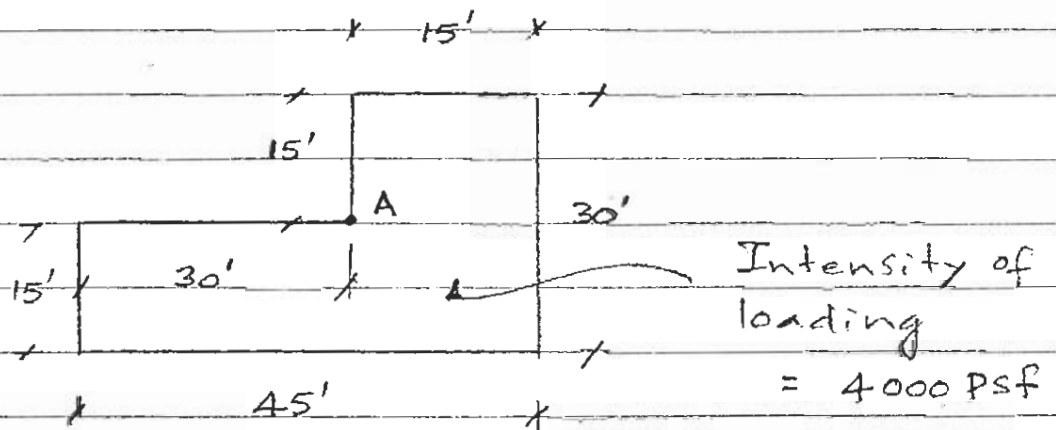
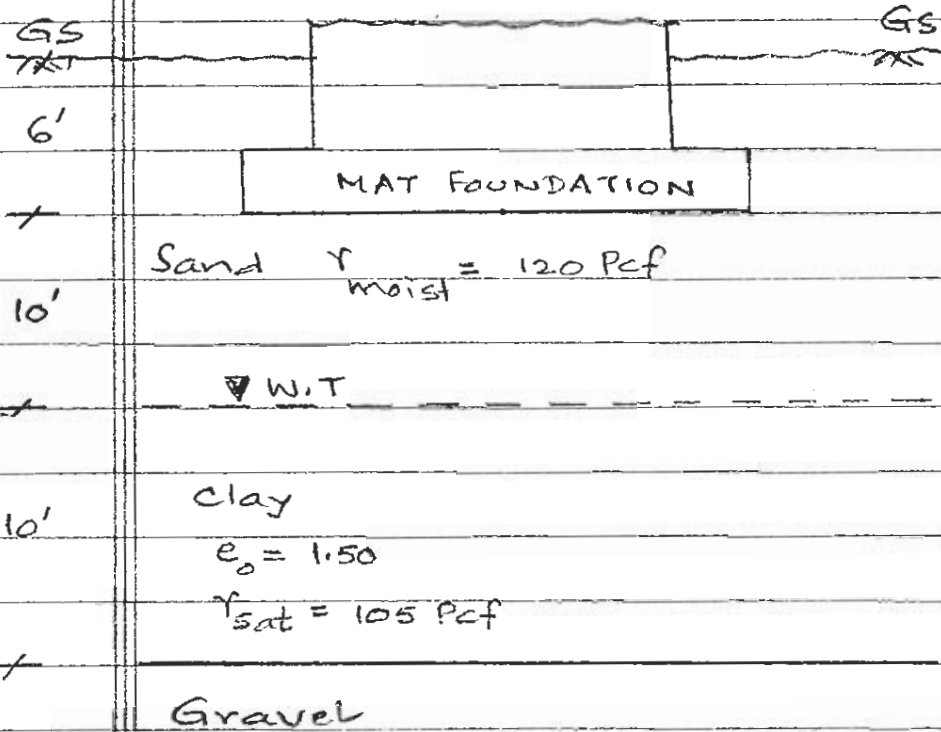
The specimen is doubly drained and its average height during the loading is 0.7692 in.; determine the coefficient of consolidation using (a) square root of time method, (b) using the log of time method. Express your results as in² per minute and in² per year.

A structure is to be constructed at this site. The foundation selected has plan shown in Figure. (a) Determine the amount of settlement of the foundation at point A shown in figure. (b) Compute the time in years for 10 through 90 percent (in 10% increments) and 99% settlement to occur in the field. Use C_v from Taylor's method. Plot a time versus settlement graph with time (to a log scale) as abscissa and settlement as ordinate. (c) Compute the excess pore pressure in the clay after 1 year, and 2 & 3 years at the mid-height of the clay layer; plot this result. What do you conclude?

I NEITHER RECEIVED HELP FROM OR GAVE HELP TO ANOTHER PERSON IN SOLVING THIS PROBLEM. SIGNATURE _____

\sqrt{t}

FIGURE FOR QUESTION 1



PLAN.

Geo Tech Notes

Soil Classification

(AASHTO)	Gravel	Sand	Fines	
			silt	Clays
American Association of State Highway & Transportation Officials	76.2 - 2	2 - 0.075	0.075 - 0.002	< 0.002
Unified Soil Classification System	76.2 - 4.75	4.75 - 0.075	< 0.075	

#4 sieve: 4.75 mm

#200 Sieve 0.075 mm

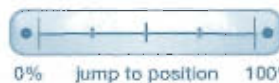
Uniformity Coefficient $C_u = \frac{D_{60}}{D_{10}}$

Coefficient of Gradation $C_c = \frac{D_{30}^2}{D_{60}(D_{10})}$

Poorly graded (grains = mostly same size)

Well graded typically $C_u > 4$ for gravels, > 6 for sands, C_c between 1 & 3

Gap graded (2+ combinations of uniformly graded fractions)



GEOTECHNICAL CHAP. 7

TERMS

h = Total Head ; Δh = Head loss / gain

u = pressure in water

v = velocity

g = acceleration due to gravity

γ_w = unit weight of water

Z = elevation head (vertical distance above/below a datum plane)

i = hydraulic gradient

L = distance between points A & B

k = hydraulic conductivity (coefficient of permeability)

A = gross cross-sectional Area

A_v = cross-sec. Area of voids in specimen

v_s = seepage velocity

q = quantity of water flowing through soil in unit time

η = viscosity of water

T = temp

K = absolute permeability

Q = volume of water collected *Note not flow rate

t = time

n = porosity

a = cross-sec. area of standpipe



Important Formulas

Bernoulli's Equ. - finds the total head at a point in water under motion

$$h = \frac{u}{\gamma_w} (\text{Pressure Head}) + \frac{v^2}{2g} (\text{Velocity Head}) + Z (\text{Elevation Head})$$

* because flow through soil is so slow we can neglect velocity head.

$$h = \frac{u}{\gamma_w} + Z$$

$$i = \frac{\Delta h}{L}$$



7.4

Constant Head Test

- To Find k for Granular Soils Not clays & silts
- Sample must be saturated

Know: $Q = qt = A \cdot v \cdot t = AKit = AK \left(\frac{h}{L} \right) t \rightarrow k = \frac{QL}{Aht}$

See Fig 7.5 p. 166

Falling Head Test

- To Find k for Silts & Clays

$$q = k \frac{h}{L} A = -a \frac{dh}{dt}, \quad dt = \frac{aL}{AK} \left(-\frac{dh}{h} \right), \quad t = \frac{aL}{AK} \log_e \frac{h_1}{h_2}$$

$$k = 2.303 \frac{aL}{Ae} \log_{10} \frac{h_1}{h_2}$$



record pause stop



jump



bookmark



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playback speed



volume

$$v \propto i$$

7.2 Darcy's Law

$$v = ki$$

where discharge velocity, v_s = amt. of water flowing in unit time through a unit gross cross-sect. area of soil at right angles to the direction of flow.

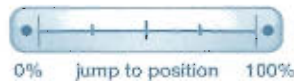
$$q = vA = A_v v_s = AKi$$

$$v_s = \frac{v}{n}$$
 Derived on p. 163

Table 7.1 K values for soil types

$$k = \frac{\gamma_w}{\eta} \bar{K} \xrightarrow{\text{Implies}} \frac{k_{T_1}}{k_{T_2}} = \left(\frac{\eta_{T_2}}{\eta_{T_1}} \right) \left(\frac{\gamma_w(T_1)}{\gamma_w(T_2)} \right)$$

Setting $T_1 = 20^\circ\text{C}$ we get Table 7.2



CHAP 8

TERMS

A = cross-sectional Area of soil



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playback speed



volume

Geotechnical chap 7 Permeability (Answers on next page)

①

- 1) What is Bernoulli's Equation?
- 2) What head loss? & hydraulic gradient?
- 3) What is Darcy's Law?
- 4) What is the name for the path water take through soils, flowing through voids & around particles?
- 5) What is the quantity of water flowing through soil in unit time? [eg: $\frac{m^3}{s}$]



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playback speed



volume

Geotechnical chap 7 (Answers on next page)

- 1) Derive Seepage velocity from $q = vA = v_s A_v$
- 2) Define hydraulic conductivity as it relates to the properties of a fluid
- 3) " " " at different temps.

Geo technical chap 7 (answers on next Page)

3

- 1) a) Name two tests for Hydraulic Conductivity & which types of soil they apply to
- b) derive formulas used



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volume

Geotechnical Chap 7 (answers on next page)

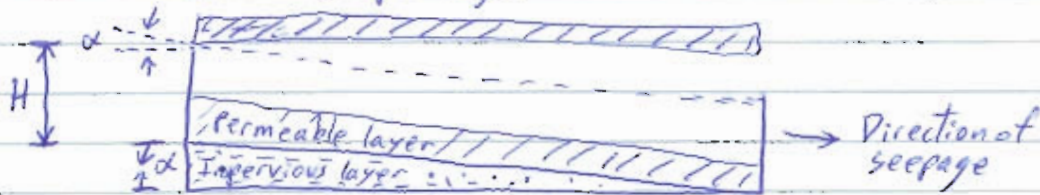
④

- 1) Given: - hydraulic conductivity (K) [$\frac{cm}{s}$]
- viscosity of water @ Temp [$\frac{g \cdot s}{cm^2}$]

Find: - absolute permeability of the soil (\bar{K}) [cm^2]

Ex 7.4

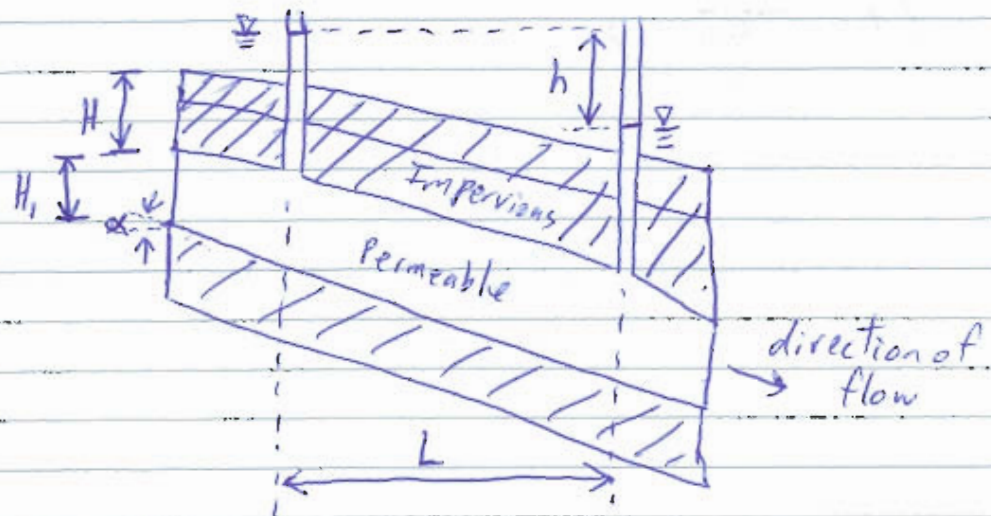
- 2) Given: - permeable layer underlain by impervious layer
- K = hydraulic conductivity
- H = height from impervious layer to groundwater table (Free surface)
- α = slope angle



Find: - Rate of seepage in $m^3/hr/m$ width = q /unit width

Geotechnical Chap 7 (answers on next page) ⑤

Ex 7.5) Given: - permeable layer between 2-impervious layers
p.171



- H, H_1, h, α, k

2) Define: Relationship of Hydraulic Conductivity & Sands (fairly uniform)

For granular soils see eqn 7.30, 7.32 p.173 (Do Not need to memorize)
" 7.34 p. 174

ex 7.6 3) Given: - The hydraulic conductivity of sand, ~~at a void ratio~~ (K_1)
- void ratio of sand, (e_1)
- void ratio of sand, (e_2)

Find: - hydraulic conductivity of sand, (K_2)

GEOTECH Chap 7 (answers on next page)

6

- 1) Given: - normally consolidated soils
- e_1, k_1
- e_2, k_2
- e_3

Req'd: Est. hydraulic conductivity of the clay @ e_3 ie: k_3

- 2) Given: - X ^{a number of layers} layered soil (for example will use 3 layered soil)
- H_1, k_1
- H_2, k_2
- H_3, k_3

Req'd: Est. ratio of equivalent hydraulic conductivity



record pause stop



jump



bookmark



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playback speed



volume

Geotechnical chap 7 (answers on next page) ⑤



record pause stop



jump



bookmark



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playback speed



volume

SHOW ALL COMPUTATIONS. WRITE THE FORMULA OR EQUATION YOU USE, SHOW THE SUBSTITUTED VALUES AND THEN THE FINAL ANSWER. REMEMBER TO WRITE UNITS. YOU CAN WRITE ON BOTH SIDES OF THE PAPER.

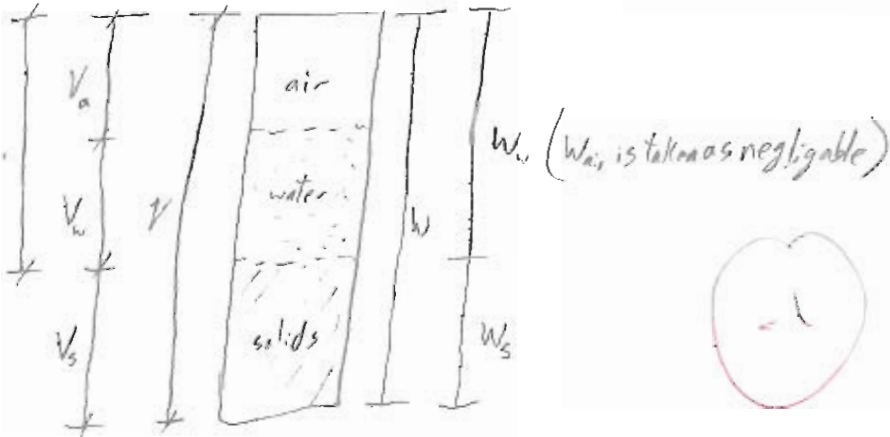
Q 1. Define the following terms with the help of a phase diagram: a) void ratio b) porosity c) degree of saturation d) water content and e) dry density. (Do not just write expressions).

(a) $e = \frac{V_v}{V_s} = \frac{n}{1-n}$ (b) $n = \frac{V_v}{V} = \frac{e}{1+e}$ (c) $S = \frac{V_w}{V_v} = \frac{w G_s}{e}$ (d) $w = \frac{W_w}{W_s}$

(5 points) $\rho = \frac{M}{V} = \frac{m}{V}$

$\rho_{dry} = \frac{W_s}{V}$

25/30



Q 2. A soil sample in its natural state has a weight of 5.05 pounds and a volume of 0.041 cu.ft. In an oven-dried state, the dry weight of the sample is 4.49 pounds. The specific gravity of the soil solids is 2.68; determine the total unit weight, water content, void ratio, porosity, and degree of saturation. (10 points)

$W = 5.05 \text{ lb}$ $V = 0.041 \text{ ft}^3$
 $W_s = 4.49 \text{ lb}$ $W_w = 0.56 \text{ lb}$ $G_s = 2.68$
 γ, w, e, n, S

$e = \frac{G_s w}{S} = \frac{2.68(0.1247)}{S}$

$\frac{(G_s + S e) \rho_w}{1+e}$

$w = \frac{0.56}{4.49} = 0.1247 = 12.47\%$

$\gamma = \frac{W}{V} = \frac{5.05 \text{ lb}}{0.041 \text{ ft}^3} = 123.2 \text{ lb/ft}^3$

$S = \frac{w(1+e)}{e} = \frac{2.68(0.1247)}{e}$

$\gamma_d = \frac{\gamma}{1+w} = \frac{123.2 \text{ lb/ft}^3}{1.1247} = 109.5 \text{ lb/ft}^3$

$123.2 \text{ lb/ft}^3 = \frac{(2.68 + S e) (62.4 \text{ lb/ft}^3)}{1+e}$

$(S e) = 1.97 = \frac{2.68}{1+e}$

$S = 63.45\%$

$123.2 \text{ lb/ft}^3 = \frac{(2.68 + (2.68(0.1247))) (62.4 \text{ lb/ft}^3)}{1 + (\frac{2.68(0.1247)}{S})}$

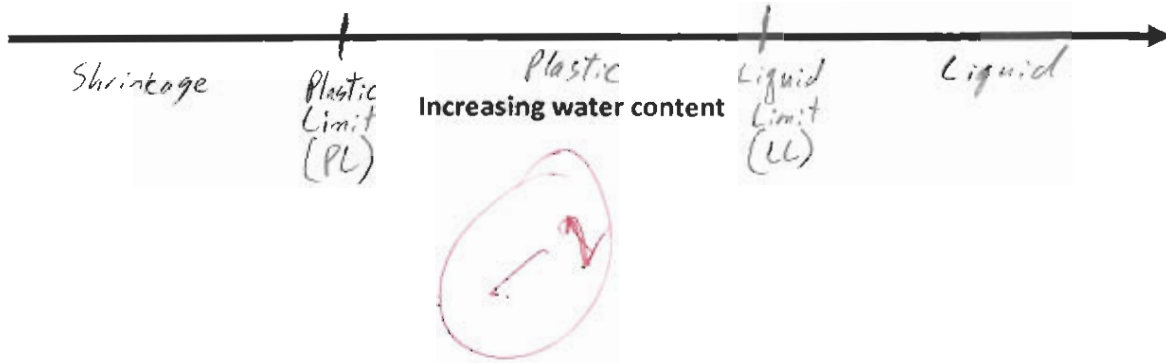
$e = 0.5267 = 52.67\%$

$n = \frac{e}{1+e} = 0.345 = 34.5\%$

$\frac{0.1247}{S} = 0.52667$
 $S = 0.6345$

Q 3. A soil mass behaves differently as the water content of the soil changes. These are collectively called Atterberg Limits. Mark the various states of the soil and write the names of limits on the sketch shown below.

(5 points)

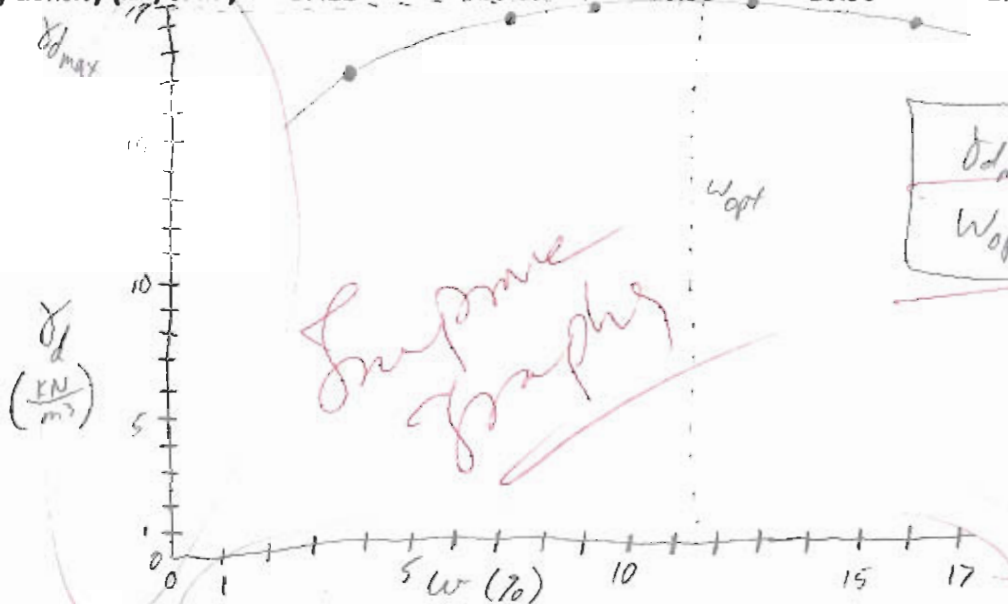


Q 4. The results of a standard compaction test are given below. Draw the compaction curve to a suitable scale and determine the maximum dry density and optimum moisture content. If in the field a dry density of 16.5 kN per cubic meter was obtained, what is the relative compaction?

0.0009433 m^3 (10 points)

Test no.	1	2	3	4	5
Water content (%)	4.5	7.5	10.1	12.9	16.4
Dry density (kN/cu.m)	17.22	18.27	18.90	18.96	17.94

$$\gamma_d = \frac{\gamma}{1+w} = \frac{w \gamma_w}{V(1+w)}$$



$$R_c = \frac{\gamma_{d, \text{field}}}{\gamma_{d, \text{max-lab}}} \times 100\% = \frac{16.5 \text{ kN/m}^3}{19 \text{ kN/m}^3} (100\%) = 86.8\%$$

SHOW ALL COMPUTATIONS

NAME: Donald Jerolleman

Q 1. A saturated soil has a moisture content of 38 percent and the specific gravity of the soil solids is 2.73. Compute the void ratio, porosity, moist density and dry density of this soil.

$w = 38\% = \frac{W_w}{W_s}$ $SG = 2.73$

$\gamma_w = 62.4 \frac{lb}{ft^3}$

$\gamma_{water} = 1000 \frac{kg}{m^3}$ $\gamma_{soil} = 2730 \frac{kg}{m^3}$

00
10

$S_e = w G_s$

$e = \frac{V_v}{V_s}$ b/c saturated = $\frac{V_w}{V_s}$

$n = \frac{V_v}{V}$ b/c saturated = $\frac{V_w}{V}$

$\gamma = \frac{W}{V}$
 $\gamma_d = \frac{W_s}{V}$
 $= \frac{G_s \gamma_w}{1+e}$

$e = \frac{V_v}{V_s} = \frac{G_s \gamma_w}{\gamma_d} - 1$

$w = \frac{W_w}{W_s}$

$\gamma_w = \frac{W_w}{V} = 1037.4 \frac{kg}{m^3}$

$\gamma_d = \frac{W_s}{V} = 1692.6 \frac{kg}{m^3}$

$S = \frac{V_w}{V_v} = 100\%$

$2730 \frac{kg}{m^3} (0.38) = 1037.4 \frac{kg}{m^3}$ water

$\gamma_{sample} - \gamma_w = \gamma_d = 1692.6 \frac{kg}{m^3}$

$G_s = 2.73$
 $w = 0.38$

$S = 1$

$e = \frac{1.037}{1 - 1.037} = 1.037$

$n = \frac{1.037}{1 + 1.037} = \frac{e}{1+e} = 0.501 = 51\%$

$\gamma = \gamma_{moist} = \frac{(G_s + S e) \gamma_w}{1+e} = 115.4 \frac{lb}{ft^3}$

$w = \frac{S e}{G_s} \Rightarrow e = \frac{w G_s}{S}$

$\gamma_d = \frac{G_s \gamma_w}{1+e} = 83.6$

$= \frac{\gamma}{1+w} = 83.6$

$n = \frac{e}{1+e} = 51\%$

$\gamma_{wet} = \frac{(G_s + S e) \gamma_w}{1+e}$

$\gamma_d = \frac{\gamma_{wet}}{1+w}$

All structures rest on soil.
If not they fly, float or fall down

GEO JAN 12 SID ①

Soil \rightarrow Particles, Water, air (relationship = phases)
(multi-phase material) \rightarrow soil is a particulate material [phase-relations] (chap. 3)

Voids (pore space): space between particles

Hydraulic Conductivity: prop. where fluid flows through voids (permeability)
(chap 7, 8)

Soil Mechanics
Dynamics / statics — Deformation problems: Settlement
strength problems: slope stability: Bearing capacity
Vibration problems

- soil is a construction or foundation material

Soil Investigation: test samples

Geo technical engineering includes rock & other environmental problems

soil: Gravel } Particle (grain)
sand } size
silt }
clay }

Gravel > 4.75 mm, sand $4.75 - 0.075$ mm, silt & clay < 0.075 mm
based on unified soil classification system

Mechanical analysis (to find size) — Sieve (for particles > 0.075 mm)
Hydrometer (for < 0.075 mm)

HYDRO. 510
Proj. Man. Jan 13 ①

$$L_{acre} = 43560 \text{ ft}^2 \quad ?$$



Rational method

$$Q = C I A$$

(cfs) A I L_{acre}
 ↑ ↑
 demand intensity (in/hr)

$$1 \text{ ac. in/hr} \approx 1.003 \text{ cfs}$$

Coriolis effect



Donald Jerolleman ENCE 3340 Jan 20 ①

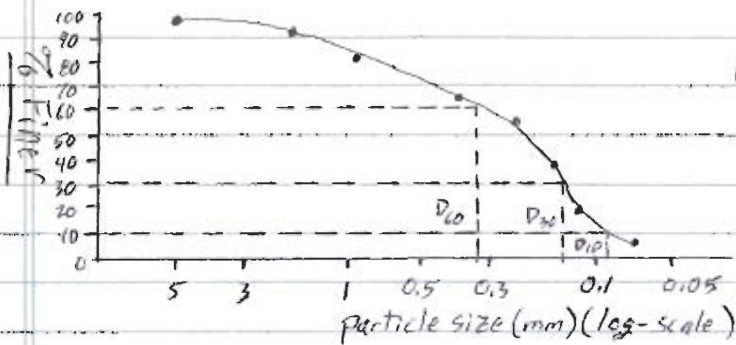
2.3) For Soil $D_{10} = 0.18 \text{ mm}$, $D_{30} = 0.32 \text{ mm}$, & $D_{60} = 0.78 \text{ mm}$. Find the $[C_u]$ uniformity coefficient & the coefficient of gradation, $[C_c]$

$$C_u = \frac{D_{60}}{D_{10}} = \frac{0.78 \text{ mm}}{0.18 \text{ mm}} = \boxed{4.33} \quad C_c = \frac{D_{30}^2}{D_{60}(D_{10})} = \frac{0.32^2}{0.78(0.18)} = \boxed{0.729}$$

2.5)

US sieve #	mass soil retained (g)	Cumulative mass retained above (g)	% finer (%)
4	0	0	100
10	44	44	92
20	56	100	81.9
40	82	182	67
60	51	233	57.7
80	106	339	38.5
100	92	431	21.8
200	85	516	6.4
PAN	35	551 = EM	0

$$\% \text{ finer} = \frac{EM - \text{col } 2}{EM} \times 100$$



$$D_{60} \approx 0.35 \text{ mm} \quad D_{30} \approx 0.165 \text{ mm}$$

$$D_{10} \approx 0.087 \text{ mm}$$

$$C_u = \frac{D_{60}}{D_{10}} = 4.02$$

$$C_c = \frac{D_{30}^2}{D_{60}(D_{10})} = 0.894$$

TDNGUYE 3@4NO

Sieve analysis - Different than Book Total wt = 729 g

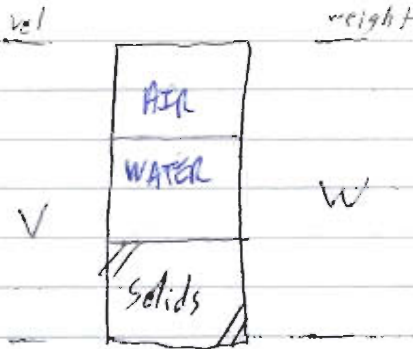
Sieve #	wt. soil retained	% retained	U_{lim} % retained (R_n)	% Finer ($100 - R_n$)
4	0	0	0	100
10	40	5.49	5.49	94.51
20	60	8.23	13.72	86.3
40	89	12.2	25.9	74.1
60	140	19.2	45.1	54.9

Poorly graded = Uniformly graded

only D_{10} is called "Effective Size" not D_{60}, D_{30}, D_{50} ... etc

D_{50} = "Average particle size"

C_c also called Coefficient of Curvature



LAB

LAB Sieve analysis

- Find particle size in sample & draw distribution curve & computational table

Equipment: Mechanical sieve shaker

set of ASTM sieves

10, 20, 40, 60, 100, 200

Electronical balance

china dish

shaking time 4-5 min

122.86 china plate

wt of sample = 703 g

sieve #	wt retained (g)
10	341.34 - 122.81
20	185.03 - 122.81
40	161.69 - 122.81
60	163.46 - "
100	229.98 - "
200	283.92 - "
PAN	192.60 - "
Σ 698.4 ?	

CE 510 1-25-20 (1)

Ex. wet wt. = 62 lb, Dry wt = 50 lb $\gamma_{soil} = 0.56 \text{ ft}^3$
 $S_c = 2.64$

Find water content, moist unit wt, dry density, void ratio, porosity, ^{Degree of Saturation}

$$w (\text{water content}) = \frac{w_w}{w_s} = \frac{12}{50} = 0.24 = \boxed{24\%}$$

$$\gamma_{moist} = \frac{w}{V} = \frac{62}{0.56} = \boxed{110.7 \text{ pcf} \left[\frac{\text{lb}}{\text{ft}^3} \right]}$$

$$\gamma_{dry} = \frac{w_s}{V} = \frac{50}{0.56} = \boxed{89.3 \text{ pcf}}$$

$$e (\text{void ratio}) = \frac{V_v}{V_s} = \frac{V - V_s}{V_s} \xrightarrow{\text{use}} = \frac{0.56 - 0.304}{0.304} = \boxed{0.84}$$

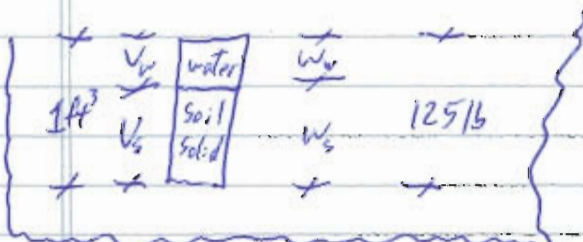
$$G_s = \frac{\gamma_s}{\gamma_w} = \frac{w_s}{V_s \cdot \gamma_w} \rightarrow V_s = \frac{50}{2.64(62.4)} = 0.304 \text{ ft}^3$$

$$n = \frac{V_v}{V} = \frac{0.56 - 0.304}{0.56} = 0.457 = \boxed{45.7\%}$$

$$S = \frac{V_w}{V_v} = \frac{0.192 \text{ ft}^3}{0.256} = 0.75 = 75\%$$

$$\text{use } \gamma_w = \frac{w_w}{V_w} \rightarrow V_w = \frac{12}{62.4} = 0.192 \text{ ft}^3$$

Ex a saturated soil w/ unit wt. = 125 pcf, water content = 25%,
 Find void ratio e & S_c



$$w = \frac{w_w}{w_s} = 0.25 \rightarrow w_w = 0.25 w_s$$

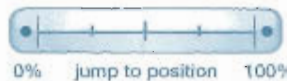
$$\text{Tot. wt} = w_w + w_s = 0.25 w_s + w_s = 125$$

$$\rightarrow w_s = 100 \text{ lb} \quad \text{ii} \quad w_w = 25 \text{ lb}$$

$$\text{b/c sat. } V_v = V_w \quad \therefore \gamma_w = \frac{w_w}{V_w} \rightarrow V_w = \frac{25}{62.4} = 0.4 \text{ ft}^3 = V_v$$

$$V_s = V - V_w = 1 - 0.4 = 0.6 \text{ ft}^3 \quad e = \frac{V_v}{V_s} = \frac{0.4}{0.6} = \boxed{0.67}$$

$$G_s = \frac{w_s}{V_s \cdot \gamma_w} = \frac{100}{0.6(62.4)} = \boxed{2.67}$$



② GEO 1-25 510

Ex. (e) Void ratio = 0.78, $S_g = 2.68$, (w) water content = 12%
 Find: Porosity (n) , Deg. of Saturation (S) , moist density (γ_{moist}) , dry density (γ_{dry})

$$n = \frac{e}{1+e} = \frac{0.78}{1+0.78} = 0.438 = \boxed{43.8\%}$$

$$w = \frac{S e}{G_s} \rightarrow S = \frac{w G_s}{e} = \frac{0.12(2.68)}{0.78} = 0.412 = \boxed{41\%}$$

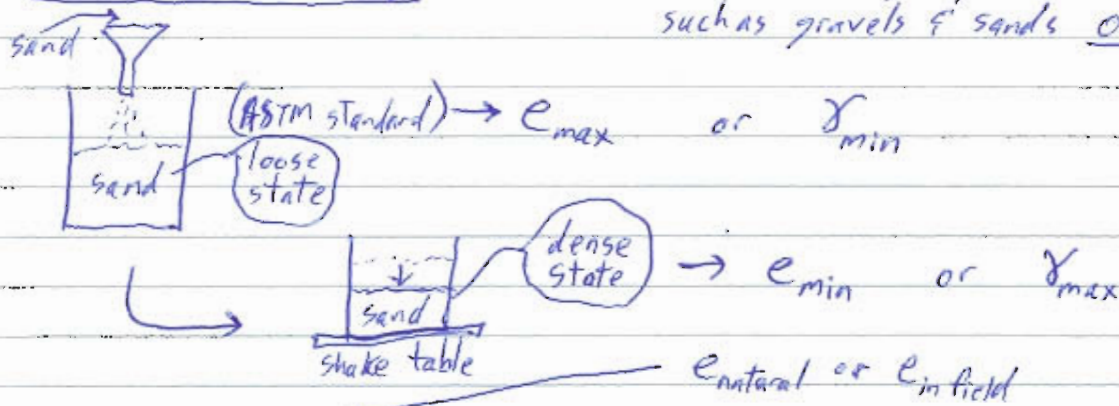
$$\gamma_{moist} = \frac{(G_s + S e) \gamma_w}{1+e} = \boxed{105.2 \text{ pcf}}$$

$$\gamma_{dry} = \frac{G_s \gamma_w}{1+e} = \boxed{94 \text{ pcf}}$$

(OR)

$$\gamma_{dry} = \frac{\gamma_{moist}}{(1+w)} = 94 \text{ pcf}$$

★ Relative Density (D_r) For Coarse-grained soils such as gravels & sands only



$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

P.66 Ex 3.5
 D.iff. method
 $\gamma_{moist} = 112 \text{ pcf}$, $S_g = 2.68$, $w = 12\%$, $e_{max} = 0.75$, $e_{min} = 0.4$

Find D_r

$$w = \frac{S e}{G_s} \rightarrow S(e) = 0.32, \gamma_{moist} = \frac{(G_s + S(e)) \gamma_w}{1+e} \rightarrow e = 0.67$$

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}} = 0.23 = \boxed{23\%}$$

Gen Feb 3 ① SID

Compaction of Soil

$$\text{wet or moist } \gamma_w \text{ density} = \frac{W_{ms} - W_m}{\frac{1}{30} \text{ ft}^3} \quad \left(\frac{\text{lb}}{\text{ft}^3} \right)$$

$$\text{dry densit} = \frac{\text{wet density}}{1 + w}$$

Density = $\frac{W}{V}$ if density increases, permeability decreases, compressibility increases to some extent, strength increases to some extent

One important way to \uparrow Density = compaction; densification due to removal of air by mechanical methods (static compaction)

- Standard Compaction Test (Proctor's S.C.T.)

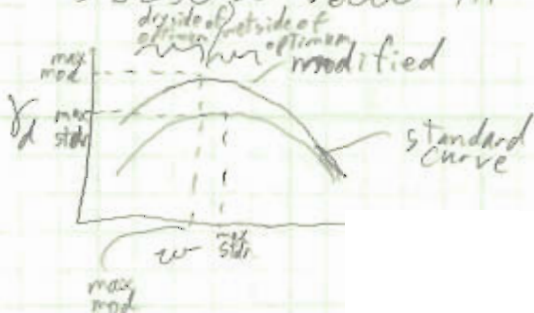
- mold: $V = \frac{1}{30} \text{ ft}^3$, S.C. hammer (5.5 lb) Fall = 12", empty mold = 1 lb (W_m)
 soil + H₂O $\frac{1}{3}$ depth mold, 25 blows, next $\frac{1}{3}$ added, 25 blows, collar @ top, add last $\frac{1}{3}$, 25 blows
 \therefore 3 layers of 25 blows ea, $W_m + W_{\text{soil}} = W_{ms}$, $W_{\text{wet soil}} = W_{ms} - W_m$, take sample & find water content

- Modified Compaction Test

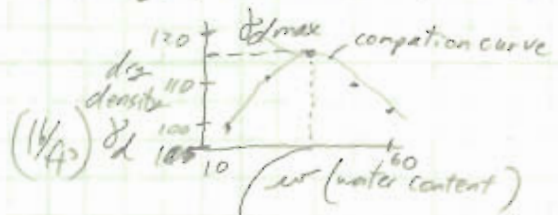
- mold Vol = $\frac{1}{30} \text{ ft}^3$
- hammer = 10 lb
- height = 18 in
- # of layers = 5 w/ 25 blows/layer

$$\text{energy} = \frac{10 \text{ lb} (1.5 \text{ ft}) (5 \text{ layers}) (25 \text{ blows/layer})}{\frac{1}{30} \text{ ft}^3}$$

$$= 56250 \approx 56000 \frac{\text{ft} \cdot \text{lb}}{\text{ft}^3}$$



To find MAX γ_d do test more times adding more water (5-6 times)



Compaction energy delivered is

$$\frac{5.5 \text{ lb} (1 \text{ ft}) (3 \text{ layers}) (25 \text{ blows/layer})}{\frac{1}{30} \text{ ft}^3}$$

$$= 12400 \frac{\text{ft} \cdot \text{lb}}{\text{ft}^3}$$

7.10) ^{mass = sand} $e_1 = 0.5$ $K_1 = 0.022 \text{ cm/s}$; if $e_2 = 0.7$ then $K_2 = ?$ 10

Solution

$$k \propto \frac{e^3}{1+e} \rightarrow \frac{K_1}{K_2} = \frac{\frac{e_1^3}{1+e_1}}{\frac{e_2^3}{1+e_2}} \rightarrow \frac{0.022}{K_2} = \frac{\frac{0.5^3}{1.5}}{\frac{0.7^3}{1.7}}$$

$$\rightarrow K_2 = \frac{0.022 \text{ cm/s}}{0.08333} (0.20176) = \boxed{0.0533 \frac{\text{cm}}{\text{s}}}$$

7.15) see table p. 186 if $e_3 = 0.9$ $K_3 = ?$ ^{mass = compacted clay}

Solution

$$K = C \left(\frac{e^n}{1+e} \right) \rightarrow \frac{K_1}{K_2} = \frac{\frac{e_1^n}{1+e_1}}{\frac{e_2^n}{1+e_2}} = \frac{\frac{0.8^n}{1.8}}{\frac{1.4^n}{2.4}} = \frac{12 \times 10^{-6}}{3.6 \times 10^{-6}} = 0.3333$$

$$= \left(\frac{0.8}{1.4} \right)^n \left(\frac{2.4}{1.8} \right) \rightarrow (0.5714)^n = 0.25 \rightarrow n = \frac{\log(0.25)}{\log(0.5714)} = \underline{2.477}$$

$$\therefore K = C \left(\frac{e^{2.477}}{1+e} \right) \rightarrow 1.2 \times 10^{-6} = C \left(\frac{0.8^{2.477}}{1.8} \right) \rightarrow C = 0.000003754 = \underline{3.754 \times 10^{-6}}$$

$$\therefore K_3 = 3.754 \times 10^{-6} \frac{\text{cm}}{\text{s}} \left(\frac{0.9^{2.477}}{1.9} \right)$$

$$= 0.000001522 = \boxed{1.522 \times 10^{-6} \frac{\text{cm}}{\text{s}}}$$

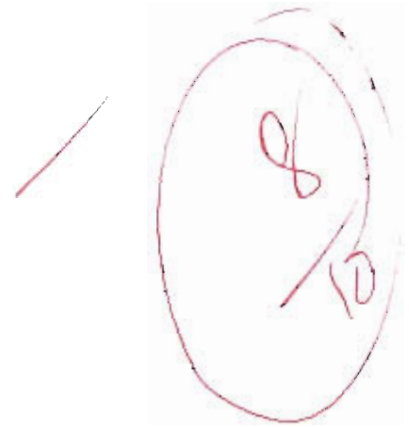
Chad Shaw
Soil Mechanics Lab
1/27/2010

Objective:

Determine particle sizes and draw particle distribution curve.

Equipment:

- Mechanical sieve shaker
- Set of sieves (#'s 10, 20, 40, 60, 100, 200)
- Electrical Balance
- China Dish



Procedure:

Place the entire soil sample into the sieve and lock sieves into the mechanical shaker. Shake the soil sample vigorously and weigh the soil which is retained on each sieve. From this information the particle sizes can be determined which allows us to draw the particle distribution curve.

Data:

Sieve #	Total Wt (g)	Net Wt (g)	Opening (mm)
10	341.34	218.53	2
20	185.03	62.22	0.85
40	161.69	38.88	0.425
60	163.46	40.65	0.25
100	229.98	107.17	0.15
200	283.92	161.11	0.075
Past	192.6	69.79	...

**** Weighing dish weight is 122.81 g ****

$$\frac{\sum M - \text{Mass retained}}{\sum M_{\text{total}}} = \% \text{ finer}$$

$$\sum M = 699 \text{ g}$$

$$100 \left(\frac{699 - 218.5}{699} \right) = 68.7\%$$

$$100 \left(\frac{699 - 280.75}{699} \right) = 59.8\%$$

$$100 \left(\frac{699 - 319.63}{699} \right) = 54.3\%$$

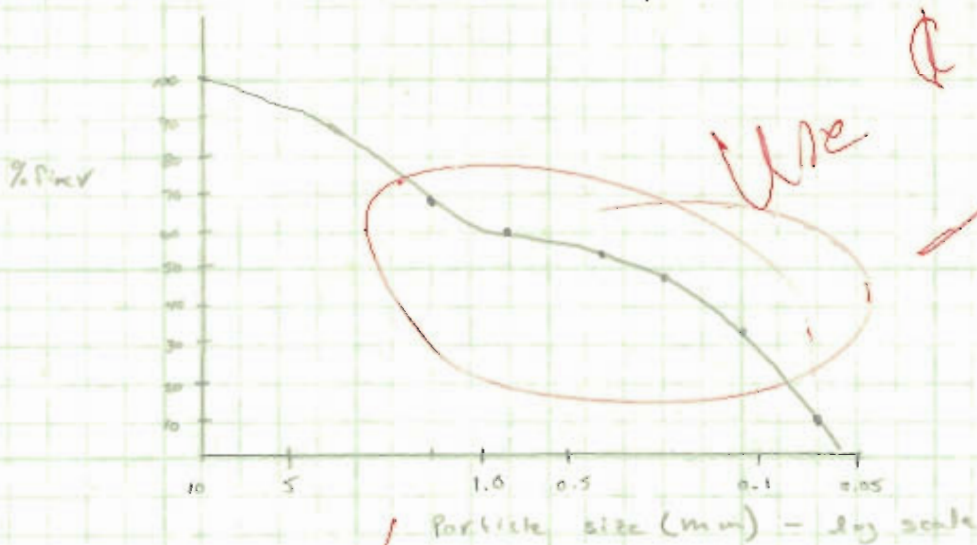
$$100 \left(\frac{699 - 360.28}{699} \right) = 48.5\%$$

$$100 \left(\frac{699 - 467.45}{699} \right) = 33.1\%$$

$$100 \left(\frac{699 - 628.56}{699} \right) = 10.0\%$$

Sieve #	Cum Mass	% Finer
10	218.53	68.7%
20	280.75	59.8%
40	319.63	54.3%
60	360.28	48.5%
100	467.45	33.1%
200	628.56	10.0%
pan	699	

Use type of computer use a semi-log sheet



Hydrometer Analysis
Soil Mechanics Laboratory
Chad Shaw

Procedure

Note: This procedure is used when more than 90 per cent of the soil is finer than No. 200 sieve.

1. Take 50 g of oven-dry, well-pulverized soil in a beaker.
2. Prepare a deflocculating agent. Usually a 4% solution of sodium hexametaphosphate (Calgon) is used. This can be prepared by adding 40 g of Calgon in 1000 cc of distilled water and mixing it thoroughly.
3. Take 125 cc of the mixture prepared in Step 2 and add it to the soil taken in Step 1. This should be allowed to soak for about 8 to 12 hours.
4. Take a 1000-cc graduated cylinder and add 875 cc of distilled water *plus* 125 cc of deflocculating agent in it. Mix the solution well.
5. Put the cylinder (from Step 4) in a constant temperature bath. Record the temperature of the bath, T (in $^{\circ}\text{C}$).
6. Put the hydrometer in the cylinder (Step 5). Record the reading. (*Note:* The *top of the meniscus* should be read.) This is the zero correction (F_z), which can be +ve or -ve. Also observe the meniscus correction (F_m).
7. Using a spatula, thoroughly mix the soil prepared in Step 3. Pour it into the mixer cup.

Note: During this process, some soil may stick to the side of the beaker. Using the plastic squeeze bottle filled with distilled water, wash all the remaining soil in the beaker into the mixer cup.

8. Add distilled water to the cup to make it about two-thirds full. Mix it for about two minutes using the mixer.
9. Pour the mix into the second graduated 1000-cc cylinder. Make sure that all of the soil solids are washed out of the mixer cup. Fill the graduated cylinder with distilled water to bring the water level up to the 1000-cc mark.
10. Secure a No. 12 rubber stopper on the top of the cylinder (Step 9). Mix the soil-water well by turning the soil cylinder upside down several times.
11. Put the cylinder into the constant temperature bath next to the cylinder described in Step 5. Record the time immediately. This is cumulative time $t = 0$. Insert the hydrometer into the cylinder containing the soil-water suspension.
12. Take hydrometer readings at cumulative times $t = 0.25$ min., 0.5 min., 1 min., and 2 min. Always read the upper level of the meniscus.
13. Take the hydrometer out after two minutes and put it into the cylinder next to it (Step 5).
14. Hydrometer readings are to be taken at time $t = 4$ min., 8 min., 15 min., 30 min., 1 hr., 2 hr., 4 hr., 8 hr., 24 hr. and 48 hr. For each reading, insert the hydrometer into the cylinder containing the soil-water suspension about 30 seconds before the reading is due. After the reading is taken, remove the hydrometer and put it back into the cylinder next to it (Step 5).



Objective:

Determine the particle size distribution in a fine grained soil using Hydrometer analysis.

Equipment:

ASTM 152-H hydrometer, Mixer, Two 1000-cc graduated cylinders, Deflocculating agent, Spatula, Beaker, Balance, Plastic squeeze bottle, Distilled water, & No.12 rubber stopper.

Procedure:

The procedure for this experiment is attached and shows the process accordingly

Calculations:

$$R(cp) = R + F(t) - F(z)$$

$$\%finer = (a \cdot R(cp) / W(s)) \cdot 100$$

$$R(cl) = R + F(m)$$

$$D = A \cdot (L/t)^{0.5}$$

Data:


S.G. = 2.70 so, A = 0.059 a = 0.99

Temp = 19.44° C

Time (m)	hydrometer	R(cp)	Percent Finer	R(cl)	L (cm)	A	D (MM)
0.25	35	30.14	60.28	36	10.6	0.059	0.38418
1	37	32.14	64.28	38	10.2	0.059	0.188431
2	35	30.14	60.28	36	10.6	0.059	0.135828
4	28	23.14	46.28	29	11.7	0.059	0.100906
8	24	19.14	38.28	25	12.4	0.059	0.073454
15	20	15.14	30.28	21	13	0.059	0.054926
30	16	11.14	22.28	17	13.7	0.059	0.03987
45	14	9.14	18.28	15	14	0.059	0.032909
60	13	8.14	16.28	14	14.2	0.059	0.028703
180	12	7.14	14.28	13	14.3	0.059	0.01663
1290	10	5.14	10.28	11	14.7	0.059	0.006298
1320	10	5.14	10.28	11	14.7	0.059	0.006226
1460	9.5	4.64	9.28	10.5	14.75	0.059	0.00593

Conclusion:

Ultimately, as the percent finer becomes smaller, the diameter of the particle size also becomes much smaller. This also correlates to a lesser hydrometer reading. As the hydrometer reading reduces, all other values in the calculations table reduces, except for the length column. The length column is the only set of values which increases as the hydrometer reading decreases.

A handwritten signature in red ink, possibly reading "S. M. S.", is written over a diagonal red line. The signature is cursive and somewhat stylized.

Chad Shaw

Liquid Limit and Plastic Limit

Objective: To determine Liquid Limit and Plastic Limit of the given soil sample

Equipment:

- Casagrande's Liquid Limit device
- Grooving Tool
- Moisture Content Cans
- Grounded Glass Plate
- Electronic Balance
- Oven
- Pair of Tongs
- Water Pitcher

Procedure: Take a given soil sample and apply water until soil is plyable and placed in Casagrande's LL device. A groove is then cut into the soil. The soil is then cranked and hammered until the cut in the soil has closed. The soil is then weighed and recorded while wet. It is then placed in a oven where it is fired at 110 c for 24 hours. After being fired the soil is again weighed and the weight of the dry soil is recorded

Data: See attached

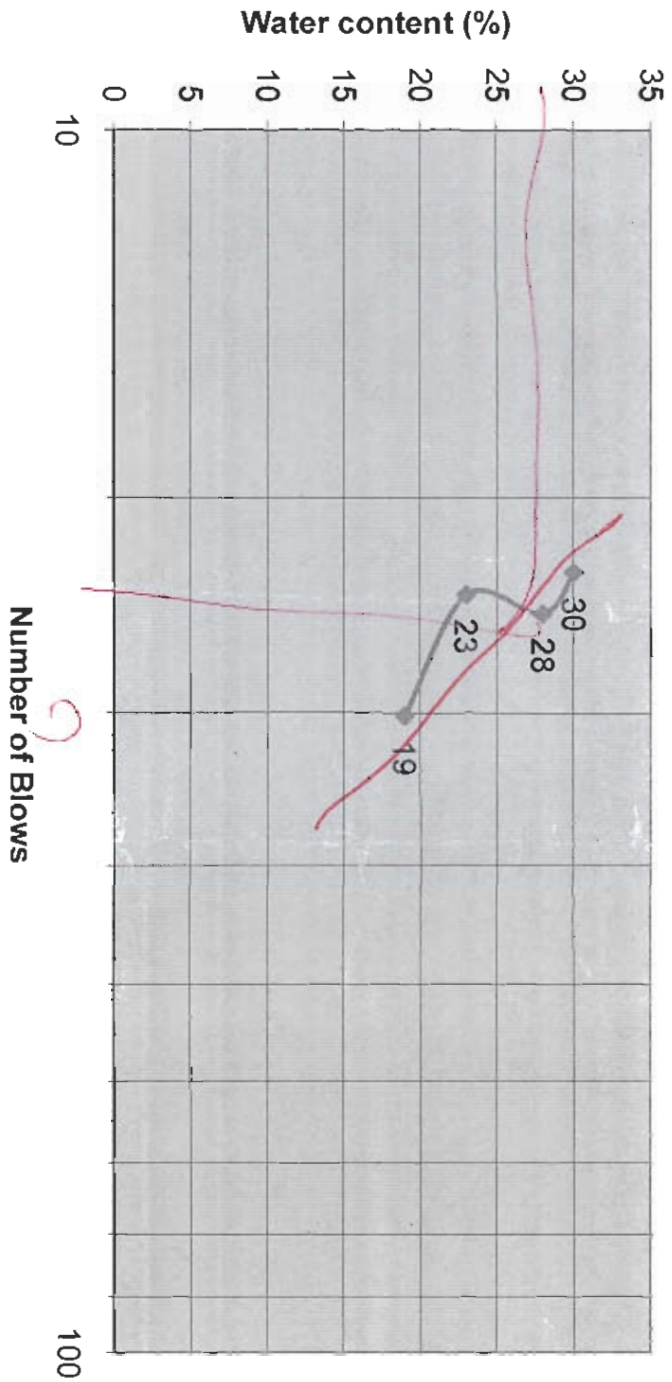
Calculations: See attached

Conclusion: This lab illustrates the correlation between Casagrande's hammer tool that shows how many blows it takes to close a set groove and the water content associated with that soil.

Show Sample Calculation

8
10

Number of Blows



◆ Number of Blows

Standard Proctor Compaction Test

Soil Mechanics Laboratory

March 2, 2010

Chad Shaw



Objective:

Develop a dry density-moisture content relationship. Plot dry density vs. water content and zero air void curve. Also find the max dry unit weight and optimum moisture content.

Equipment:

Standard proctor mold (volume= $1/30 \text{ ft}^3$) and standard rammer 5.5 lbs with 12 inch drop. Also, soil sample, spatula, moisture content cans, sample extractor, and oven (110° C)

Procedure:

- 1.) Coat sides of mold with a thin layer of vasaline to allow dirt to be easy removed.
- 2.) Take 1 lbs of soil and add water (quantity not known at first). Use chart to correlate LL and PL.
- 3.) Fill 1/3 of mold, put rammer in mold and ram 25 blows.
- 4.) Take spatula and scrap to create a good bond between layers, put another 1/3 soil and repeat steps, then put another 1/3 and attach collar, then repeat steps.
- 5.) Weigh mold and soil sample together then use sample extractor to remove soil.
- 6.) Take weight of the moisture sample and insert into oven to dry.
- 7.) Add 2% water and repeat all of the above steps, repeating adding 25 increments of water.

Data:

Assume specific gravity to be 2.7

Test	Wt. of Mold(lb)	Mold + moist soil(lb)	W2- W1(lb)	Moist unit weight (lb/ft ³)
1	10.35	14.19	3.84	115.2
2	10.35	14.41	4.06	121.8
6	10.35	14.53	4.18	125.4
4	10.35	14.63	4.28	128.4
5	10.35	14.51	4.16	124.8
6	10.35	14.47	4.12	123.6

Can #	W3 (g)	W4 (g)	W5 (g)	w(%)	unit wt. (lb/ft ³)
1	54	253	237	8.743169	105.9376884
2	53.3	354	326	10.26769	110.4584636
3	53.3	439	401	10.92896	113.0453202
4	54	490	441.5	12.51613	114.1169725
5	54.8	422.8	374.7	15.03595	108.4878261
6	40.8	243	211.1	18.73165	104.1002967

Max dry unit weight = 114.1 lb/ft³

See attached dry density vs. moisture content graph

Conclusion:

Ultimately, I was able to determine the optimum moisture content and maximum dry unit weight from the information provided. Maximum dry unit weight is 114.1 lb/ft³ and the optimum moisture content is 12.5%.

$\gamma_{dry} \left(\frac{20}{1.3} \right)$

γ_{MAX}
 $= 114.1$

115

110

105

100

2

4

6

8

10

12

14

16

18

20

$w(\%)$

OMC = 12.5%

