

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
CVEG 4100 GEOTECHNICAL ENGINEERING DESIGN LAB
Fall 2021**

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 - Average (Graded original work)**
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 - Average (Graded original work)**
 - Below Average (Graded original work)**

(Note: All Pages shown in Yellow should be printed on YELLOW PAPER)

**One or Two-Page Course Description
in ABET Format (Format provided below)**

I. COURSE DESCRIPTION IN ABET FORMAT

CIVIL ENGINEERING DEPARTMENT CVEG 4100 GEOTECHNICAL ENGINEERING DESIGN LAB

Course Designation	Required Course		
2020-21 Catalog Data	CVEG 4100. Geotechnical Engineering Lab. 1 Credit. Subsoil Exploration method and report, Borelog reading and interpretation, Design of Shallow foundation, Stress increase and distribution, Settlement analysis, Design of Deep foundation, Earth retaining structures design, Slope stability Analysis.		
Prerequisites	CVEG 3300		
Corequisite	N/A		
Textbook	1. Principles of Foundation Engineering, 9th Edition Braja M. Das and N. Sivakugan, Cengage Learning		
References	USACE and NAVFAC Manuals		
Main Instructor	Assistant Professor Md Jobair Bin Alam, Civil Engineering		
Course Objectives	1. Understand the importance of subsoil exploration and analyze the soil behavior. 2. Be proficient in finding the precise soil data from soil exploration report. 3. Be proficient in applying the engineering judgement in designing foundation system. 4. Applying the knowledge of geotechnical engineering to determine the most suitable foundation system for structures. 5. Be proficient in basic analysis of earth structures design.		
Topics Covered	1. Sub-soil Exploration 2. Standard Penetration Test 3. Shallow Foundation Design 4. Settlement Calculation for Shallow Foundation 5. Potential Vertical Rise (PVR) 6. Mat Foundation 7. Deep Foundation 8. Lateral Earth Pressure and Slope Stability		
Class Schedule	Lecture: 1 three-hour session per week		
Contribution to Professional Component	Mathematics	0	Credits
	Engineering Science	1	Credits
	General Education Requirements	0	Credits
	Major design Experience	1	Credits
Program Objectives Covered by Course	Program objectives 7		
Program Outcomes Covered by Course	Program Outcomes 7		
Program Outcomes Measured by Course	1. Program outcomes 7 assessed in project report		

**Data Used in Assessing
Outcomes in Course**

1. Class Tests /Exams
2. Homework assignments
3. Project Reports

**Data Used to Show
Student Proficiency
in Outcomes**

1. Samples of student work in a Binder
2. Grade sheet showing student performance and class average in outcomes
3. End of Semester Course Assessment report

Prepared by:

Dr. Md Jobair Bin Alam

Date: December 10, 2021

II ASSESSMENT RESULTS FOR CURRENT AND PAST FOUR ASSESSMENT PERIODS

Program Outcomes Assessed in this course

Outcome 7: An ability to acquire and apply new knowledge as needed using appropriate learning strategies.

Assessment Summary of Class Semester Averages for Outcomes: Fall 2020-Spring 2021

Outcomes	7
Semester	Semester Class Average (%)
Fall 2021	*81
Comments on Data	The projects were given to them to solve real life problems using engineering calculations and judgement. Students gradually performed better. The project report was found below standard in some cases.

*Expected Semester Class Average = 75%

End of Semester Course Assessment Reports

Fall 2021

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class.
- The acceptable class average for the class in each outcome area as set by your department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's critical **evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend of assessment periods

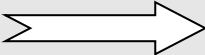
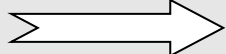
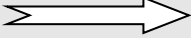
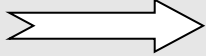
- Instructors' summary of overall performance trend for each outcome measured over the last three periods.

6. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO**.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CVGE 4100 GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021 SEMESTER

Report Prepared by: Dr. Md Jobair Bin Alam
Report Date: December 10, 2021

Semester	Analysis Type	Number of Students	Outcome 7 An ability to acquire and apply new knowledge as needed using appropriate learning strategies.			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2021	Direct	12	75	75	80	81
Implementation Summary	Items implemented from previous report or after meeting previous instructor		All the implementation summary for the sub-outcomes were implemented for this outcome.			
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 		Major problems were inability to produce a standard report. Students' technical ability to solve engineering problems by applying innovative idea improved.			
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 		Provide the students with sample professional technical engineering report to better present their technical work.			
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 		Students' performance was above the expected average.			
Were Expectations Met?			YES			

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Title of Assignment: 1

TOPICS COVERED IN ASSIGNMENT 1

Test 1 covered the following topics:

1. Subsoil Investigation
2. Shallow Foundation Design

**NOTE: Pages T1 through T7 should be repeated for each Test and
Similarly for all the other assignments in the course binder**

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

SAMPLE ASSIGNMENT QUESTIONS

Problem 1

A boring log is shown in Figure 1. Read the boring log thoroughly. Determine the standard penetration number from the boring log and show your results in a tabulated form. Describe the soil profile based on the SPT values.

TERRA Since 1977		BORING LOG PROJECT NO.: STR 2454S INVOICE NO.: 501512 PROJECT: New 417-Foot Tower - SARCO Site LOCATION: 16207 US 183 Goliad, Texas 77963 CLIENT: Uniti Towers CONTACT: Mr. John Felton						TEST HOLE: B-2 SHEET NUMBER: 1 of 1 DATE STARTED: 3/21/2019 DATE FINISHED: 3/21/2019 DRILLER: Leo K. LOGGER: Jason W. REVIEWED BY: Dr. Alam						
DRILL RIG: CME 75		TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:										
DRILLING METHOD: Hollow Stem Auger		TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS							
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	3/21/2019			Dry				
SYMBOL	None	S ☒	U ☒	T ☒	G ☒	C ☒								
FIELD RESULTS				LABORATORY RESULTS										
DEPTH (FEET)	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	ROD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0	1	1	3					17.2	48	14	34			
3	3	3	6				Clayey sand (SC), brown	14.0				42.8		
4	4	7	12					12.8	40	15	25			
6	6	7	12				Sandy lean clay with gravel (CL), light gray	10.4				53.3		
9	4	9	14					13.2	42	14	28			
15	5	9	9				Clayey sand (SC), tannish gray	12.0				46.0		
19	5	9	13					3.0						
20							Silty sand (SM), tannish gray							
							Bottom of Borehole at 20 feet							

Figure: 1

Problem 2

For a continuous foundation, the following are given:

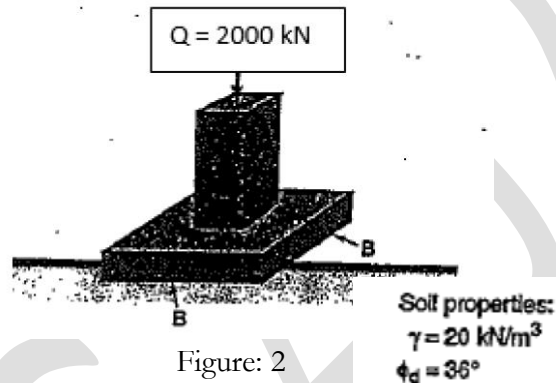
a. $B = 4 \text{ ft}$, $D_f = 3 \text{ ft}$, $\gamma = 110 \text{ lb/ft}^3$, $\phi' = 25^\circ$, $c' = 600 \text{ lb/ft}^2$

b. $B = 2 \text{ m}$, $D_f = 1 \text{ m}$, $\gamma = 17 \text{ kN/m}^3$, $\phi' = 30^\circ$, $c' = 0$

Use Terzaghi's equation and a factor of safety of 4 to determine the gross allowable vertical load-bearing capacity. Assume that general shear failure occurs in soil.

Problem 3

A square footing resting on a granular soil for a column to carry a loading of 2000 kN. Determine footing dimensions when bearing on granular soil having properties shown in Figure 2. Use Factor of Safety of 2.5 for calculation.

**Problem 4**

If the water table at a site for a strip footing in the following figure (Figure 3) is at a position

- 1.25 m below ground level
- 1.25 m below foundation base

What will be the net safe bearing pressure for both the cases? Given, unit weight of soil above water table is 17.5 kN/m^3 and saturated unit weight of the soil (below water table) is 18.5 kN/m^3 .

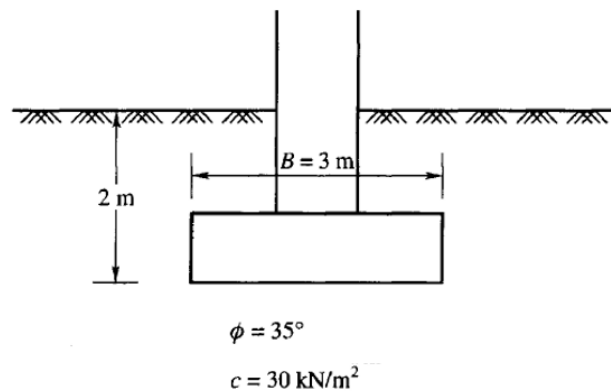


Figure: 3

ABOVE AVERAGE

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department

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CVEG 4100: Geotechnical Engineering Design

Section: P81

Course Number: 17736

Title: Homework # 1

Submitted By: Abram Auguste (Roster# 1)

Submitted To: Dr. Alam, Md Jobair Bin Ph.D., P.E.

Issue Date: September 7, 2021

Due Date: September 15, 2021 NLT 10:00 a.m.



Problem 1

A boring log is shown in Figure 1. Read the boring log thoroughly. Determine the standard penetration number from the boring log and show your results in a tabulated form. Describe the soil profile based on the SPT values.

BORING LOG														
		PROJECT NO.: STR 2454S INVOICE NO.: 501512 PROJECT: New 417-Foot Tower - SARCO Site LOCATION: 16207 US 183 Goliad, Texas 77963 CLIENT: Uniti Towers CONTACT: Mr. John Felton				TEST HOLE: B-2 SHEET NUMBER: 1 of 1 DATE STARTED: 3/21/2019 DATE FINISHED: 3/21/2019 DRILLER: Leo K. LOGGER: Jason W. REVIEWED BY: Dr. Alam								
		DRILL RIG: CME 75 DRILLING METHOD: Hollow Stem Auger TEST HOLE DIAMETER (in): 8 TOTAL DEPTH (ft): 20				GROUND WATER DATA: DATE: 3/21/2019 TIME: WATER DEPTH (ft): REMARKS: Dry								
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE								
SYMBOL	None	S ☒	U ☐	T ☒	G ☒	C ☐								
FIELD RESULTS							LABORATORY RESULTS							
DEPTH (FEET)	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	ROD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE #200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0	1	1	1	3										
3	3	3	3	6			Clayey sand (SC), brown	17.2	48	14	34			
5	4	7	12					14.0				42.8		
6	6	7	12				Sandy lean clay with gravel (CL), light gray	12.8	40	15	25			
10	4	9	14					10.4				53.3		
15	5	9	9				Clayey sand (SC), tannish gray	13.2	42	14	28			
20	5	9	13				Silty sand (SM), tannish gray	12.0				46.0		
20							Bottom of Borehole at 20 feet	3.0						

Figure: 1

Problem 2

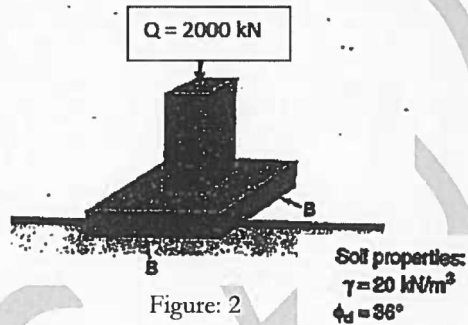
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- a. $B = 4 \text{ ft}$, $D_f = 3 \text{ ft}$, $\gamma = 110 \text{ lb/ft}^3$, $\phi' = 25^\circ$, $c' = 600 \text{ lb/ft}^2$
 b. $B = 2 \text{ m}$, $D_f = 1 \text{ m}$, $\gamma = 17 \text{ kN/m}^3$, $\phi' = 30^\circ$, $c' = 0$

Use Terzaghi's equation and a factor of safety of 4 to determine the gross allowable vertical load-bearing capacity. Assume that general shear failure occurs in soil.

Problem 3

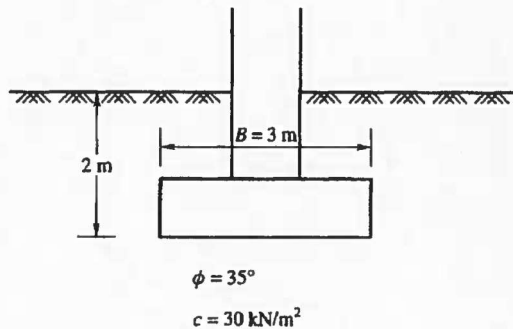
A square footing resting on a granular soil for a column to carry a loading of 2000 kN. Determine footing dimensions when bearing on granular soil having properties shown in Figure 2. Use Factor of Safety of 2.5 for calculation.

**Problem 4**

If the water table at a site for a strip footing in the following figure (Figure 3) is at a position

- a) 1.25 m below ground level
 b) 1.25 m below foundation base

What will be the net safe bearing pressure for both the cases? Given, unit weight of soil above water table is 17.5 kN/m^3 and saturated unit weight of the soil (below water table) is 18.5 kN/m^3 .



1

Depth (ft.)	N (SPN)	σ'	C_N	N_{60}	Soil
0	1+3=4	$115 \times 0 = 0$	—	—	Clayey sand
2.5	3+6=9	$115 \times 2.5 = 287.5$	2.64	23.74	clayey sand
4.5	7+12=19	$115 \times 4.5 = 517.5$	1.97	37.33	clayey sand
6.5	7+12=19	$= 747.5$	1.64	31.08	Sandy lean clay
8.5	9+14=23	$= 977.5$	1.43	32.90	sandy lean clay
13.5	9+19=28	$= 1552.5$	1.14	20.43	clayey sand
18.5	9+13=22	$= 2127.5$	0.97	21.33	clayey sand

loose state

loose state

Assume: $\sigma'_0 = \sigma' = \gamma \times h = (115 \times 20') = 2,300 \text{ psf}$

$\gamma_{\text{unit weight}} = 115 \text{ pcf}$

$$C_N = \sqrt{\frac{2,000}{\sigma'_0}}, \sigma' = \text{in psf unit}$$

$$N_{60} = N \times C_N$$

2

$$q_u = c' \times N_c + \gamma \times D_f \times N_q + \frac{1}{2} \times \gamma \times B \times N_\gamma$$

Using Terzaghi's Bearing Capacity Factors in Textbook we get for $\phi = 30^\circ$ (Table 15.1)

$$N_c = 30.14; N_q = 18.40; N_\gamma = 22.40$$

Substituting the given values

$$q_u = (0 \times 30.14) + (17 \times 1 \times 18.40) + \frac{1}{2} (17 \times 2 \times 22.40) = 0 + 382 + 325.2 = 689.18 \text{ kN/m}^2$$

Next,

$$q_{all} = \frac{q_u}{F.S.} = \frac{689.18}{4} = 172.295 \text{ kN/m}^2$$

Therefore, the allowable load bearing capacity of a continuous footing is 172.3 kN/m^2

Using Terzaghi's Bearing Capacity Factors in Textbook we get for $\phi' = 25^\circ$

$$N_c = 20.71; N_q = 10.7; N_\gamma = 10.89$$

Substituting the given values

$$q_u = (600 \times 20.71) + (110 \times 3 \times 10.66) + \frac{1}{2} (4 \times 110 \times 10.88) = 18,356.6 \text{ lb/ft}^2$$

$$\text{Next, Net ultimate bearing capacity } (q_{nu}) = q_u - \gamma \times D_f = 18,356.6 - 330 \frac{\text{lb}}{\text{ft}^2} = 18,026.6 \frac{\text{lb}}{\text{ft}^2}$$

$$q_{all} = \frac{q_{nu}}{F.S.} = \frac{18,026.6}{4} = 4,506.65 \text{ lb/ft}^2$$

Therefore, the allowable load bearing capacity of a continuous footing is $4,506 \times 10^3 \text{ lb/ft}^2$

3

Given: Square footing $\rightarrow$ Area = $B \times B$
 $Q = 2,000 \text{ kN}$
 $\gamma = 20 \text{ kN/m}^3$
 $\phi_d = 36^\circ$
 $F.S. = 2.5$

Assume: $q_{all} = \frac{Q}{B^2} = \frac{2000}{B^2}$ — (1)

Solution: $q_u = 1.3 \times C' \times N_c + q \times N_q + 0.4 \times \gamma \times B \times N_\gamma$

for $\phi' = 36^\circ \rightarrow N_c = 50.15 ; N_q = 37.7 ; N_\gamma = 40.0 ; C' = 0$

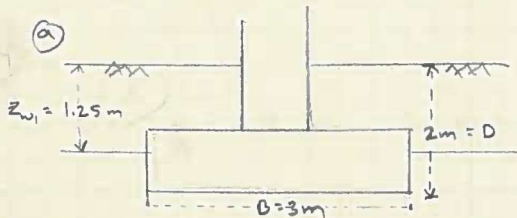
$\rightarrow q = \gamma \times D_f = 20 \text{ kN/m}^3 \times 0 = 0$

Therefore, $q_u = 0.4 \times 20 \text{ kN/m}^3 \times B \times 40.0 = 320 \times B$

Next, $q_{all} = \frac{q_u}{F.S.} = \frac{320 \times B}{2.5} = 128 \times B$ — (2)

By comparing (1) and (2) we get $\frac{2000}{B^2} = 128 \times B \rightarrow B = 2.5 \text{ m}$

4



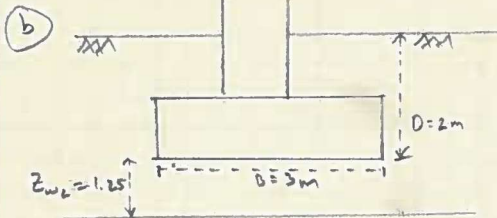
$\phi = 35^\circ$
 $C = 30 \text{ kN/m}^2$
 $\gamma_{sat} = 18.5 \text{ kN/m}^3$
 $\gamma_{w1} = 17.5 \text{ kN/m}^3$

Solution: $q_u = 1.3 \times C \times N_c + \gamma_a \times D \times N_q + 0.4 \times \gamma' \times B \times N_\gamma$

and $\gamma_a = \frac{(z_{w1} \times \gamma) + (D - z_{w1}) \times \gamma'}{D} = \frac{(1.2 \times 17.5) + (2 - 1.25) \times (18.5 - 9.81)}{2} = 17.13 \frac{\text{kN}}{\text{m}^3}$

$\therefore q_u = (1.3 \times 30 \times 46.12) + (17.13 \times 2 \times 33.3) + (0.4 \times (18.5 - 9.81) \times 3 \times 48.03) = 3440.39 \text{ kPa}$

Safe Net allowable bearing capacity $\rightarrow \frac{q_u - \gamma_a \times D}{F.S.} \Rightarrow \frac{3440.39 - (17.13 \times 2)}{3} = 1135.38 \text{ kPa}$



$\phi = 35^\circ$
 $C = 30 \text{ kN/m}^2$
 $\gamma_{sat} = 18.5 \text{ kN/m}^3$
 $\gamma_{w1} = 17.5 \text{ kN/m}^3$

$\therefore q_u = 1.3 \times C \times N_c + \gamma \times D \times N_q + 0.4 \times \gamma_a \times B \times N_\gamma$

$\rightarrow \gamma_a = \frac{(z_{w2} \times \gamma) + (D - z_{w2}) \times \gamma'}{B} = \frac{(1.25 \times 17.5) + (3 - 1.25) \times (18.5 - 9.81)}{3} = 12.36 \frac{\text{kN}}{\text{m}^3}$

$\therefore q_u = (1.3 \times 30 \times 46.12) + (17.5 \times 2 \times 33.3) + (0.4 \times 12.36 \times 3 \times 48.03) = 3676.56 \text{ kPa}$

Net safe Net allowable bearing pressure $\rightarrow \frac{q_u - \gamma \times D}{F.S.} \Rightarrow \frac{3676.56 - (17.5 \times 2)}{3} = 1213.83 \text{ kPa}$

AVERAGE

Civil & Environmental Engineering Department
Prairie View A&M University

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CVEG 4100 – P81 Geotechnical Engineering Design

Fall 2021

Homework #1

Michael LeBlanc Jr.

Given On

September 8, 2021

Submitted On

September 15, 2021

To

Dr. J. Alam

1.)

Blows

Depth (ft)	N	σ	Description
0	4	0	Clayey sand
2.5	9	287.5	
4.5	19	518.5	
6.5	19	747.5	Sandy loam
8.5	23	972.5	
13.5	18	1552.5	Clayey sand
18.5	22	2127.5	

The STP (Standard penetration) is the sum of the number of blows use to penetrate the soil sample. Description is given above

5

2.)

$$FOS = 4ft$$

A. $B = 4ft$, $D_f = 3ft$, $\gamma = 110 lb/ft^3$, $\phi' = 25^\circ$, $c' = 600 lb/ft^2$

Bearing capacity factor for $\phi = 25^\circ$ Table 6.

$$N_c = 20.72, N_q = 10.66, N_\gamma = 10.88$$

$$q_{safe} = \frac{cN_c + \gamma D_f N_q + 0.5 B \gamma N_\gamma}{FOS} - \gamma D_f + \gamma D_f$$

$$= \frac{600(20.72) + 110(3)(10.66) + 0.5(4)(110)(10.88) + 110(3)}{4}$$

$$= 4833.35 lb/ft^2$$

Gross allowable load = $q_{safe} \cdot B$

$$= 4833.35 lb/ft^2 \cdot 4ft$$

$$= 19333.4 lb/ft$$

5

B. $B = 2m$, $D_f = 1m$, $\gamma = 17 kN/m^3$, $\phi = 30^\circ$, $c' = 0$ $FOS = 4$

Bearing capacity factor for $\phi = 30$

$$N_c = 30.72, N_q = 18.40, N_\gamma = 22.40$$

$$q_{safe} = \frac{0(30.72) + 17(1)(18.40) + 0.5(2)(17)(22.40) + 0(17)}{4}$$

$$= 186.15 N/m^2$$

Gross allowable load = $186.15 N/m^2 \cdot 2m$

$$= 372.3 N/m$$

2

3.) $Q_{safe} = 2000 \text{ kN}$, $FOS = 2.5$, $\phi = 36^\circ$, $c = 0$
 $\gamma = 20 \text{ kN/m}^3$

Factor for $\phi = 36^\circ$

Table G.2

$$N_c = 50.59, \quad N_q = 37.75, \quad N_\gamma = 56.31$$

$$\begin{aligned} q &= 1.3 c N_c + \gamma D_f (N_q - 1) + 0.4 \gamma B N_\gamma \\ &= 0 + 20 \cdot 0 \cdot (37.75 - 1) + 0.4 \gamma \cdot 20 \cdot 56.31 \\ &= 450.48 \gamma \text{ kN/m}^2 \end{aligned}$$

$$Q_{safe} = q_{safe} \cdot A = \left(\frac{450.48 \gamma}{2.5} + 20 \cdot 0 \right) \cdot B^2 = 2000$$

$$2000 = 180.192 \gamma B^3$$

$$B = \left(\frac{2000}{180.192 \gamma} \right)^{1/3}$$

$$= \boxed{2.231 \text{ m}}$$

4.)

A.)

$$FOS = 3$$

Table 6.2 for
Bearing Capacity factors
 $\phi = 35^\circ$

$$R_q^x = \frac{1}{2} \left(1 + \frac{z}{D_f} \right)$$

$$R_q^x = \frac{1}{2} \left(1 + \frac{1.25}{2} \right) = 0.8125$$

$$\gamma_{avg} = \frac{17.5 \cdot 1.25 + 18.5 \cdot (2 - 1.25)}{2} = 17.875 \text{ KN/m}^3$$

$$q_u = 30(46.12) + 0.8125 \cdot 17.875 \cdot 2 \cdot 33.30 + 0.5 \cdot 3 \cdot \frac{1}{2} \cdot 18.5 \cdot 48.03$$

$$q_u = 3017.28 \text{ KN/m}^2$$

$$R_q \cdot \gamma_{avg} \cdot D_f = 0.8125 \cdot 17.875 \cdot 2 = 29.047 \text{ KN/m}^3$$

$$\text{Net Bearing safe pressure} = \frac{3017.28 - 29.047}{3} = 996.08 \text{ KN/m}^2$$

B.)

$$R_q = \frac{1}{2} \left(1 + \frac{1.25}{3} \right) = 0.708$$

$$\gamma_{avg} = \frac{17.5 \cdot 1.25 + 18.5 \cdot (3 - 1.25)}{3} = 18.08 \text{ KN/m}^3$$

$$q_u = 30(46.12) + 35(33.30) + 0.5(3)(0.708 \cdot 18.08) \cdot 48.03$$

$$q_u = 3471.32 \text{ KN/m}^2$$

$$q_{ux} = \frac{3471.32 \text{ KN/m}^2 - 35 \text{ KN/m}^2}{3}$$

$$q = 1145.44 \text{ KN/m}^2$$

BELOW AVERAGE

Civil Engineering Department



70

CVEG 4100- Geotechnical Engineering Design

Homework #1

Shadaria Lynch

Date Given: 9/8/21

Date Due: 9/15/21

Problem 1

feet		blows	
S/m	Depth	S-P.T	Soil
1	0	4 ✓	Clayey sand
2	2.5	9 ✓	↓
3	5	19 ✓	↓
4	6.5	19 ✓	Sandy lean
5	8.5	23 ✓	↓
6	13.5	18 ✓	Clayey Sand
7	18.5	22 ✓	



Problem 2

Given: $B = 4 \text{ ft}$
 $D = 3 \text{ ft}$
 $q = 110 \text{ lb/ft}^3$
 $\phi = 25^\circ$
 $c' = 600 \text{ lb/ft}^2$

$$\begin{aligned} q_u &= cN_c + qN_q + 0.5 Y_B N_\gamma \\ &= 600 N_c + \sqrt{D} N_q + 0.5 \times 110 \times 4 \times N_\gamma \\ &= 600 \times 25.13 + 110 \times 2 \times 12.72 + 0.5 \times 110 \times 4 \times 8.34 \\ &= 19.7 \times 10^3 \text{ lb} \end{aligned}$$

$$q_{\text{allow}} = \frac{19.7 \times 10^3 \text{ lb}}{4} = 4.92 \times 10^3 \text{ lb}$$

$$\begin{aligned} q &= (\sqrt{D}) \\ D &= \frac{2}{3} \times D \\ &= \frac{2}{3} \times 3 = 2 \end{aligned}$$

Given: $B = 2$
 $D = 1$
 $q = 17 \text{ kN/m}$
 $\phi' = 30^\circ$
 $c' = 0$

$$\begin{aligned} q_u &= cN_c + qN_q + 0.5 Y_B N_\gamma \\ &= 0 + \sqrt{D} N_q + 0.5 \times \sqrt{B} \times N_\gamma \\ &= 17 \times 0.66 \times 22.456 + 0.5 \times 17 \times 2 \times 19.13 \\ q_u &= 577.26 \text{ kN} \end{aligned}$$

$$q_{\text{allow}} = \frac{577.26}{4} = 144.315 \text{ kN}$$

$$\begin{aligned} N_q &= 22.456 \\ N_\gamma &= 19.13 \\ D &= \frac{2}{3} \times 1 = 0.66 \end{aligned}$$

Problem 3

$$Q = 2000 \text{ kN} \quad \gamma = 20 \text{ kN/m}^3 \\ \phi = 36^\circ \quad F = 2.5, C = 0, D = 0 \text{ (resting on granular soil)}$$

$$q_a = \frac{1}{F} [1.3 C N_c + \gamma D N_q + 0.4 \gamma B N_\gamma]$$

$$F \text{ at } \phi = 36^\circ \quad N_c = 63.528 \quad \checkmark \\ N_q = 47.156 \\ N_\gamma = 54.36$$

$$q_a = \frac{1}{2.5} [0 + 20 \times 0 \times 47.156 + 0.4 \times 20 \times B \times 54.36] \quad \checkmark$$

$$\frac{2000}{B^2} = 174.952 B$$

$$B = 2.25 \text{ m} \quad \checkmark$$

Problem 4

$$\phi' = 35^\circ$$

$$c' = 30 \text{ kN/m}^2$$

$$a = e \left(\frac{3H}{4} - \phi'/2 \right) \tan \phi = e \left(\frac{3H}{4} - \frac{35^\circ \times H/180}{2} \right) \tan 35^\circ$$

$$a = 4.203$$

$$N_q = \frac{a^2}{2 \cos^2(45 + \phi'/2)} = \frac{4.203^2}{2 \cos^2(45 + 35/2)} = 41.426$$

$$N_\gamma = \frac{1}{2} \left(\frac{K_p}{\cos^2 \phi'} - 1 \right) \tan \phi$$

$$K_p = \frac{1 + \sin \phi'}{1 - \sin \phi'} = \frac{1 + \sin 35}{1 - \sin 35} = 3.69$$

$$N_\gamma = \frac{1}{2} \left(\frac{3.69}{\cos^2 35^\circ} - 1 \right) \tan 35 = 1.57$$

$$N_c = \cot \phi \left(\frac{a^2}{2 \cos^2(45 + \phi'/2)} - 1 \right) = 57.73$$

d) 1.25 m below ground level

$$B = 3 \text{ m}, D_f = 2 \text{ m}, c = 30 \text{ kN/m}^2$$

For strip footing ultimate bearing capacity (q_u)

$$q_u = c N_c + R_q \gamma_{\text{avg}} D_f N_q + 0.5 (B) \left(\frac{1}{2} \gamma_{\text{sat}} \right) N_\gamma \quad \text{--- (1)}$$

R_q^* → water table correction factor for soil above the footing level

$$R_q^* = \frac{1}{2} \left(1 + \frac{z}{D_f} \right) = \frac{1}{2} \left(1 + \frac{1.25}{2} \right) = 0.8125$$

$$\gamma_{\text{avg}} = \frac{\gamma \times z + \gamma_{\text{sat}} (D_f - z)}{D_f} = \frac{17.5 \times 1.25 + 18.5 (2 - 1.25)}{2} \quad B = 3 \text{ m}$$

$$\gamma_{\text{avg}} = 17.875 \text{ kN/m}^3$$

put values in eqn (1)

$$q_u = 30 \times 57.73 + 0.8125 \times 17.875 \times 2 \times 41.426 + 0.5 \times 3 \times \frac{1}{2} \times 18.5 \times 1.57$$

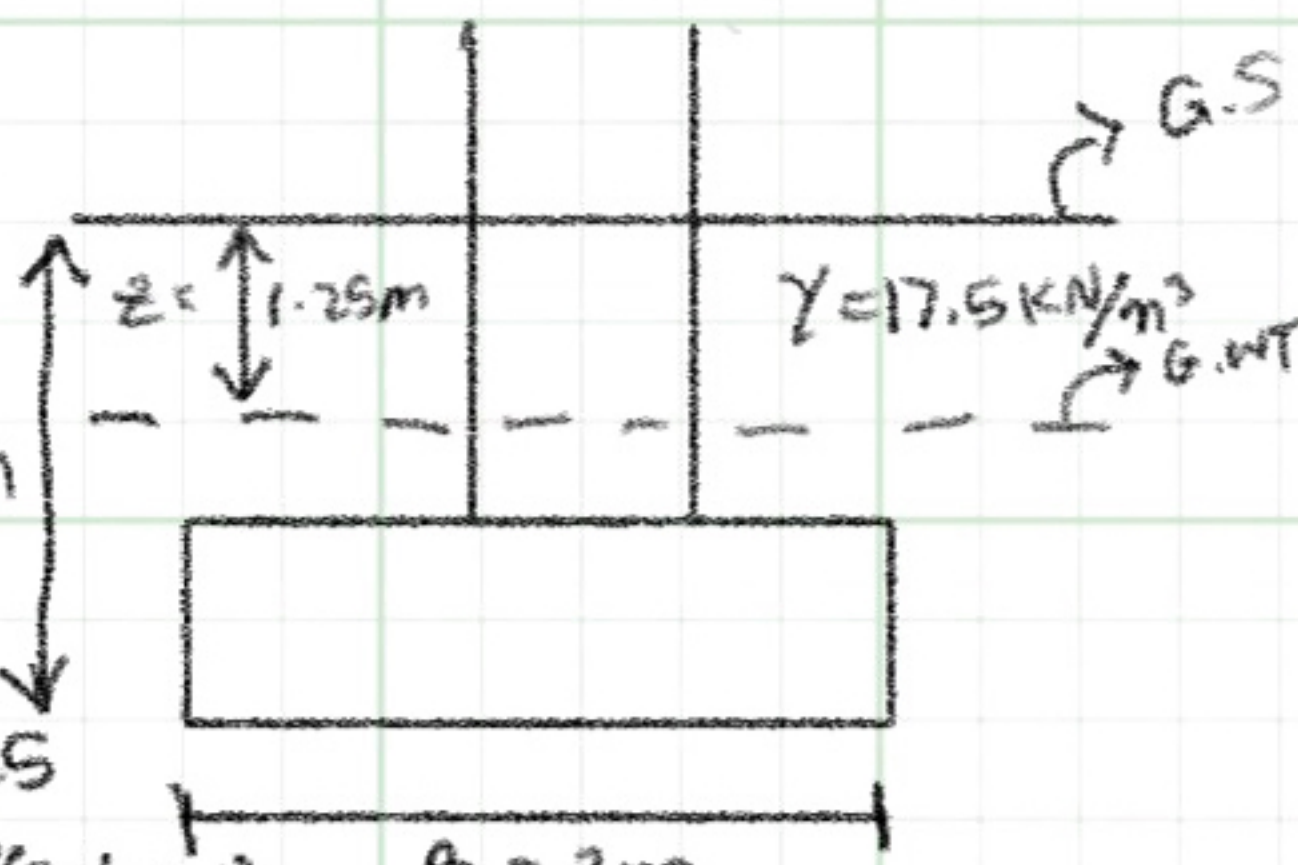
$$= 1731.9 + 1203.29 + 21.78 = 2956.97 \text{ kN/m}^2$$

Net safe bearing capacity (q_{ns}) / pressure

$$q_{ns} = \frac{q_{nu}}{F} = \frac{q_u - \bar{\sigma}}{F}$$

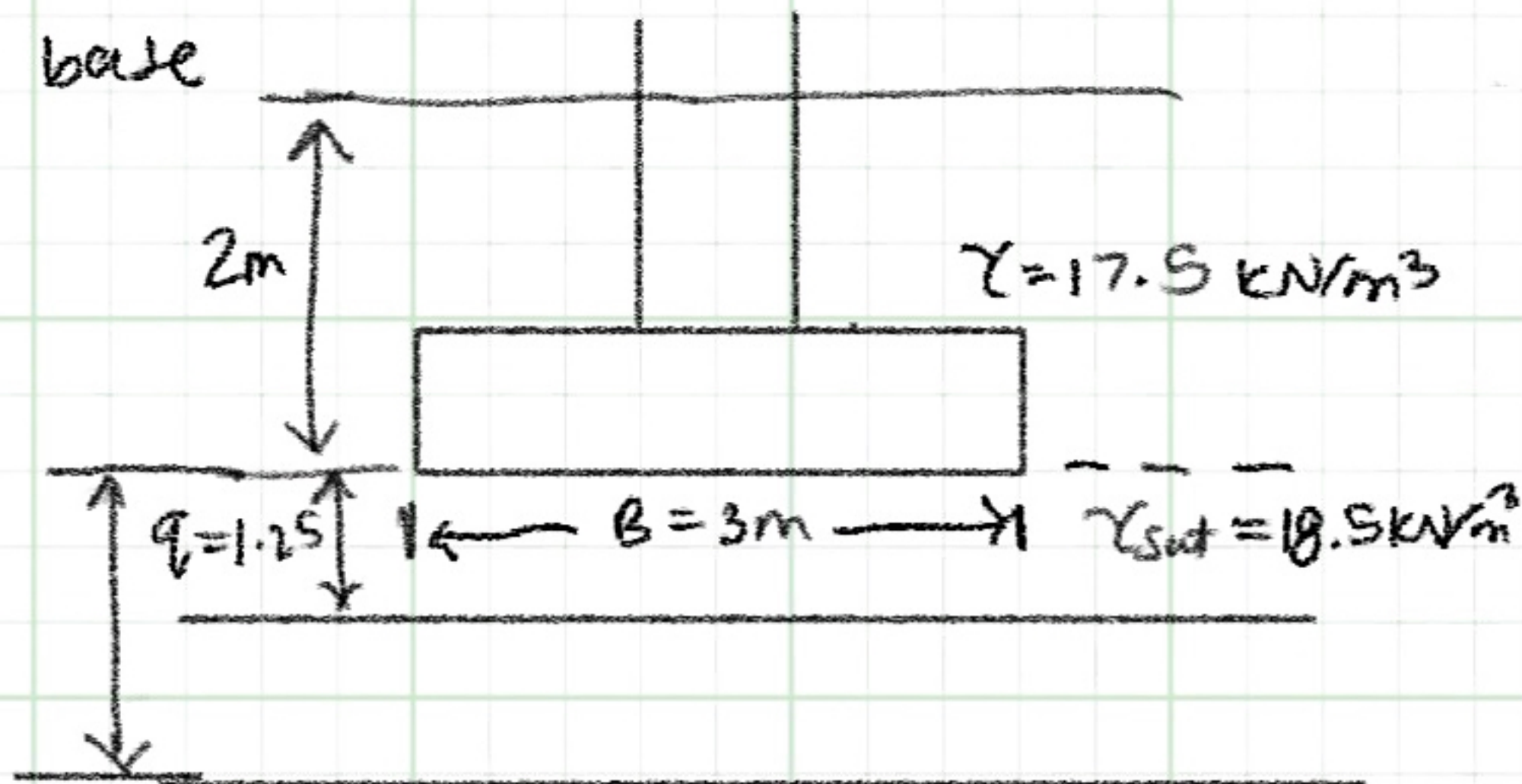
$$\bar{\sigma} = R_q^* \times \gamma_{\text{avg}} \times D_f = 0.8125 \times 17.875 \times 2 = 29.046 \text{ kN/m}^2$$

assume F.O.S = 3 $q_{ns} = \frac{2956.97 - 29.046}{3} = 975.97 \text{ kN/m}^2$



Problem 4

(b) 1.25 m below foundation base



For strip footing footing

$$q_u = C N_c + q N_q + 0.5 B (R \gamma_{\text{avg}}) N_\gamma \quad \text{--- (2)}$$

$$q = \gamma D_f = 17.5 \times 2 = 35\text{ kN/m}^2$$

$$R_r = \frac{1}{2} (1 + \frac{z}{B}) = \frac{1}{2} (1 + \frac{1.25}{3}) = 0.708$$

$$\gamma_{\text{avg}} = \frac{\gamma \times z + \gamma_{\text{sat}} (B - z)}{B} = \frac{17.5 \times 1.25 + 18.5 \times (3 - 1.25)}{3} = 18.08\text{ kN/m}^2$$

put values in eqn (2)

$$q_u = 30 \times 57.73 + 35 \times 41.426 + 0.5 \times 3 \times (0.708 \times 18.08) \times 1.57$$

$$= 1731.9 + 1449.91 + 30.145 = 3211.95\text{ kN/m}^2$$

net safe bearing capacity (q_{ns})

$$q_{ns} = \frac{q_u}{\text{F.O.S}} = q_u - \bar{\sigma}$$

$$\bar{\sigma} = \gamma \times D_f = 17.5 \times 2 = 35\text{ kN/m}^2$$

assume $\text{F.O.S} = 3 \Rightarrow q_{ns} = \frac{3211.95 - 35}{3} = 1058.98\text{ kN/m}^2$

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Title of Assignment: 2

TOPICS COVERED IN ASSIGNMENT 1

Test 1 covered the following topics:

1. Stress Distribution
2. Settlement Analysis

**NOTE: Pages T1 through T7 should be repeated for each Test and
Similarly for all the other assignments in the course binder**

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

SAMPLE ASSIGNMENT QUESTIONS

Problem 1

Find the stress increase of the circular concrete water tank (when the tank is full of water) at 10 m, 20 m and 30 below the center of the tank as shown in Figure 1. The self weight of the tank is 60,000 kN.

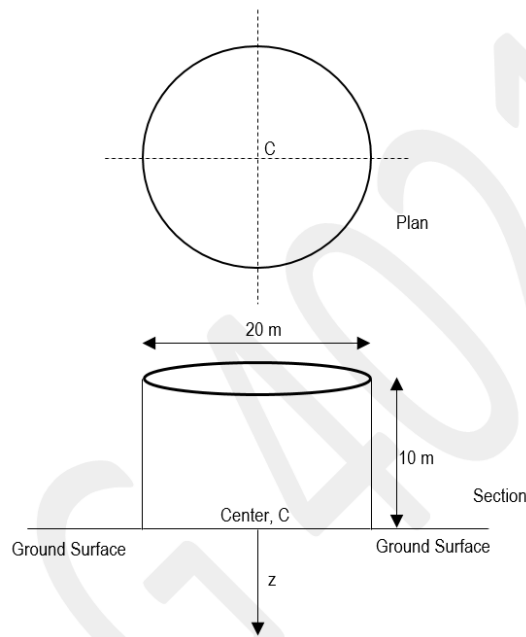


Figure: 1

Problem 2

A rectangular concrete slab, 10 ft $\times$ 15 ft, rests on the surface of a soil mass. The load on the slab is 450 kips. Determine the vertical stress increase at a depth of 10 ft (a) under the center of the slab, point A (Figure 2); (b) under point B (Figure 2); (c) at a distance of 5 ft from a corner, point C (Figure 2); and (d) compare the results from 'a' with an estimate using the approximate method. (e) Plot the distribution of stress increase at point A with depth till 40 ft depth with a depth increment of 8 ft (using m & n method).

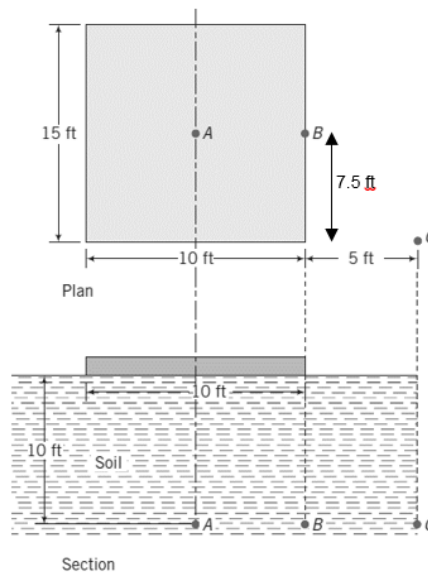


Figure: 2

Problem 3

Proportion a square footing such that the consolidation settlement is not over 40 mm for the given conditions of Figure 3.

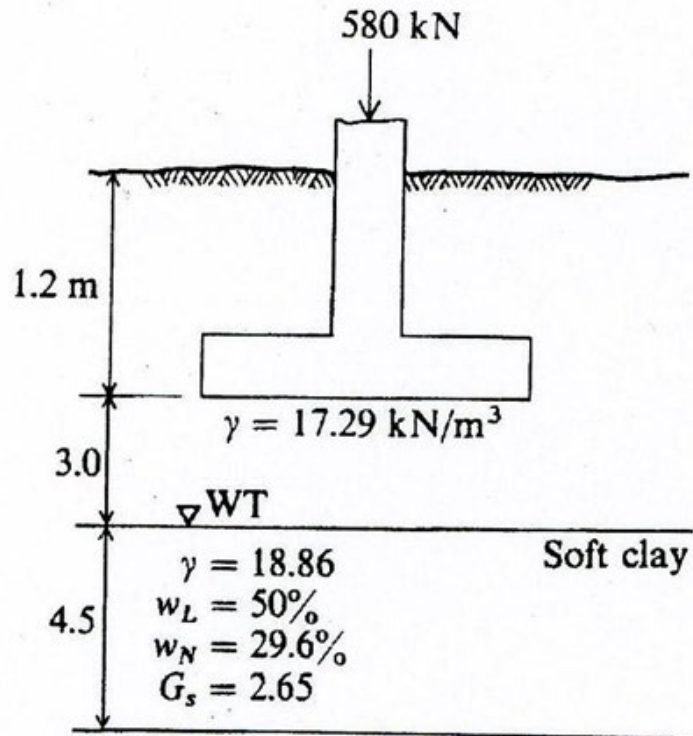


Figure: 3

Problem 4

A shallow foundation is to be constructed on a sandy soil layer underlain by clayey soil as shown in Figure 4. Find the consolidation settlement for the footing.

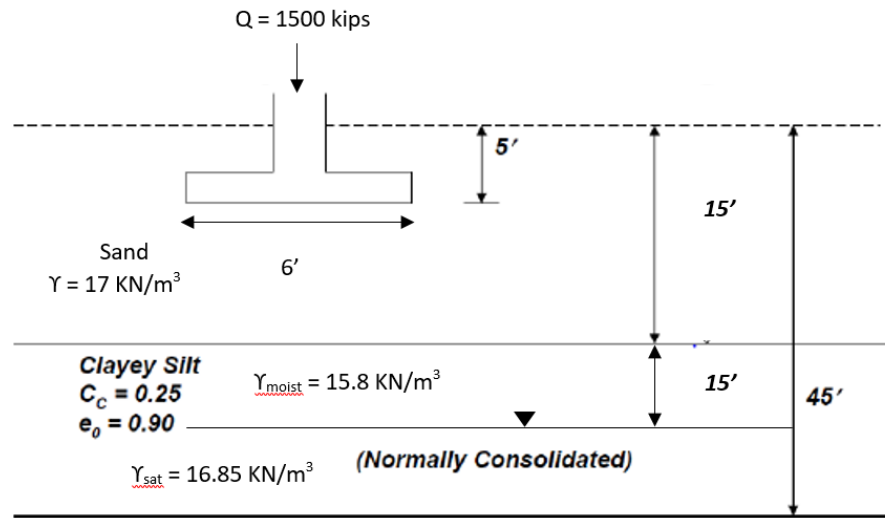
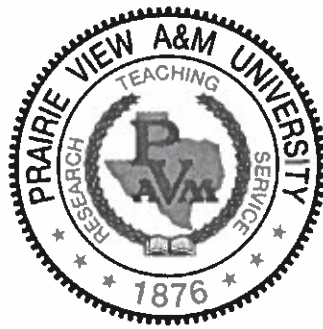


Figure: 4

ABOVE AVERAGE

Prairie View A&M University
Roy G Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4100 P81 – Geotechnical Engineering
Design Lab

Fall 2021

Homework #2

Submitter: *Johnathon Chevalier*

Grader: *Dr. J. Alam, MD*

Roster #4

Date Assigned: 21 September 2021

Date submitted: 29 September 2021

Problem 1

Given

- Full tank of water

@ 10 m

@ 20 m

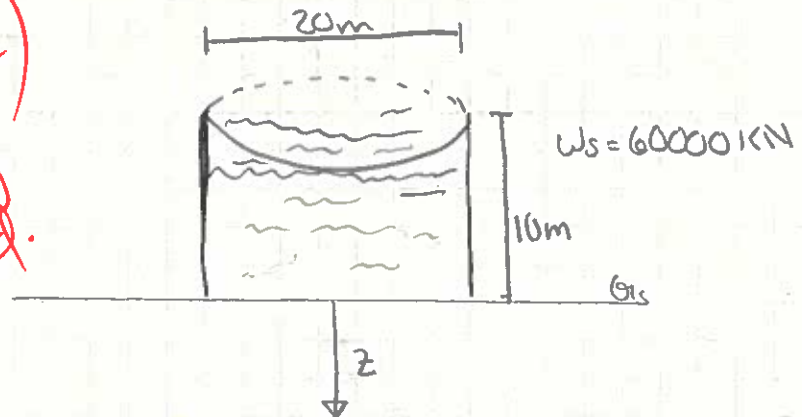
@ 30 m

$W_{self} = 60,000 \text{ kN}$

Question

Stress increase = ?

Solve



①

$W_{water} = \gamma V$

$$L = (9.81 \times \pi/4) (20^2 \times 10)$$

$$L = 30819.02 \text{ kN}$$

$$q = \frac{60000 + 30819.02}{(\pi/4 \times 20^2)}$$

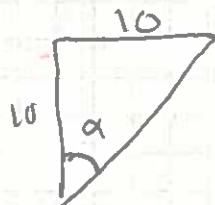
$$L = 289.1 \text{ kN/m}^2$$

②

@ $z = 10 \text{ m}$

$$\alpha = \tan^{-1}(\frac{10}{10}) =$$

$$L = 45^\circ$$



$$\sigma_z = (1 - \cos^2(45^\circ)) 289.1$$

$$L = 186.89 \text{ kN/m}^2$$

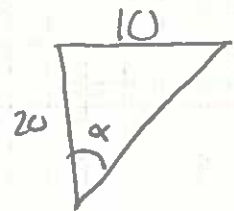
③ @ $z = 20 \text{ m}$

$$\alpha = \tan^{-1}(\frac{10}{20})$$

$$L = 26.56^\circ$$

$$\sigma_z = (1 - \cos^2(26.56^\circ)) 289.1$$

$$L = 82.237 \text{ kN/m}^2$$



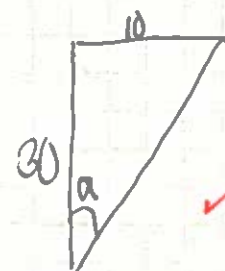
④ @ $z = 30 \text{ m}$

$$\alpha = \tan^{-1}(\frac{10}{30})$$

$$L = 18.43^\circ$$

$$\sigma_z = (1 - \cos^2(18.43^\circ)) 289.1$$

$$L = 42.262 \text{ kN/m}^2$$



Solution

@ $z = 10 \text{ m}$, 186.89 kN/m^2

@ $z = 20 \text{ m}$, 82.237 kN/m^2

@ $z = 30 \text{ m}$, 42.262 kN/m^2

(+2)
very good.

Problem 2

Given

rectangle
10 ft x 15 ft
450 kips
40 ft, 8 ft
depth

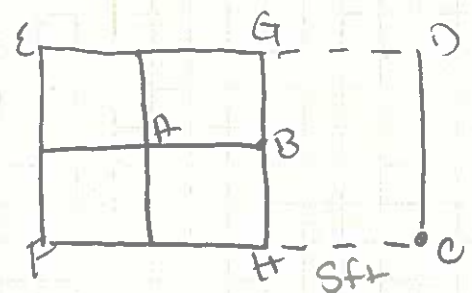
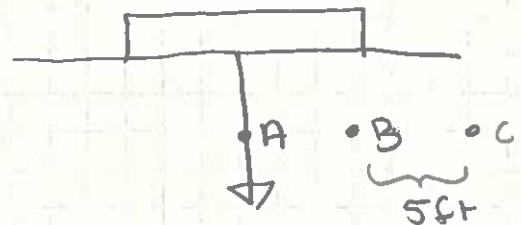
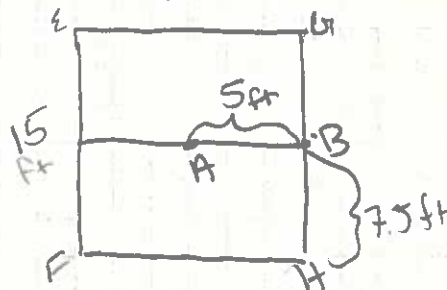
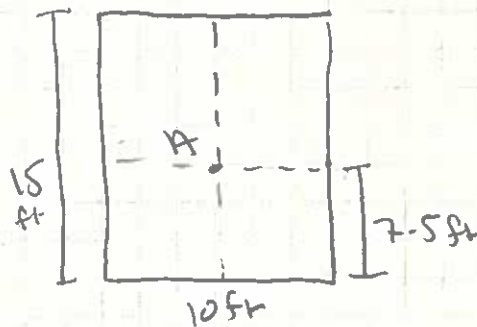
Solve

vertical stress

@ center, A,
B, C,

distribution plot

Solve



$$z = 10 \text{ ft}$$

$$Q = 450 \text{ kips}$$

$$q = \frac{Q}{z \cdot B}$$

$$q = \frac{450}{10 \times 15}$$

$$q = 3 \text{ kips/ft}^2$$

$$m = \frac{B}{2} = \frac{x}{z}$$

$$m = \frac{10}{2} = 5$$

$$n = \frac{z}{2} = \frac{y}{z}$$

$$n = \frac{15}{2} = 7.5$$

$$I = .105$$

$$\sigma = 4 \times q \times I$$

$$\sigma = 4 \times 3 \times .105$$

$$\sigma = 1.26 \text{ kips/ft}^2$$

$$m = x/z$$

$$m = 10/10 = 1$$

$$n = y/z$$

$$n = 7.5/10 = .75$$

$$I = .158$$

$$\sigma = 4 \times 3 \times .158$$

$$\sigma = .948 \text{ kips/ft}^2$$

$$(4)$$

$$\sigma = \frac{qBL}{(B+z)(L+z)}$$

$$\sigma = \frac{3 \times 15 \times 10}{(15+10)(10+10)}$$

$$\sigma = .9 \text{ kips/ft}^2$$

$$m = x/z = 10/10 = 1.5$$

$$n = y/z = 15/10 = 1.5$$

$$CDFF \quad I_1 = .22$$

$$m = x/z = 10/10 = .5$$

$$n = y/z = 15/10 = 1.5$$

$$CDFF \quad I_2 = .13$$

$$\sigma = 3 \times (I_1 - I_2)$$

$$\sigma = 3 \times (.22 - .13)$$

$$\sigma = .27 \text{ kips/ft}^2$$

$$(5)$$

$$z = 8$$

$$m = x/z = 5/8$$

$$n = y/z = 7.5/8$$

$$I = .1301$$

$$\sigma = 4 \times 3 \times .1301$$

$$\sigma = 1.632 \text{ kips/ft}^2$$

$$z = 16$$

$$m = .3125$$

$$n = .468$$

$$I = .045$$

$$\sigma = .54 \text{ kips/ft}^2$$

$$z = 24$$

$$m = .2$$

$$n = .31$$

$$I = .023$$

$$\sigma = .276 \text{ kips/ft}^2$$

$$z = 32$$

$$m = .15$$

$$n = .23$$

$$I = .008$$

$$\sigma = .11 \text{ kips/ft}^2$$

$$z = 40$$

$$m = .125$$

$$n = .187$$

$$I = 0$$

$$\sigma = 0$$

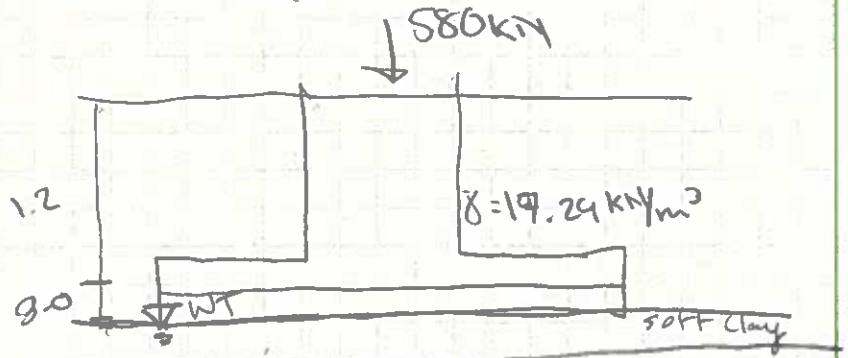
(-5)
Plot
d

Problem 3

Given

- CS ≥ 40 mm
- 580 kN
- WT - 4.2 m
- soft clay
- $\gamma = 18.86$ $\gamma_{sat} = 29.6\%$
- $w_L = 50\%$ $G_s = 2.65$

Solve



Solve

Proportional
Square
footing

$$P_0' = [3 + 12] [17.29] + \frac{1.5}{2} [18.86 - 9.807] = 93 \text{ kPa}$$

$$C_c = .009(w_L - 10)$$

$$L_c = .004(50 - 10) = .36$$

$$P_0 = w G_s = \frac{29.6}{100} (2.65)$$

$$L_D = .784$$

$$\Delta H = \frac{C_c H}{H L_c} \log \frac{P_0' + \Delta P}{P_0'}$$

$$L_D = \frac{.36(4.5)}{1.784} \log \frac{93 + \Delta P}{93}$$

$$L_D = .91 \log \frac{93 + \Delta P}{93}$$

B=2.4:

$$\Delta P = \frac{1}{3} (15/3) \left(\frac{.25 + .06}{2} + .13 + .08 \right)$$

$$L_D = \frac{.36}{3} = .1215 \text{ m} \quad 2.4$$

B=4.8

$$\Delta P = \frac{1}{3} \left[\frac{.6 + .17}{2} + .4 + .25 \right] = .3446$$

B=7.2

$$\Delta P = \frac{1}{3} \left[\frac{.77 + .21}{2} + .6 + .4 \right] = .5178$$

$$\Delta H_{2.4} = .91 \log \left(\frac{93 + 12}{93} \right)$$

$$L_D = .048 \text{ m}, 48 \text{ mm}$$

$$\Delta H_{4.8} = .91 \log \left(\frac{93 + 3.8}{93} \right)$$

$$L_D = .036 \text{ m}, 36 \text{ mm}$$

$$\Delta H_{7.2} = .91 \log \left(\frac{93 + 5.8}{93} \right)$$

$$L_D = .024 \text{ m}, 24 \text{ mm}$$

	B=2.4		D=4.8		B=7.2	
Dim	P/3	q/4	P/3	q/4	P/3	q/4
3	1.25	.25	.62	.6	.42	.77
4.5	1.87	.13	.94	.4	.62	.60
6.0	2.5	.08	1.25	.25	.83	.40
7.5	3.12	.06	1.50	.17	1.04	.34

2.4

$$q_{2.4} = .12 \times \frac{580}{2.42}$$

$$L_D = 2.87 \text{ kPa or } 12 \text{ kPa}$$

$$q_{4.8} = .35 \times \frac{580}{4.82}$$

$$L_D = 42.116 \text{ or } 8.8 \text{ kPa}$$

$$q_{7.2} = .52 \times \frac{580}{7.22} = 41.77 \text{ or } 5.8 \text{ kPa}$$

Solution

B=4m

(-2)
B=2.4m

Problem 4

Given

-shallow foundation

$$Q = 1500 \text{ kips}$$

$$\gamma = 17 \text{ kN/m}^3$$

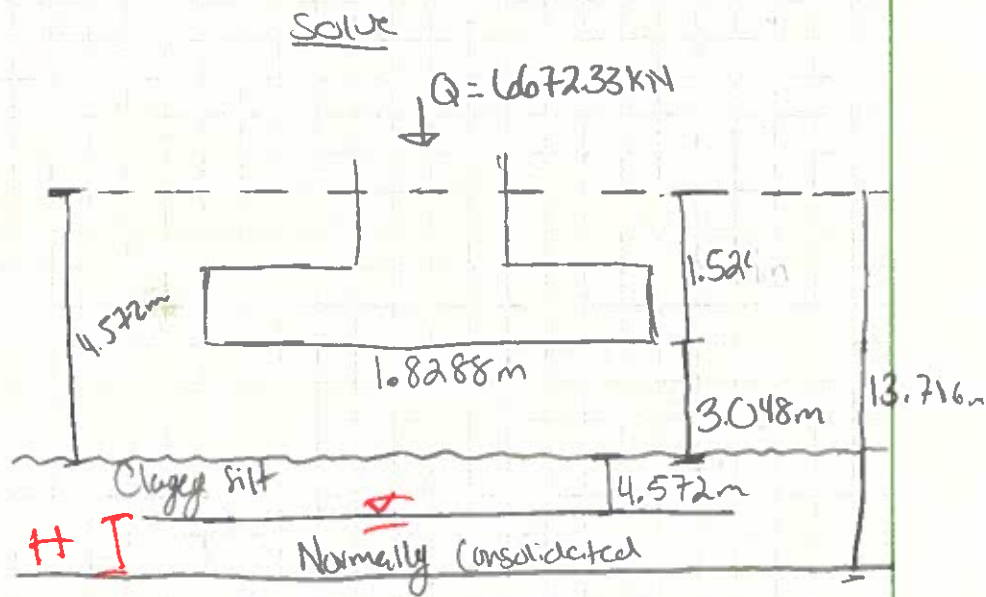
$$C_c = 0.25 \quad \gamma_{sat} = 16.85 \text{ kN/m}^3$$

$$e_0 = 0.9$$

$$\gamma_{water} = 15.8 \text{ kN/m}^3$$

Question

Consolidation Settlement = ?



$$z = (4.572 + 4.572) - 1.52$$

$$L = 7.62 \text{ m}$$

$$\sigma_0 A = (17 \times 4.572) + (15.8 \times 4.572)$$

$$L = 149.96 \text{ kN/m}^2$$

$$A_s = \frac{P}{A} = \frac{Q}{(z + 0)^2}$$

$$L = \frac{667233}{(0.18288 + 7.62)^2}$$

$$L = 24.73 \text{ kN/m}^2$$

$$AH = \frac{H_0}{H_0} C_c \log_{10} \left(\frac{\sigma_0 + A_s}{\sigma_0} \right)$$

$$L = \frac{4.572 \times 2}{1 + 0.9} \times 0.25 \times \log_{10} \left(\frac{149.96 + 24.73}{149.96} \right)$$

$$L = 0.211 \text{ m or } 211.88 \text{ mm}$$

Solution

$$AH = 0.211 \text{ m or } 211.88 \text{ mm}$$

(m,n) ⇒ method

(-5)

AVERAGE

CIVIL ENGINEERING DEPARTMENT

82



CVEG 4100- Geotechnical Engineering Design

Homework #2

Shadaria Lynch

Problem 1

load = 60,000 kN

pressure (q) = $\frac{\text{load}}{\text{area}} = \frac{60,000}{\pi/4 (20)^2} = \frac{60,000}{314.2} = 191 \text{ kN/m}^2$

Stress increase (σ_z) = $q \left[1 - \frac{1}{1 + (R/z)^2} \right]^{3/2}$

radius (R) = 20/2 = 10m

z = depth

@ 10m depth:

$\sigma_z = 191 \left[1 - \frac{1}{1 + (10/10)^2} \right]^{3/2}$

= 67.5 kN/m²

@ 20m depth:

$\sigma_z = 191 \left[1 - \frac{1}{1 + (10/20)^2} \right]^{3/2}$

= 17.1 kN/m²

@ 30m depth:

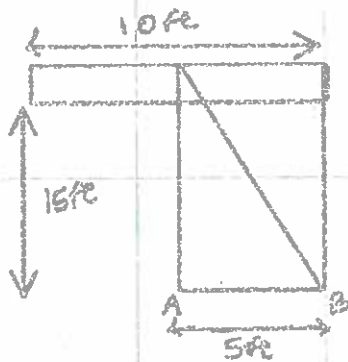
$\sigma_z = 191 \left[1 - \frac{1}{1 + (10/30)^2} \right]^{3/2}$

= 6.04 kN/m²

$q = \frac{60,000}{A} + \gamma_w h$

(5)

Problem 2



$$z = 10 \text{ ft}$$

$$Q = 450 \text{ kips}$$

a) vertical stress @ center of slab, point A

$$q = \frac{450}{10 \times 15} = 3 \text{ kips/ft}^2$$

$$m = \frac{b}{z} = \frac{5}{10} = 0.5 \quad n = \frac{L}{z} = \frac{7.5}{10} = 0.75$$

$$\text{vertical stress } \sigma_a = 4 \times q \times I_2$$

$$= 4 \times 3 \times 0.105 = 1.26 \text{ kips/ft}^2$$

b) at B

$$m = 10/10 = 1$$

$$n = 7.5/10 = 0.75$$

$$I_2 = 0.158$$

$$\sigma_b = 2 \times 3 \times 0.158 = 0.948 \text{ kips/ft}^2$$

c) at C

$$m = 15/10 = 1.5$$

$$n = 15/10 = 1.5$$

$$I_2 = 0.22 \text{ (CDEF)}$$

$$m = 5/10 = 0.5$$

$$n = 15/10 = 1.5$$

$$I_2 = 0.13 \text{ (CDGH)}$$

$$\sigma_c = 3 \times (0.22 - 0.13)$$

$$= 0.27 \text{ kips/ft}^2$$



d) Using approximate method

$$\sigma_c = \frac{qL}{(B+z)(L+z)} = \frac{3 \times 15 \times 10}{(15+10)(10+10)} = 0.9 \text{ kips/ft}^2$$

e) At $z = 8$

$$m = 9/8 = 0.625 \quad n = 7.5/8 = 0.975$$

$$\sigma_z = 4 \times 3 \times 0.1361 = 1.6332$$

At $z = 16$

$$m = 0.3125 \quad n = 0.468$$

$$\sigma_z = 4 \times 3 \times 0.045 = 0.54$$

At $z = 24$

$$m = 0.2 \quad n = 0.31$$

$$\sigma_z = 4 \times 3 \times 0.023 = 0.276$$

At $z = 32$

$$m = 0.15 \quad n = 0.23$$

$$\sigma_z = 0.10$$

At $z = 40$

$$m = 0.125 \quad n = 0.187$$

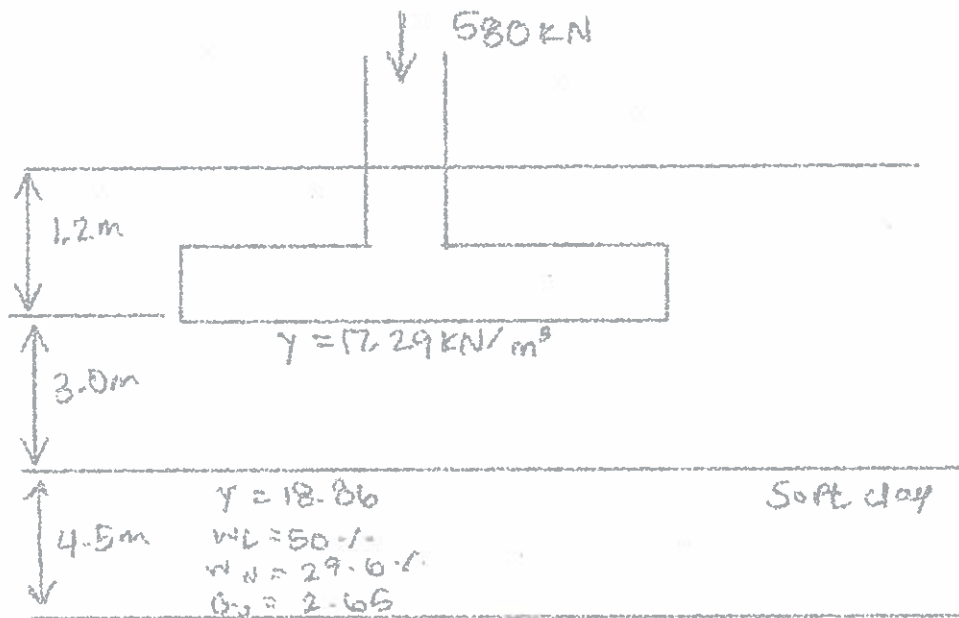
$$\sigma_z \approx 0$$

plot

46

(-5)

Problem 3



$$\Delta H = \frac{C_c H \log \sigma_2 / \sigma_1}{1 + e_0}$$

$$C_c = 0.007(WL - 10) = 0.28$$

$$H = 4.5 \text{ m}$$

$$e = \frac{G W_n}{S_d} = \frac{2.65 \times 0.296}{1} = 0.784$$

$$\sigma_1 = 17.29(3 + 1.2) + (18.86 - 9.81)(2.25) = 92.98 \text{ kN/m}^2$$

$$\sigma_2 = \sigma_1 + \Delta \sigma$$

$$\Delta \sigma = \frac{P}{(B + z)^2}$$

$$B = 2$$

$$z = 5.25 \text{ m}$$

$$C_c = 0.007(WL - 10) = 0.28$$

$$\Delta H = \frac{0.28 \times 4.5 \log \sigma_2 / \sigma_1}{1 + 0.784} \Rightarrow \log \sigma_2 / \sigma_1 = 0.056$$

$$\frac{\sigma_2}{\sigma_1} = 1.13$$

$$\sigma_2 = 92.98 \times 1.13 = 105.1$$

$$\Delta \sigma = \sigma_2 - \sigma_1 = 105.1 - 92.98 = 12.12 \text{ kN/m}^2$$

$$12.12 = \frac{580}{(B + 5.25)^2} \Rightarrow (B + 5.25)^2 = 47.85$$

$$B + 5.25 = 6.9$$

$$B = 1.65 \text{ m}$$

(2)

$$B = 2.4 \text{ m}$$

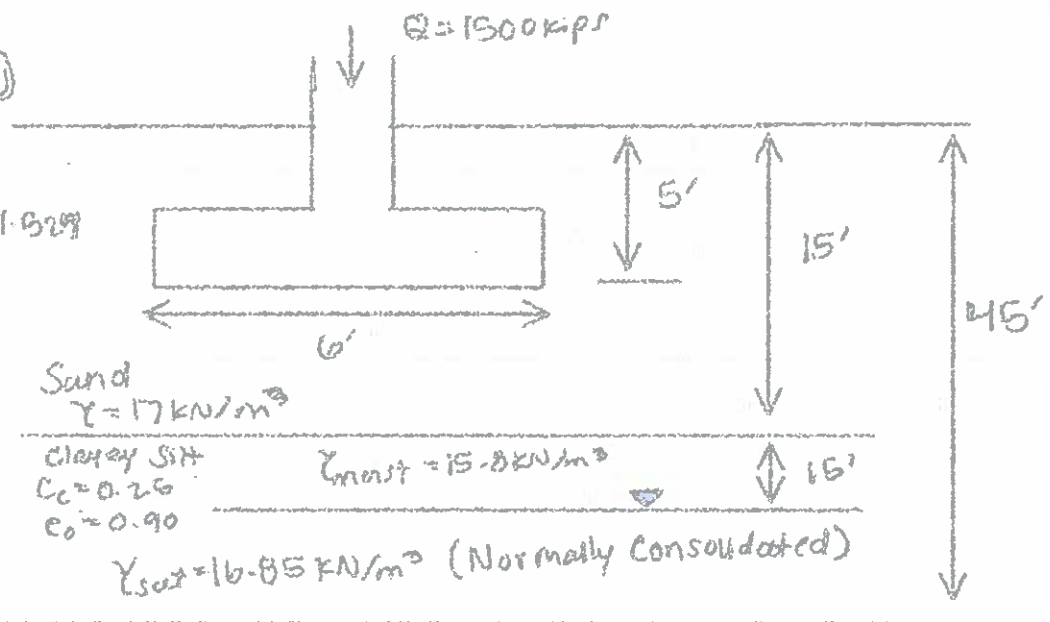
check

Problem 4

$$1 \text{ ft} = 0.3048 \text{ m}$$

$$B = 1.829 \text{ m}$$

$$Z = 2 \times 4.572 - 1.829 \\ = 7.62$$



$$Q = 1500 \text{ kips} \times \frac{4.448 \text{ kN}}{1 \text{ kips}} = 6672 \text{ kN}$$

$$\Delta H = \frac{H_0}{1 + e_0} C_c \log_{10} \left(\frac{\sigma_0 + \Delta \sigma}{\sigma_0} \right)$$

$$\sigma_0 = 17 \times 4.572 + 15.8 \times 4.572 = 149.96 \text{ kN/m}^2$$

$$\Delta \sigma = \frac{Q}{(Z + B)^2} = \frac{6672}{(7.62 + 1.829)^2} = 74.73 \text{ kN/m}^2$$

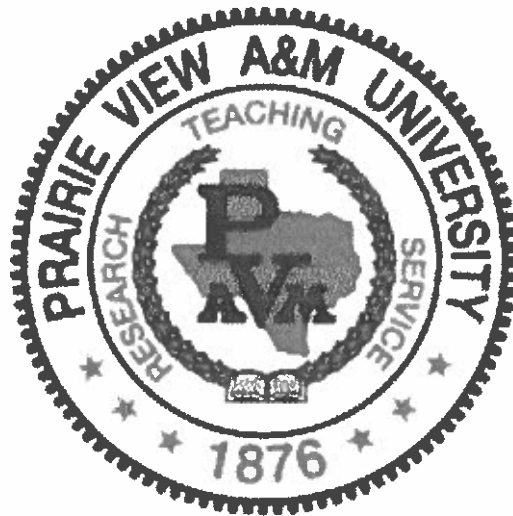
$$\Delta H = \frac{4.572}{1 + 0.90} \times 0.25 \times \log \left(\frac{149.96 + 74.73}{149.96} \right)$$

$$= 0.211 \text{ m} = 211 \text{ mm}$$

(m, n) $\Rightarrow$ method

BELOW AVERAGE

CIVIL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY



CVEG 4100 P81 GEOTECHNICAL ENGINEERING
DESIGN

Homework #2

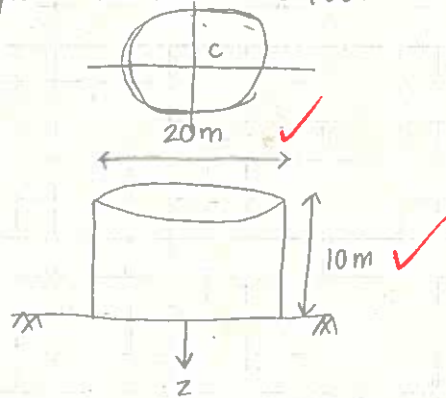
Perla Zaldivar (#10)

Given: September 22, 2021

Due: September 28, 2021

PROBLEM 1

Find the stress increase of the circular concrete water tank (when the tank is full of water) at 10m, 20m and 30m below the center of the tank. The self weight of the tank is 60,000 kN.



$$\text{pressure } (q_0) = \frac{\text{load}}{\text{area}} = \frac{60,000 \text{ kN}}{(\pi/4)(20\text{m})^2} = 191 \text{ kN/m}^2$$

$$\begin{aligned} \text{load} &= \frac{60,000}{\text{A}} + \gamma_w h \\ &= \frac{60,000}{\text{A}} + 9.81 \times 10 \\ &= \frac{60,000}{\text{A}} + 98.1 \text{ kN} \end{aligned}$$

$$\Delta \sigma = q_0 \left[1 - \frac{1}{1 + (R/z)^2} \right]^{3/2}$$

at 10m $R = 10\text{m}/2 = 10\text{m}$ $z = 10\text{m}$

$$\Delta \sigma = (191 \text{ kN/m}^2) \left[1 - \frac{1}{1 + \left(\frac{10}{10}\right)^2} \right]^{3/2} = 107.53 \text{ kN/m}^2$$

at 20m $R = 20\text{m}/2 = 10\text{m}$ $z = 20\text{m}$

$$\Delta \sigma = (191 \text{ kN/m}^2) \left[1 - \frac{1}{1 + \left(\frac{10}{20}\right)^2} \right]^{3/2} = 17.09 \text{ kN/m}^2$$

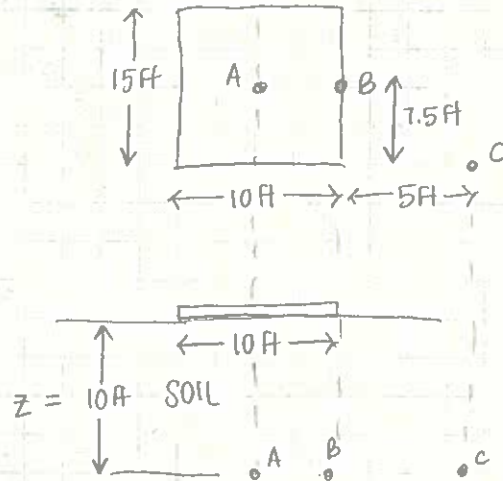
at 30m $R = 10\text{m}/2 = 10\text{m}$ $z = 30\text{m}$

$$\Delta \sigma = (191 \text{ kN/m}^2) \left[1 - \frac{1}{1 + \left(\frac{10}{30}\right)^2} \right]^{3/2} = 6.04 \text{ kN/m}^2$$

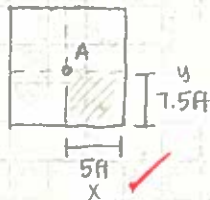
(5)

PROBLEM 2

- A rectangular concrete slab, 10 x 15 ft, rests on the surface of a soil mass. The load on the slab is 450 kips. Determine the vertical stress increase at a depth of 10 ft. (a) under the center of the slab at point A (b) under point B (c) at distance of 5 ft from corner point C (d) compare the results from 'a' with an estimate using the approximate method (e) plot the distribution of stress increase at point A with depth till 40 ft depth with a depth increment of 8 ft (using m & n method)



PART A



$$m = x/z = 5/10 = 0.5$$

$$n = y/z = 7.5/10 = 0.75$$

$$450 \text{ kip} -$$

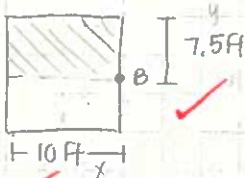
$$\Delta \sigma = 4 I q$$

$$q = \frac{Q}{A} = \frac{450 \text{ kip}}{(10 \text{ ft} \times 15 \text{ ft})} = 3 \text{ kip/ft}^2$$

$$I \text{ (from Fig 4)} = 0.107$$

$$\Delta \sigma = 4 (0.107) (3 \text{ kip/ft}^2) = 1.284 \text{ kip/ft}^2$$

PART B



$$m = x/z = 10/10 = 1$$

$$n = y/z = 7.5/10 = 0.75$$

$$\Delta \sigma = 4 I q$$

$$q = \frac{Q}{A} = \frac{450 \text{ kip}}{(10 \text{ ft} \times 15 \text{ ft})} = 3 \text{ kip/ft}^2$$

$$I = 0.101$$

$$\Delta \sigma = 4 (0.101) (3 \text{ kip/ft}^2) = 1.932 \text{ kip/ft}^2$$

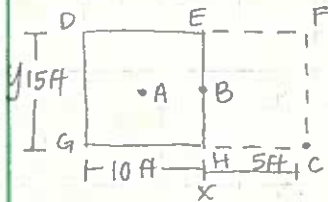
2

X

(-5)

PROBLEM 2 CONTINUE

PART C



for DFCG

$$m = x/z = 15/10 = 1.5$$

$$n = y/z = 15/10 = 1.5$$

$$I_1 = 0.218$$

$$I = (I_1 - I_2) \Delta q$$

$$I = (0.218 - 0.131)(3 \text{ kip/ft}^2)$$

$$0.261 \text{ kip/ft}^2$$

for EFCH

$$m = x/z = 5/10 = 0.5$$

$$n = y/z = 15/10 = 1.5$$

$$I_2 = 0.131$$

$$q = \frac{Q}{A} = \frac{450 \text{ kip}}{(10 \text{ ft} \times 15 \text{ ft})} = 3 \text{ kip/ft}^2$$

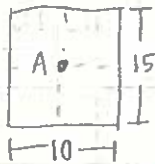
PART D

$$\Delta \sigma = \frac{q_0 B L}{(B+Z)(L+Z)} \quad (\text{eq 8.15})$$

$$q = \frac{Q}{A} = 3 \text{ kip/ft}^2$$

$$\Delta \sigma = \frac{(3 \text{ kip/ft}^2)(10 \text{ ft})(15 \text{ ft})}{(10 \text{ ft} + 10 \text{ ft})(15 \text{ ft} + 10 \text{ ft})} = 0.9 \text{ kip/ft}^2$$

PART E



$$q = \frac{Q}{A} = \frac{450 \text{ kips}}{10 \text{ ft} \times 15 \text{ ft}} = 3 \text{ kip/ft}^2$$

at $Z = 8 \text{ m}$

$$m = x/z = 5/8 = 0.625$$

$$n = y/z = 7.5/8 = 0.9375$$

$$I = 0.136$$

$$\Delta \sigma = 4 I q = 4(0.136)(3 \text{ kip/ft}^2) = 1.032 \text{ k/ft}^2$$

at $Z = 10 \text{ m}$

$$m = x/z = 5/10 = 0.5$$

$$n = y/z = 7.5/10 = 0.75$$

$$I = 0.055$$

$$\Delta \sigma = 4 I q = 4(0.055)(3 \text{ kip/ft}^2) = 0.66 \text{ k/ft}^2$$

Part E (continue)

at $z = 24 \text{ ft}$

$$m = x/z = 5/24 = 0.208$$

$$n = y/z = 7.5/24 = 0.3125$$

$$I = 0.028$$

$$\Delta\sigma = 4Iq = 4(0.028)(3 \text{ kip/ft}^2) = \boxed{0.336 \text{ kip/ft}^2}$$
 ✓

at $z = 32 \text{ ft}$

$$m = x/z = 5/32 = 0.156$$

$$n = y/z = 7.5/32 = 0.234$$

$$I = 0.011$$

$$\Delta\sigma = 4Iq = 4(0.011)(3 \text{ kip/ft}^2) = \boxed{0.132 \text{ kip/ft}^2}$$
 ✓

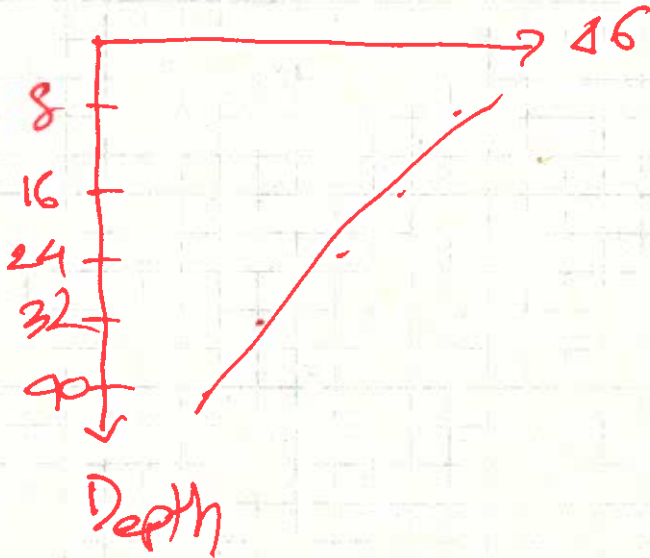
at $z = 40 \text{ ft}$

$$m = x/z = 5/40 = 0.125$$

$$n = y/z = 7.5/40 = 0.1875$$

$$I = 0.008$$

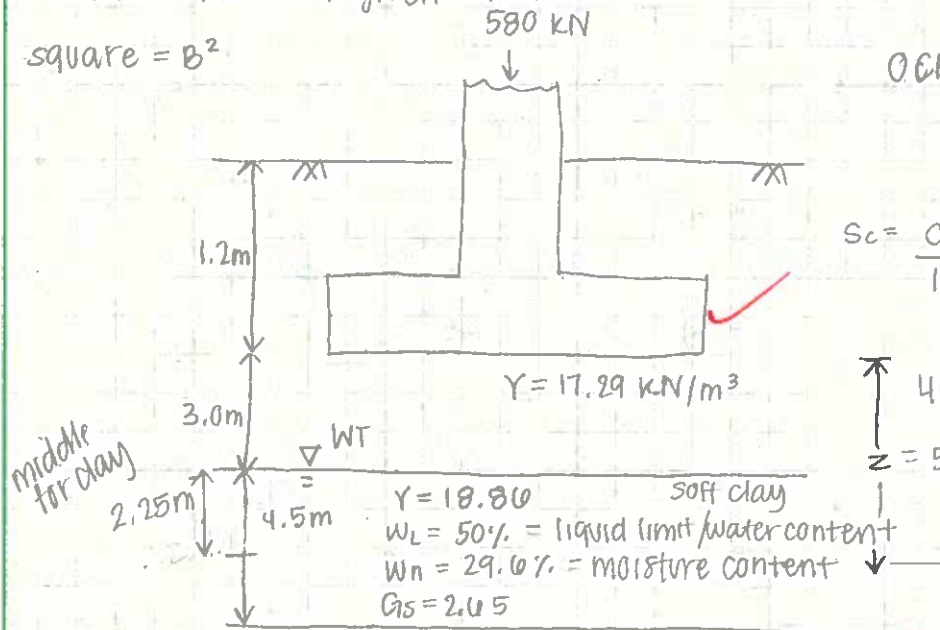
$$\Delta\sigma = 4Iq = 4(0.008)(3 \text{ kip/ft}^2) = \boxed{0.096 \text{ kip/ft}^2}$$
 ✓



PROBLEM 3

Proportion a square footing such that the consolidation settlement is not over 40mm for given conditions

square = B^2



$$OCR = \frac{\sigma'_b}{\sigma'_o}$$

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

$$40 \text{ mm} \rightarrow 0.04 \text{ m}$$

$$z = 5.25$$

determine if its OC or NC

$$\sigma'_o = (1.2 + 3) \text{ m} (17.29 \text{ kN/m}^3) + (2.25 \text{ m}) (18.80 \text{ kN/m}^3 - 9.81 \text{ kN/m}^3)$$

$$\sigma'_o = 92.98 \text{ kPa} = 93 \text{ kPa}$$

$$e_o = W G_s = \frac{(29.6)(2.65)}{100} = 0.7844$$

$$(2.54) \quad CC = 0.009 (w_L - 10) = 0.009 (50 - 10) = 0.36$$

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

$$0.04 = \frac{(0.36)(4.5)}{1 + 0.7844} \log \left(\frac{\Delta \sigma'_o}{93} \right)$$

$$0.04 = 0.907 \log \left(\frac{\Delta \sigma'_o}{93} \right)$$

$$10^{0.044} = \frac{\Delta \sigma'_o}{93}$$

$$1.106 = \frac{\Delta \sigma'_o}{93}$$

$$\Delta \sigma'_o = 102.93$$

$$\Delta \sigma'_o = \frac{q_o}{(B + z)^2}$$

$$102.93 = \frac{580 \text{ kN}}{(B + 5.25)^2}$$

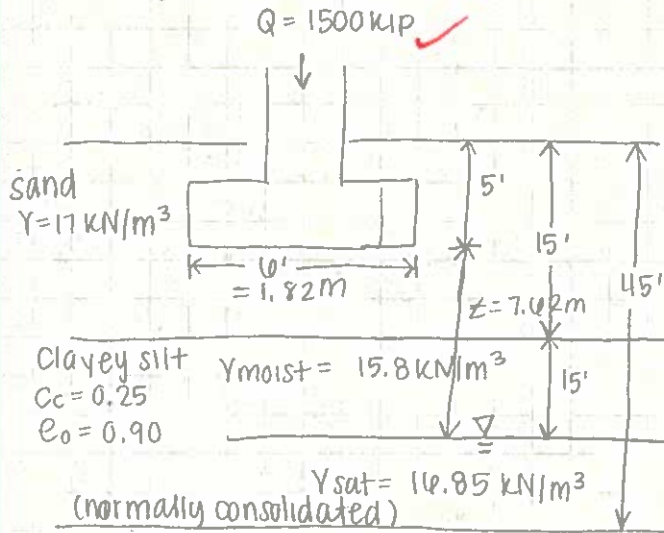
$$102.93 (B + 5.25)^2 = 580$$

$$\sqrt{(B + 5.25)^2} = \sqrt{5.63}$$

$$B + 5.25 = 2.37 \text{ m}$$

PROBLEM 4

A shallow foundation is to be constructed on a sandy soil layer underlain by clayey soil. Find the consolidation settlement for the footing.



$$\begin{aligned} 15' &= 4.5\text{m} \\ 5' &= 1.5\text{m} \\ 45' &= 13.7\text{m} \end{aligned}$$

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

$$\begin{aligned} \text{kip} &\rightarrow \text{kN} \\ 6672.33 \text{ kN} \end{aligned}$$

mid point

$$+ 7.5 (16.85 - 9.81)$$

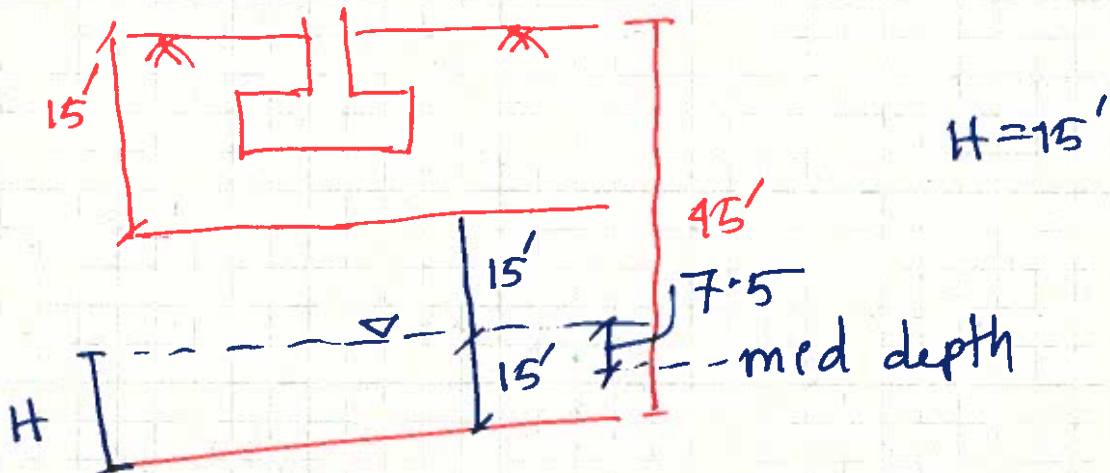
$$\sigma'_0 = (4.5\text{m})(17 \text{ kN/m}^3) + (4.5\text{m})(15.8 \text{ kN/m}^3) = 147.6 \text{ kN/m}^2$$

eq
(8.15a)

$$\Delta \sigma = \frac{6672.33 \text{ kN}}{\text{Area of shallow}} = \frac{6672.33 \text{ kN}}{(9.44 \text{ m})^2} = 74.87 \text{ kN/m}^2$$

$$S_c = \frac{0.25(9\text{m})}{1 + 0.90} \log \left(\frac{147.6 \text{ kN/m}^2 + 74.87 \text{ kN/m}^2}{147.6 \text{ kN/m}^2} \right)$$

$$S_c = 0.21\text{m}$$



(5)

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Title of Assignment: 3

TOPICS COVERED IN ASSIGNMENT 1

Test 1 covered the following topics:

1. Deep Foundation Design
2. Bearing Capacity of Driven Pile

**NOTE: Pages T1 through T7 should be repeated for each Test and
Similarly for all the other assignments in the course binder**

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

SAMPLE ASSIGNMENT QUESTIONS



Problem 1

A concrete pile of 45 cm diameter is driven through a system of layered cohesive soils as shown in Figure 1. The length of the pile is 16m. The following data are available. The water table is at the ground surface. The first two layers are normally consolidated clay.

Layer 1: Soft clay, thickness = 8 m, cohesion $c_u = 30 \text{ kN/m}^2$. $\gamma_{\text{sat}} = 16.7 \text{ kN/m}^3$

Layer 2: Medium stiff, thickness = 6 m, cohesion $c_u = 50 \text{ kN/m}^2$. $\gamma_{\text{sat}} = 17 \text{ kN/m}^3$

Layer 3: Stiff stratum extends to a great depth, cohesion $c_u = 105 \text{ kN/m}^2$. $\gamma_{\text{sat}} = 18 \text{ kN/m}^3$.

Determine the ultimate bearing capacity of the pile (Q_u). Determine Q_s using Lambda method.

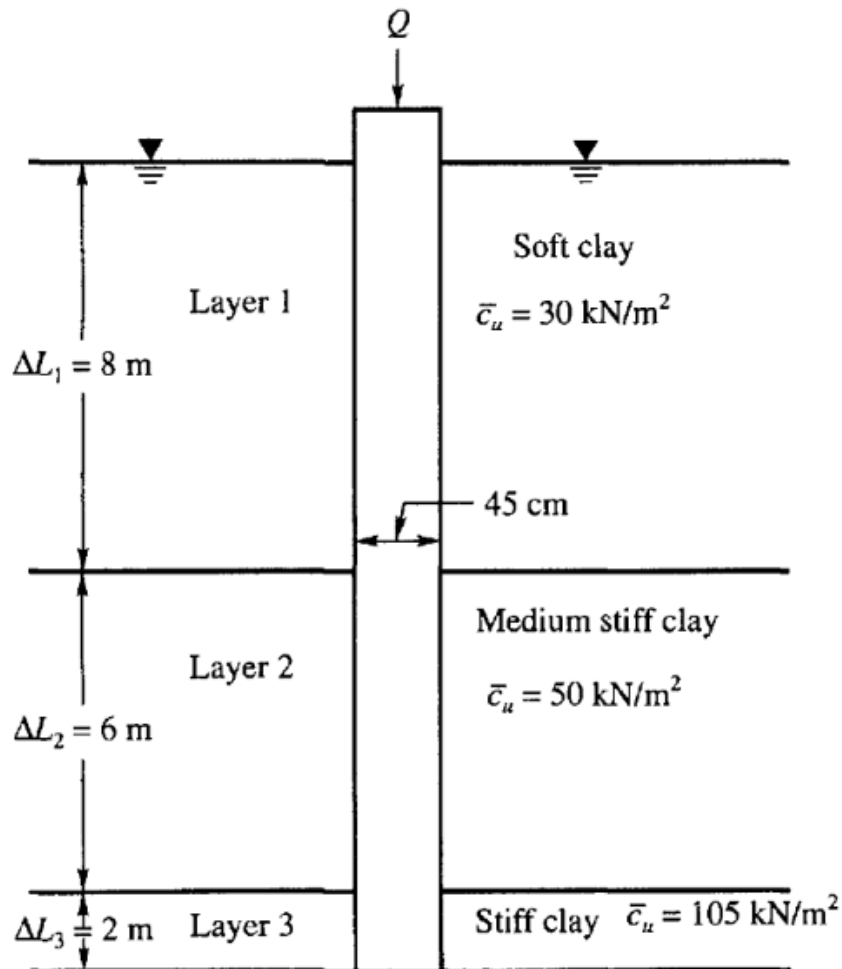


Figure: 1



Problem 2

A 12 inch diameter concrete pile is to be driven into a clay deposit as shown in Figure 2. The pile's design capacity is 30 tons. Determine the length of the pile to carry that 30 tons load if the factor of safety is 2.

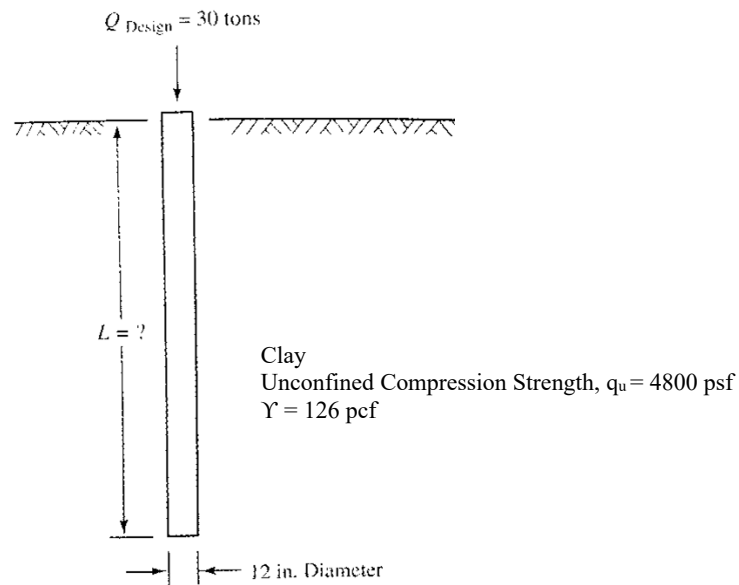


Figure: 2

Problem 4

Determine the design capacity of the concrete pile shown in Figure 3 for a factor of safety of 2.

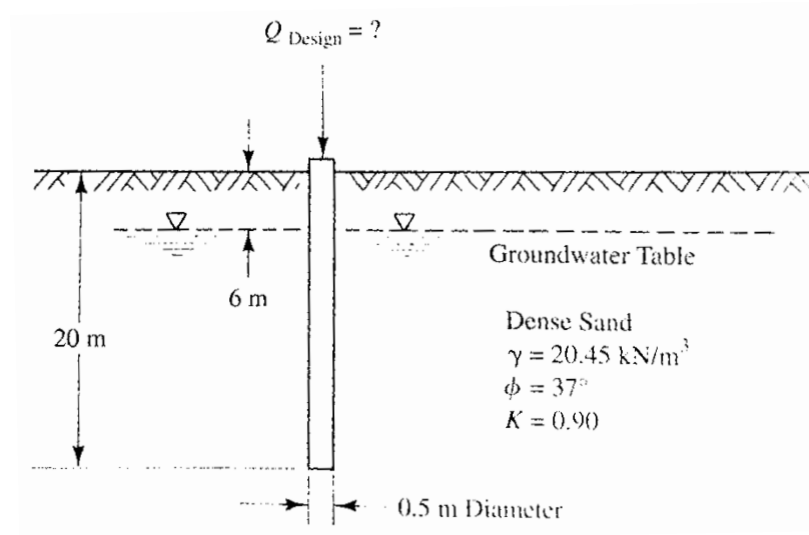
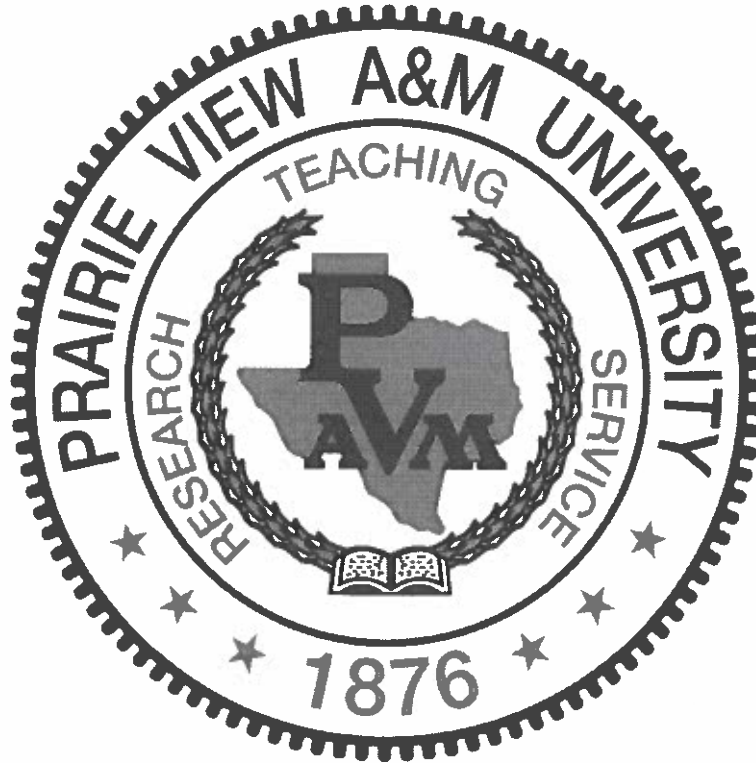


Figure: 3

ABOVE AVERAGE

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4100: Geotechnical Engineering Design

Section: P81

Course Number: 17736

Title: Homework # 3

Submitted By: Abram Auguste (Roster # 1)

Submitted To: Dr. Alam, Md. Jobair

Issue Date: October 27, 2021

Due Date: November 3, 2020 1 NLT 10:00 a.m.



Problem 1

A concrete pile of 45 cm diameter is driven through a system of layered cohesive soils as shown in Figure 1. The length of the pile is 16m. The following data are available. The water table is at the ground surface. The first two layers are normally consolidated clay.

Layer 1: Soft clay, thickness = 8 m, cohesion $c_u = 30 \text{ kN/m}^2$. $\gamma_{\text{sat}} = 16.7 \text{ kN/m}^3$

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Determine the ultimate bearing capacity of the pile (Q_u). Determine Q_s using Lamda method.

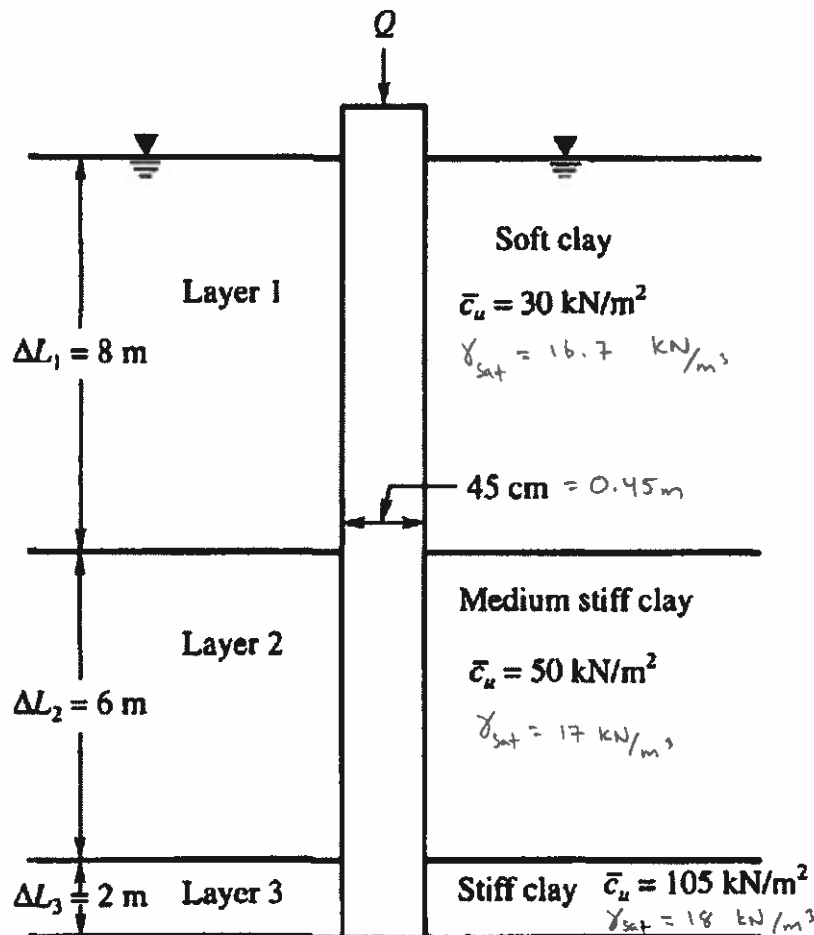


Figure: 1



Problem 2

A 12 inch diameter concrete pile is to be driven into a clay deposit as shown in Figure 2. The pile's design capacity is 30 tons. Determine the length of the pile to carry that 30 tons load if the factor of safety is 2.

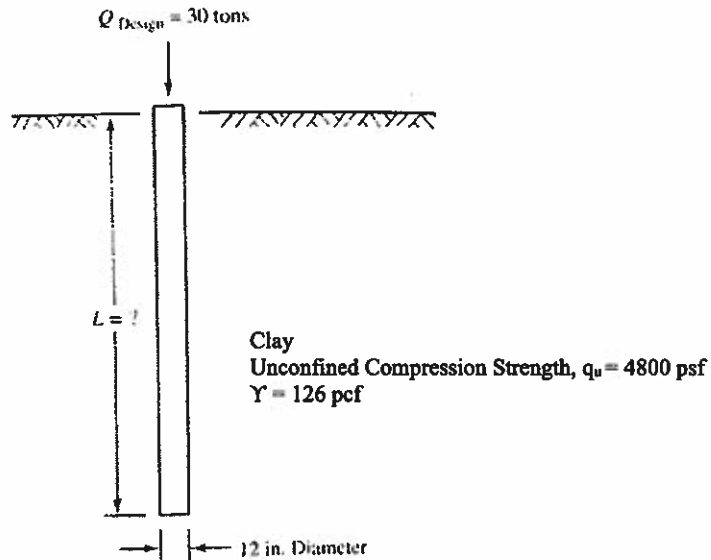


Figure: 2

Problem 4

Determine the design capacity of the concrete pile shown in Figure 3 for a factor of safety of 2.

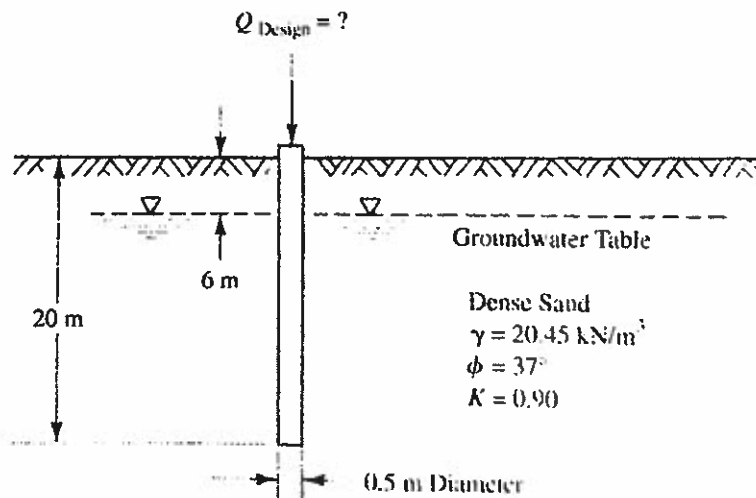


Figure: 3

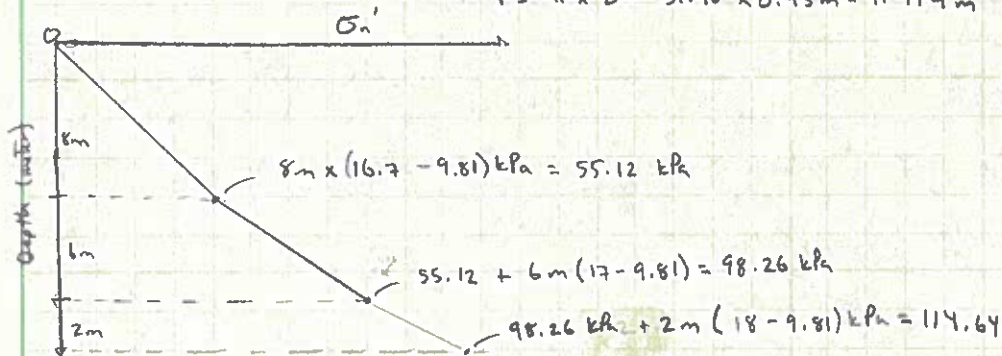
$$① Q_u = Q_p + Q_s$$

$$\hookrightarrow Q_p = 9 \times C_u \times A_p = 9 \times (105 \text{ kPa}) \times (\pi \times (0.45 \text{ m})^2) = 150.296 \text{ kN}$$

Using Lambda Method - (1)

$$\hookrightarrow Q_s = f_{avg} \times P \times \Delta L = (\lambda (\bar{\sigma}_o' + 2C_u)) \times P \times \Delta L \quad \text{from Table 12.10 @ } L=16', \lambda \approx 0.200$$

$$\hookrightarrow P = \pi \times D = 3.14 \times 0.45 \text{ m} = 1.414 \text{ m}$$



$$\bar{\sigma}_o' = \frac{A_{\text{area}_1} + A_{\text{area}_2} + A_{\text{area}_3}}{L_{\text{total}}} \Rightarrow \begin{aligned} A_1 &= \frac{1}{2} \times 8 \text{ m} \times 55.12 = 220.48 \text{ kN/m} \\ A_2 &= \frac{1}{2} \times (55.12 + 98.26) \times 6 \text{ m} = 460.14 \text{ kN/m} \\ A_3 &= \frac{1}{2} \times (98.26 + 114.64) \times 2 \text{ m} = 212.9 \text{ kN/m} \end{aligned}$$

$$\Rightarrow \bar{\sigma}_o' = \frac{220.48 + 460.14 + 212.9}{8 \text{ m} + 6 \text{ m} + 2 \text{ m}} = 55.845 \text{ kPa}$$

$$\Rightarrow C_u = \frac{\sum (C_u \times \Delta L)}{L} = \frac{30 \text{ kN/m}^2 \times 8 \text{ m} + 50 \text{ kN/m}^2 \times 6 \text{ m} + 105 \text{ kN/m}^2 \times 2 \text{ m}}{16 \text{ m}} = 46.785 \text{ kPa}$$

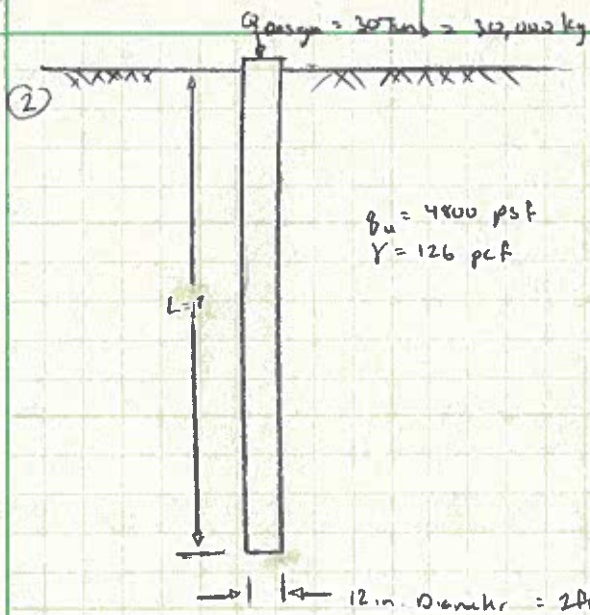
$$\Rightarrow f_{avg} = \lambda (\bar{\sigma}_o' + 2C_u) = 0.200 (55.845 \text{ kPa} + 2 \times 46.785 \text{ kPa}) = 29.919 \text{ kPa}$$

Next, air skin friction

$$Q_s = f \times P \times \Delta L = 29.919 \text{ kPa} \times 1.414 \text{ m} \times 16 \text{ m} = 676.75 \text{ kN}$$

$$\text{Therefore, } Q_u = Q_p + Q_s = (150.296 + 676.75) \text{ kN} = 827.048 \text{ kN}$$

$$\text{Finally, } Q_{\text{allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{827.048 \text{ kN}}{2.5} = 330.82 \text{ kN} \quad (\text{NOT REQUIRED BUT FOR PRACTICE})$$



pg. 482 (Table 12.11)

$$\text{Nok } \frac{C_u}{p_u} = \frac{2400 \text{ psf}}{2,000 \text{ lb/ft}^2} = 1.2 \rightarrow \alpha = 0.42$$

SOLUTION:

$$Q_u = Q_p + Q_s \quad \text{where} \quad Q_p = q \times \Delta p \times C_u = q \times \left(\frac{\pi}{4} \times (1 \text{ ft})^2 \right) \times 2400 \frac{\text{lb}}{\text{ft}^2} = 16964.6 \text{ lb}$$

$$\hookrightarrow C_u = \frac{q_{ultimate}}{F.S.} = \frac{4800}{2} = 2400 \text{ psf}$$

$$Q_s = f \times p \times \Delta L = (\alpha \times C_u) \times (\pi \times d) \times L = (0.42 \times 2400 \text{ psf}) \times (\pi \times 1 \text{ ft}) \times L = 3166.73 L$$

Therefore

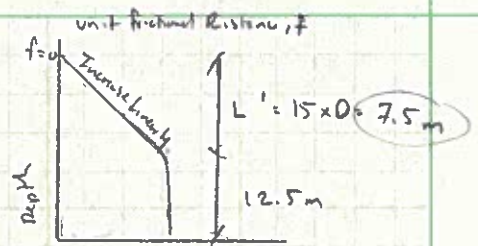
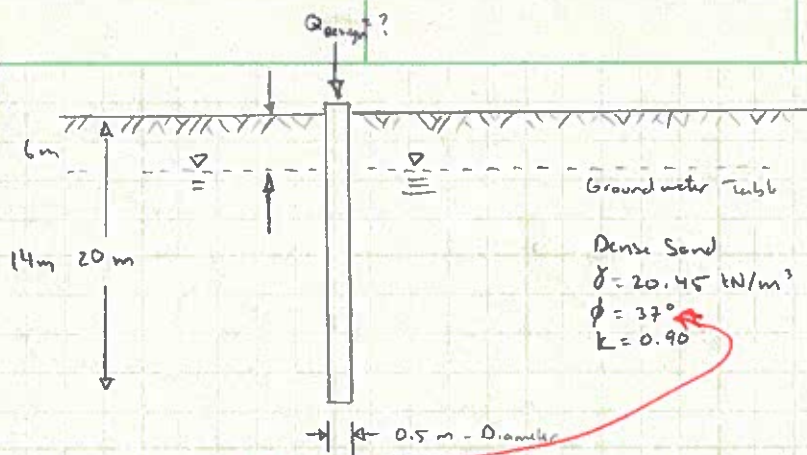
$$Q_u = Q_p + Q_s$$

$$Q_u = \text{Capacity} \times F.S. = 30 \text{ tons} \times 2 = 60 \text{ tons} = 120,000 \text{ lb}$$

$$\rightarrow 120,000 \text{ lb} = 16,964.6 \text{ lb} + 3166.73 L$$

$$\rightarrow L = 32.54 \text{ ft}$$

4



Find: Design capacity of the concrete

Assume: $\delta' = (\frac{2}{3} \times 37^\circ) = 20^\circ$

Solution: $Q_s = f \times P \times \Delta L \rightarrow \Delta L = L = 20 \text{ m}$

$$P = \pi \times D = \pi \times 0.5 \text{ m} = 1.571 \text{ m}$$

$$f = K \times \sigma'_v \times \tan(\delta') = 0.9 \times (20.45 \frac{\text{kN}}{\text{m}^3} \times 6 \text{ m} + ((20.45 \frac{\text{kN}}{\text{m}^3} - 9.81 \frac{\text{kN}}{\text{m}^3}) \times 14 \text{ m})) \times \tan 20^\circ = 88.99 \frac{\text{kN}}{\text{m}^2}$$

$$\Rightarrow Q_s = f \times P \times \Delta L = P \times (f_{0-L_1} \times \Delta L_1 + f_{L_1-L_2} \times \Delta L_2)$$

$$= 1.571 \text{ m} \times \left[\frac{0 + 88.98}{2} \times 7.5 \text{ m} + 88.98 \times 12.5 \text{ m} \right] = 2271.795 \text{ kN}$$

$$\Rightarrow Q_{\text{design}} = \frac{Q_s}{F.S.} = \frac{2271.95}{2} = 1135.9 \text{ kN}$$

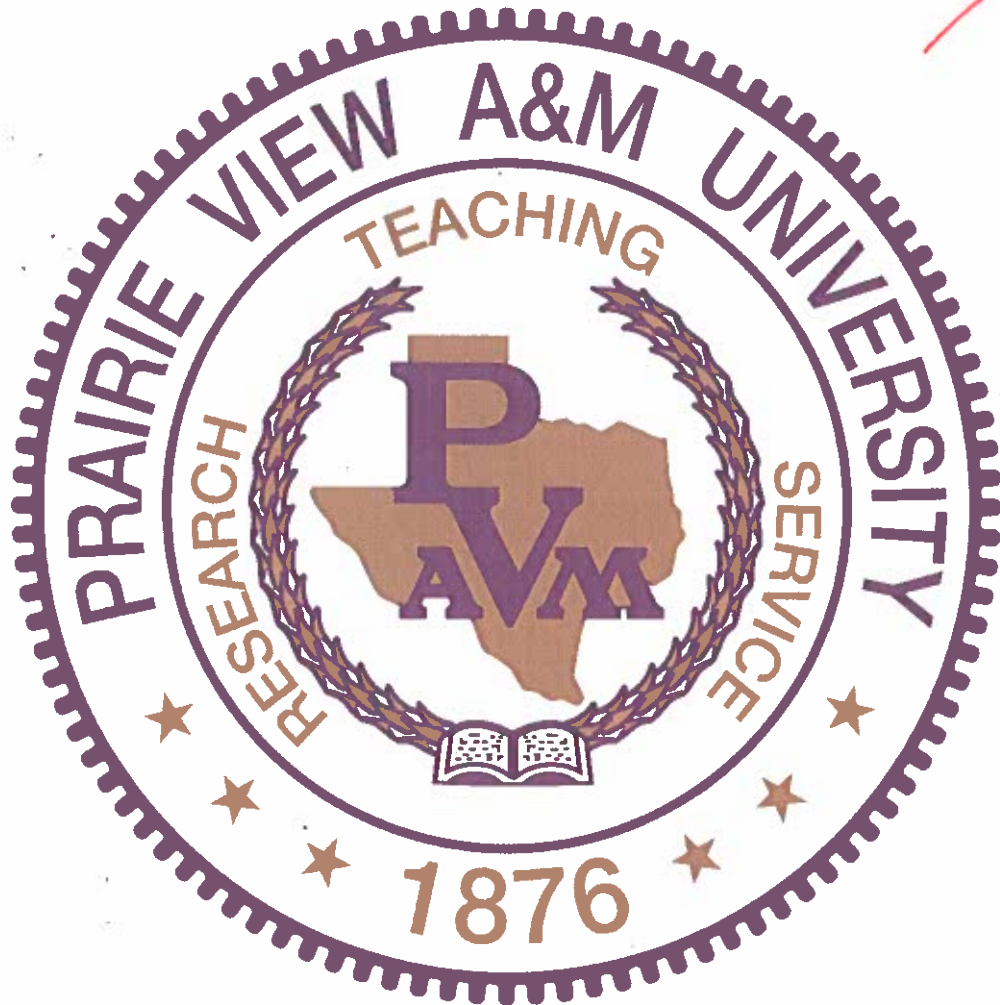
92 check
?

(10)

AVERAGE

Prairie View A&M University

80



CVEG 4100-P01 Geotechnical Engineering Design

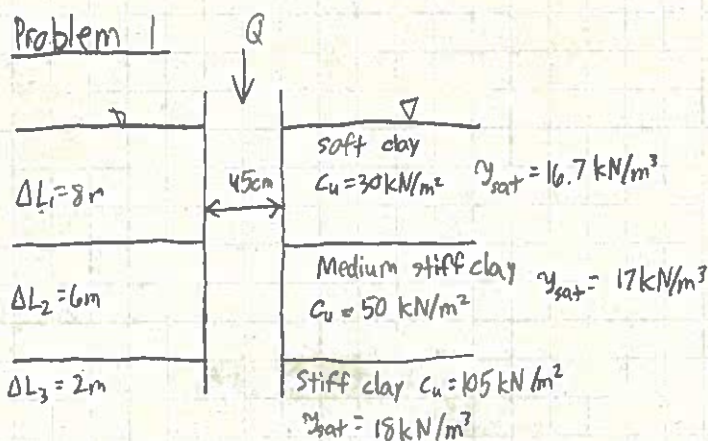
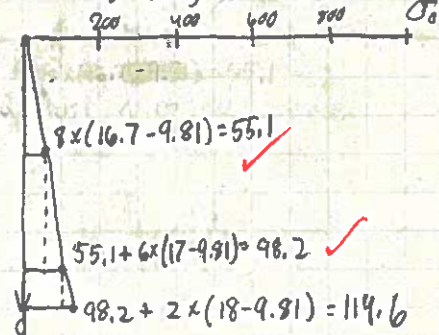
Homework 3

Due: Wednesday November 3, 2021

Submitted By: Nathaniel Smith

Submitted to: Dr. Alam

Problem 1

Find: $Q_u = ?$ Q_s using λ method

$$Q_u = Q_p + Q_s$$

$$Q_s = f_s \cdot P \cdot \Delta L, \quad Q_p = q c_u A_p$$

$$f_s = \lambda (\sigma_v + 2c_u)$$

$$\lambda = 0.200 + (16\text{ m} - 15\text{ m}) \times \frac{(0.173 - 0.200)}{(20\text{ m} - 15\text{ m})} = 0.19$$

$$\sigma_v = \frac{A_1 + A_2 + A_3}{L} = \frac{220.4 + 459.9 + 212.8}{16} = 55.8\text{ kPa}$$

$$A_1 = \frac{1}{2} (8) (55.1) = 220.4\text{ kN/m}, \quad A_2 = (6 \times 55.1) + \frac{1}{2} (98.2 - 55.1) (6) = 459.9\text{ kN/m}$$

$$A_3 = (2 \times 98.2) + \frac{1}{2} (114.6 - 98.2) (2) = 212.8\text{ kN/m}$$

$$c_u = \frac{\sum c_u \times \Delta L}{L} = \frac{(30 \times 8) + (50 \times 6) + (105 \times 2)}{16} = 46.9\text{ kPa}$$

$$f_s = 0.19 (55.8\text{ kPa} + 2(46.9\text{ kPa})) = 28.4\text{ kPa}$$

$$P = \pi (45\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}}) = 1.4\text{ m}$$

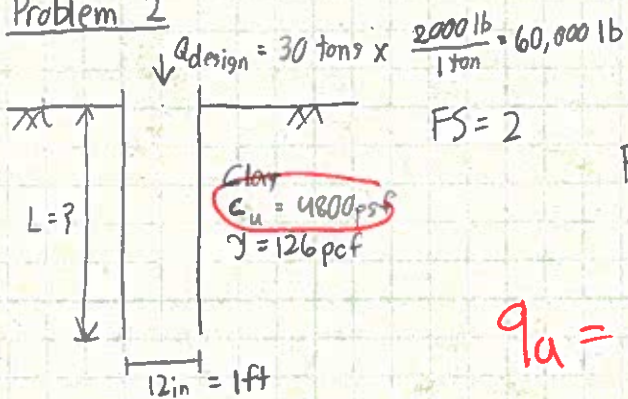
$$Q_s = 28.4\text{ kPa} (1.4\text{ m}) (16\text{ m}) = 636.2\text{ kN}$$

$$A_p = \frac{\pi (0.45\text{ m})^2}{4} = 0.16\text{ m}^2$$

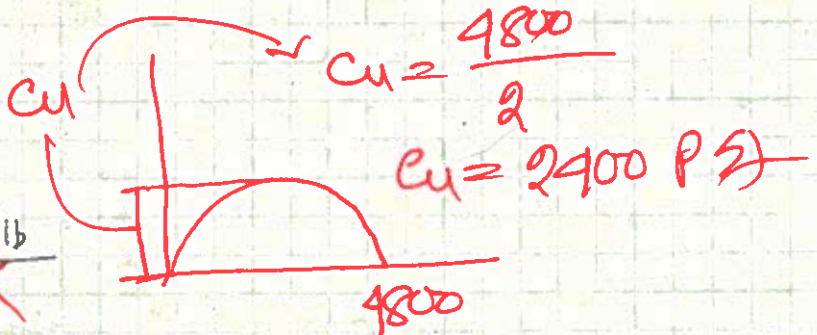
$$Q_p = q (105\text{ kPa}) (0.16\text{ m}^2) = 151.2\text{ kN}$$

$$Q_u = 151.2 + 636.2 = 787.4\text{ kN} = Q_u$$

Problem 2



$$q_u = 4800 \text{ psf}$$



$$Q_u = Q_p + Q_s$$

$$Q_p = q A_p C_u$$

$$A_p = \frac{\pi (1 \text{ ft})^2}{4} = .79 \text{ ft}^2$$

$$Q_p = q (.79 \text{ ft}^2) (4800 \text{ psf}) = 34,128 \text{ lb}$$

$$Q_s = \gamma P L$$

$$\gamma = \alpha C_u, \frac{C_u}{p_a} = \frac{4800}{2000} = 2.4 \rightarrow \alpha = .34$$

$$\gamma = .34 (4800) = 1632 \text{ psf}$$

$$P = \pi (1 \text{ ft}) = 3.14 \text{ ft}$$

$$Q_s = 1632 \text{ psf} (3.14 \text{ ft}) L$$

$$= 5124.5 L$$

$$Q_u = 34,128 + 5124.5 L$$

$$Q_{\text{all}} = \frac{Q_u}{FS} = 17,064 + 2562.3 L$$

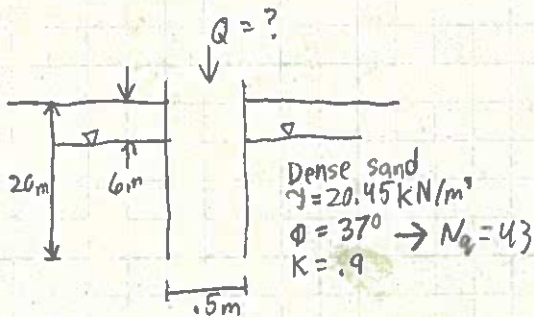
$$Q = Q_{\text{all}} \rightarrow 60,000 = 17,064 + 2562.3 L$$

$$42,936 = 2562.3 L$$

$$L = 16.8 \text{ ft}$$

(-15)

Problem 4



$$Q_s = s \cdot P \cdot \Delta L, \Delta L = L = 20\text{m}, P = \pi(0.5\text{m}) = 1.57\text{m}$$

$$s = K \sigma'_0 \tan \delta$$

$$\delta = \frac{2}{3} \phi = \frac{2}{3}(37^\circ) = 24.7^\circ$$

$$L' = 15D = 15(0.5\text{m}) = 7.5\text{m}$$

$$\sigma'_0 @ L' = 7.5\text{m} \rightarrow \sigma'_0 = (20.45\text{kN/m}^3 - 9.81\text{kN/m}^3) \times 7.5\text{m} = 79.8\text{kPa}$$

$$s = 0.9(79.8\text{kPa}) \tan 24.7^\circ$$

$$s = 33.03\text{kPa}$$

$$Q_s = P[s_{0-L'} \cdot \Delta L + s_{L'-L} \cdot \Delta L]$$

$$= 1.57\text{m} \left[\frac{0 + 79.8}{2} \times 7.5 + 79.8 \times 12.5 \right]$$

$$= 2035.9\text{kN}$$

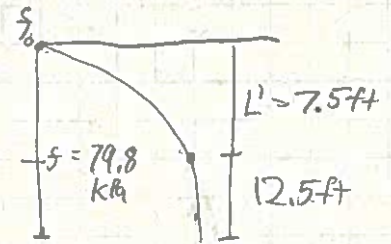
$$Q_p = q_p A_p$$

$$q_p = [(20.45 \times 6) + (20.45 - 9.81) \times 14] \times 43 = 11681\text{kPa}$$

$$Q_p = 11681\text{kPa} \left(\frac{\pi(0.5\text{m})^2}{4} \right) = 2293.6\text{kN}$$

$$Q_u = Q_p + Q_s = 2293.6\text{kN} + 2035.9\text{kN} = 4329.5\text{kN}$$

$$Q = Q_{all} = \frac{Q_u}{FS} = \frac{4329.5\text{kN}}{2} = 2164.8\text{kN}$$



q_p check

$$A_p \cdot q_p \leq A_p \cdot q_u$$

$$q_u = \frac{1}{2} \rho_a N_q^* \text{ Hand}$$

?

(-5)

BELOW AVERAGE

CIVIL ENGINEERING DEPARTMENT



75

CVEG 4100- Geotechnical Design

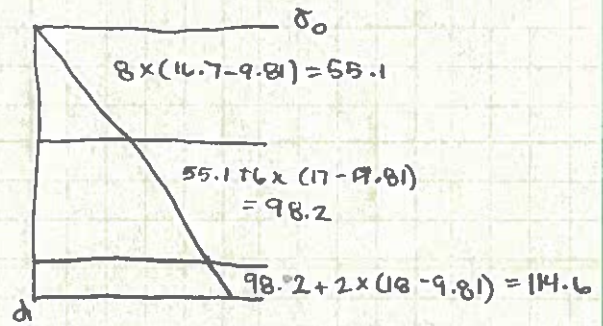
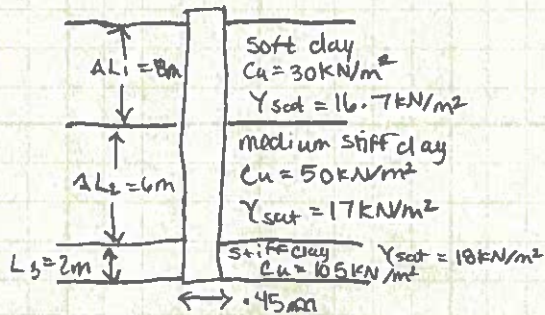
Homework #3

November 3, 2021

Shadaria Lynch

Problem 1

Given :



$$Q_u = ? \quad Q_s = ?$$

Solution:

$$Q_p = 9 c_u \times A_p \\ = 9 \times 105 \times 0.159 \\ = 150.3\text{ kN}$$

$$Q_s = f \times p \times \Delta L \\ f_{av} = \lambda (\sigma_0 + 2 c_u) \\ = 19 (55.8 + 2 \times 46.9) \\ = 28.4\text{ kPa}$$

$$P = \pi (0.45\text{m}) = 1.4\text{m}$$

$$Q_s = 28.4\text{ kPa} \times 1.4\text{m} \times 16\text{m} \\ = 636.16\text{ kN}$$

$$Q_u = Q_p + Q_s \\ = 150.3 + 636.16 \\ = 786.46\text{ kN}$$

$$A_p = \frac{\pi d^2}{4} = \frac{\pi (0.45)^2}{4} = 0.159\text{ m}^2$$

$$\lambda = .200 + (16\text{m} - 15\text{m}) \times \frac{(.173 - .200)}{20\text{m} - 15\text{m}}$$

$$\lambda = .19$$

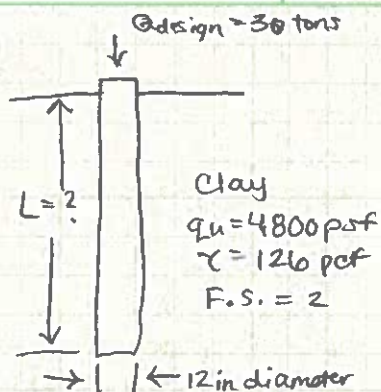
$$\sigma_0 = \frac{A_1 + A_2 + A_3}{L} = \frac{220.4 + 459.9 + 22.8}{16}$$

$$\sigma_0 = 55.8\text{ kPa}$$

$$c_u = \frac{\sum (c_u \times \Delta L)}{16} \\ = \frac{(30 \times 8) + (50 \times 6) + (105 \times 2)}{16} = 46.9\text{ kPa}$$

Problem 2

Given:



Solution:

$$Q_s = \frac{Q_{\text{design}}}{F.S.} = \frac{30 \text{ tons}}{2} = 15 \text{ tons}$$

$$C_u = \frac{q_u}{2} = \frac{4800}{2} = 2400 \text{ pcf} \quad \checkmark$$

$$Q_s = 9 C_u A_p + \pi \alpha C_u \times D \times L$$

$$15 \times 2000 = 9 \times 2400 \times \frac{\pi (1 \text{ ft})^2}{4} + \pi \times 0.5 \times 2400 \times 1 \times L$$

$$\Rightarrow L = 3.45 \text{ ft}$$

$$A_p = \frac{\pi (1)^2}{4} = 0.785 \text{ ft}^2$$

assume $\alpha = 0.5$

F.S. = 2

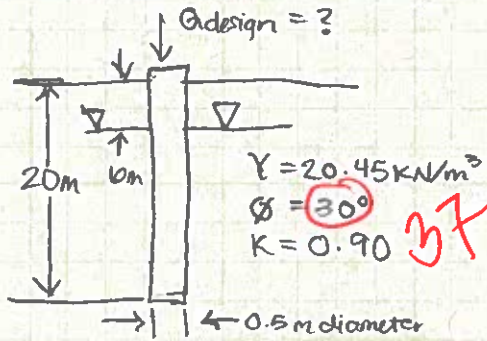
$Q_u = Q_s + Q_p$

$$Q_{\text{all}} = \frac{Q_s + Q_p}{F.S.}$$

(-10)

Problem 3

Given :



$$Q_s = f \cdot p \cdot \Delta L$$

$$= 0.476 \times 1.57 \times 20$$

$$= 14.946 \text{ kN}$$

$$Q_p = q A_p$$

$$= 11681.38 \times \left(\frac{\pi (0.5)^2}{4} \right)$$

$$= 2293.63 \text{ kN}$$

$$\Delta L = L = 20 \text{ m}$$

$$p = \pi (0.5 \text{ m}) = 1.57 \text{ m}$$

$$f = K \sigma_v \tan \delta$$

$$\delta = \frac{2}{3} (30^\circ) = 20.38^\circ$$

$$L' = 15D = 15(0.5 \text{ m}) = 7.5 \text{ m}$$

$$\sigma_v = (20.45 \text{ kN/m}^3 - 9.81 \text{ kN/m}^3) \times 7.5 \text{ m} = 79.8 \text{ kPa}$$

$$f = 0.90 \times 79.8 \tan(20.38^\circ) = 0.476 \text{ kPa}$$

$$q = [(20.45 \times 6) + (20.45 - 9.81) \times 14] \times 1.43$$

$$= 11681.38 \text{ kPa}$$

$$Q_u = Q_p + Q_s = 2293.63 \text{ kN} + 14.946 \text{ kN} = 2254.576$$

$$Q_{all} = \frac{Q_u}{FS} = \frac{2254.576}{2} = \boxed{1127.3 \text{ kN}}$$

q_e check
?

(-15)

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Title of Assignment: Project Report 1

TOPICS COVERED IN PROJECT REPORT 1

1. Shallow Foundation Design

**NOTE: Pages L1 through L7 should be repeated for each Report and
Similarly for all the other assignments in the course binder**

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

SAMPLE PROJECT QUESTIONS



Design Project

Initial information search or review:

Read the letter of request thoroughly for a project to be completed in Lubbock. Find out the necessary information from the letter required to design the foundation system for the project. The column loading from the structural design is also provided in the letter. Based on the review of the documents, design the shallow foundation system for the proposed project.

Design of the foundation system should include (BUT NOT LIMITED TO):

1. Soil boring information and sub-surface soil condition.
2. Ground water table location (if any).
3. Detail soil information and design soil parameters.
4. Design the foundation for both bearing capacity and settlement consideration.
5. Recommend the best shallow foundation system providing all the details, calculation, reason for choosing your particular type of foundation.
6. Show detail of the foundation in CAD drawing.

Note:

A professional comprehensive report is expected. Put detailed information, design detail, necessary graphs, assumption (if any) and other details in the report. To design the foundation systems of the project, a sample calculation from each design component is required in the appendix. Use of Auto CAD is recommended in drawing detailing (where required).

It is a group project, team work is necessary to complete the project. Project report and presentation will be evaluated and graded separately for each individual student.



June 12, 2019

Md. Jobair Bin Alam, Ph.D., P.E., A.M., ASCE
Assistant Professor
Department of Civil & Environmental Engineering
Roy G. Perry College of Engineering
P.O. Box 519, Mail Stop 2510
SR Collins Building, Suite 312
Prairie View A&M University
Prairie View, TX 77446

Dr. Alam,

Please prepare for us a written proposal to perform a comprehensive geotechnical investigation and to prepare a written report of your analysis and recommendations for the building foundation and parking cross section for this project. BGR Architects would like to receive your proposal to perform the testing and prepare the report as soon as possible. We will work with Jim Melton at BGR to review the proposal and approve it if it is acceptable. We hope to get your proposal approved quickly after we receive it and that you would be able to start the geotechnical investigation and have the completed report in our office as soon as possible. The geotechnical investigation shall determine:

1. Physical characteristics of the soils including depth, thickness, and composition of each soil and rock stratum.
2. Depth, thickness, and composition of old excavation or fill materials, if present.
3. The elevation of ground water and whether dewatering is required.
4. The engineering properties of the soil and rock strata that affect the performance of the building structure.



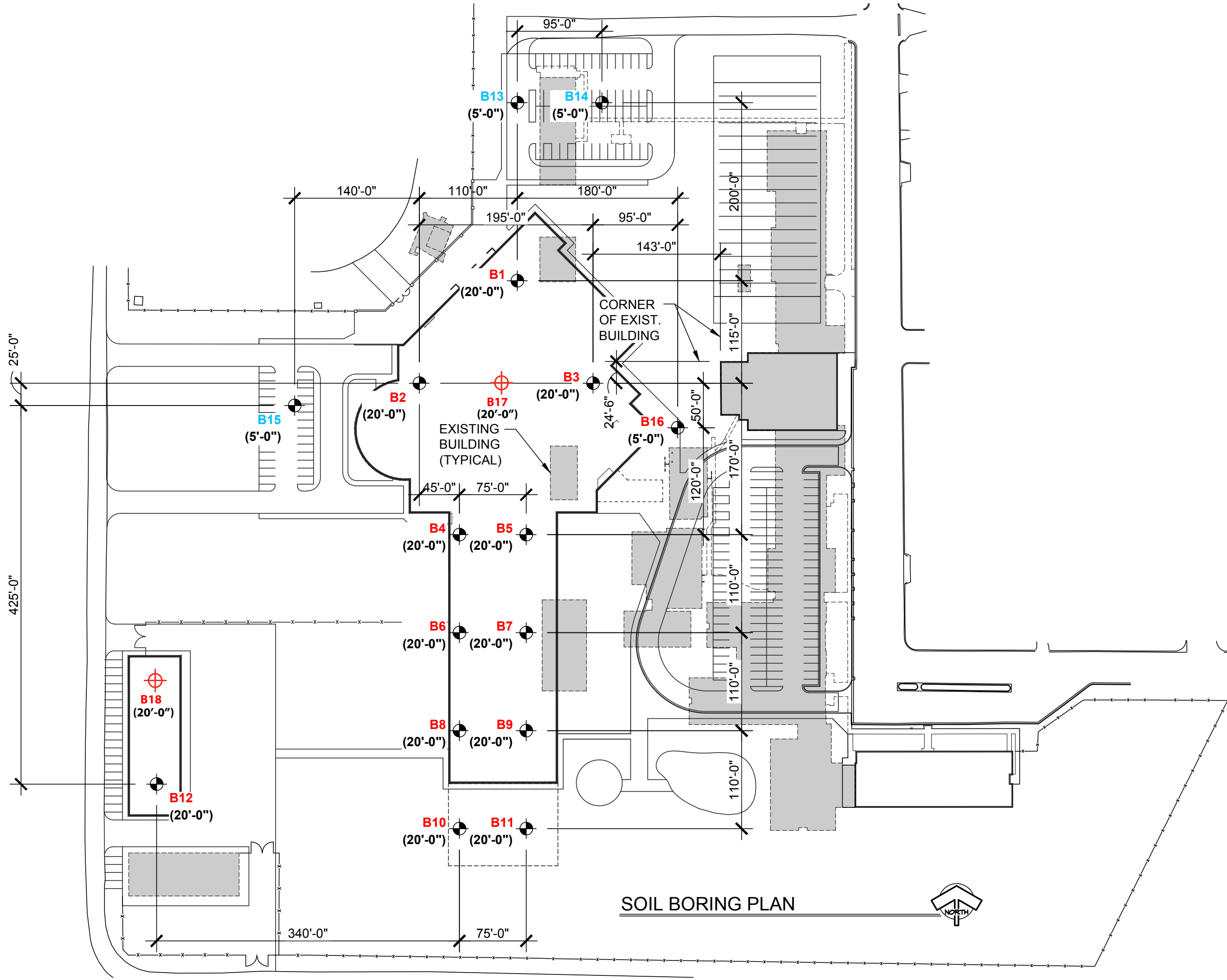
The geotechnical report should include, but not necessarily be limited to, the following:

1. General description of the site and a plot plan locating borings and any outstanding surface features such as rock outcroppings.
2. Log of borings, including ground water levels and rock surface features.
3. Field and laboratory test data.
4. Classification of soil strata at the surface, underlying the surface, and at the various recommended bearing levels.
5. Recommended foundation type (spread footings or drilled piers).
6. Recommended allowable bearing capacities (depending on the type of foundation recommended) for isolated footings, continuous footings, or drilled piers. Allowable bearing values shall be indicated as net values.
7. Recommended bearing depths (depending on the type of footing recommended) for isolated footings, continuous footings, or drilled piers.
8. Recommended minimum sizes (depending on the type of footing recommended) for isolated footings, continuous footings, or drilled piers.
9. Recommended allowable horizontal bearing values for drilled piers.
10. Recommendations for excavation, including evaluation of any difficulties that might be expected with the excavation operation, such as dewatering. Provide recommendations regarding the feasibility of using drilled, cast-in-place concrete piers. Where rock is present, recommendations regarding need for ripping or blasting shall be provided.
11. Recommendations for structural fill materials including anticipated depths of undercut, depth of fill required, type of materials to be used for structural fill, if the existing onsite soils could be used in various types of compacted fills, and the amount of compaction required.
12. Recommendations for paving parking areas and light and heavy duty traffic areas. Include thickness and types of materials for the top wearing surface, base course, and sub-base, as well as subgrade preparation, compaction requirements, CBR values and other appropriate design data.

A site plan for this project showing the location of the new buildings is included with this request for proposal. The site plan indicates the locations of 12 soil borings located under the proposed buildings and each soil boring shall be a minimum of 20'-0" deep. These soil borings shall be used to determine recommendations for the building foundations. The buildings will be constructed with a conventional steel framed building structural system. The maximum column loads under the columns will be approximately 50 kips. We anticipate the foundations will consist of continuous footings around the perimeter of the building and spread footings under isolated steel columns. The site plan also indicates the location of 4 soil borings under the proposed parking areas. These soil borings shall be a minimum of 5'-0" deep. These soil borings shall be used to determine paving recommendations.

Sincerely,

Mr. Jim Melton, A.I.A.
BGR Architects, INC.



SOIL BORING PLAN



PROJECT NO.	PROJECT: New K-12 School Petersburg ISD	Petersburg, Texas	DATE: 6/12/19 SCALE: NONE
THOMA ENGINEERING, INC. FIRM REGISTRATION NO. F-1575			DRAWING NO. SB-1



BORING LOG

PROJECT NO.: STR 2481L
 INVOICE NO.: 239609
 PROJECT: New K-12 School Petersburg ISD
 LOCATION: Petersburg, TX
 CLIENT: BGR Architects Inc.
 CONTACT: Mr. Jim Melton, AIA

TEST HOLE: B-1
 SHEET NUMBER: 1 of 1
 DATE STARTED: 7/11/2019
 DATE FINISHED: 7/11/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: Jobair

DRILL RIG: CME 75							TEST HOLE DIAMETER (in): 8			GROUND WATER DATA:				
DRILLING METHOD: Hollow Stem Auger							TOTAL DEPTH (ft): 21.5			DATE	TIME	WATER DEPTH (ft)	REMARKS	
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019				Dry			
SYMBOL	None	S 	U 	T 	G 	C 								
DEPTH (FEET)	FIELD RESULTS						DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)		GRAPHIC LOG	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		10	9	9					11.0	38	15	23	66.7	
		6	9	9	N=30			Sandy lean clay (CL), dark gray	12.3					
5		10	17	18	N=35				13.8	35	14	21	74.1	
		3	4	9				Lean clay with sand (CL), pink	13.2					
10		6	13	21					15.5	41	13	28	77.1	
								Lean clay with sand (CL), light reddish brown	13.7					
15		8	16	25										
														
20		9	19	34				Sandy lean clay (SCL)  light reddish brown	17.5	34	13	21	60.6	
								Bottom of Borehole at 21.5 feet						



PROJECT NO.: STR 2481L
INVOICE NO.: 239609
PROJECT: New K-12 School Petersburg ISD

LOCATION: Petersburg, TX
CLIENT: BGR Architects Inc.
CONTACT: Mr. Jim Melton, AIA

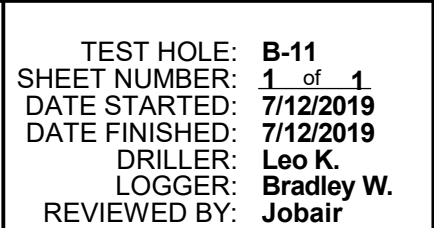
TEST HOLE: **B-10**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **B.Caro**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019			Dry
SYMBOL	None									

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS	
		0-6"	6-12"	12-18"											
0		3	5	5				Lean clay with sand (CL), very dark gray	13.3						
		3	3	4				(CL), pinkish gray	13.0	43	16	27	70.8		
5		3	7	7				(CL), reddish brown	12.6						
		9	13	18				Sandy lean clay (CL), reddish brown	11.0	38	13	25	64.4		
10		9	12	16					8.7						
15		13	28	26				(CL), pink	12.2	39	14	25	66.7		
20		15	30	39					12.8						
								Bottom of Borehole at 21.5 feet							





BORING LOG

PROJECT NO.: STR 2481L
 INVOICE NO.: 239609
 PROJECT: New K-12 School Petersburg ISD
 LOCATION: Petersburg, TX
 CLIENT: BGR Architects Inc.
 CONTACT: Mr. Jim Melton, AIA

TEST HOLE: B-12
 SHEET NUMBER: 1 of 1
 DATE STARTED: 7/11/2019
 DATE FINISHED: 7/11/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: Jobair

DRILL RIG: CME 75							TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:						
DRILLING METHOD: Hollow Stem Auger							TOTAL DEPTH (ft): 21.5		DATE	TIME	WATER DEPTH (ft)	REMARKS			
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019				Dry				
SYMBOL	None	S 	U 	T 	G 	C 									
DEPTH (FEET)	FIELD RESULTS						DESCRIPTION	LABORATORY RESULTS							
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)		GRAPHIC LOG	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS	
		0-6"	6-12"	12-18"											
0		0	0	3				Lean clay with sand (CL), reddish brown	22.4						
		3	4	5											
5		3	3	4				(CL), reddish gray	18.1						
		2	3	4				Sandy lean clay (CL), reddish gray	21.8	40	12	28	67.8		
10		4	11	14					12.2						
		17	14	15				(CL), pink	15.4	35	15	20	60.6		
15															
20		8	14	19					17.7						
								Bottom of Borehole at 21.5 feet							



BORING LOG

PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**
LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-13**
SHEET NUMBER: **1** of **1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG: CME 75 TEST HOLE DIAMETER (in): 8							GROUND WATER DATA:						
DRILLING METHOD: Hollow Stem Auger TOTAL DEPTH (ft): 6.5							DATE	TIME	WATER DEPTH (ft)	REMARKS			
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019			Dry			
SYMBOL	None	S ☐	U ☐	T ☒	G ☒	C ☐							
DEPTH (FEET)	FIELD RESULTS						LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)
0-6"	6-12"	12-18"											
0	2	4	7					5.1	38	16	22	44.3	
	4	7	7				Clayey sand (SC), reddish brown	9.9					
5	7	11	14				Lean clay with sand (CL), reddish brown	14.5	45	14	31	73.6	
							Bottom of Borehole at 6.5 feet						



PROJECT NO.: STR 2481L
INVOICE NO.: 239609
PROJECT: New K-12 School Petersburg ISD

LOCATION: Petersburg, TX
CLIENT: BGR Architects Inc.
CONTACT: Mr. Jim Melton, AIA

TEST HOLE: **B-14**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	6.5

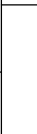
DATE	TIME	WATER DEPTH (ft)	REMARKS
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TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE
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7/12/2019			Dry
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SYMBOL	None	S 	U 	T 	G 	C 
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DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		4	4	4					11.1					
														
		4	4	4				Lean clay with sand (CL), reddish brown	14.0	38	12	26	74.6	
														
5		3	9	16					16.0					
								Bottom of Borehole at 6.5 feet						



PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**

LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-15**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/11/2019**
DATE FINISHED: **7/11/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	6.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019			Dry
SYMBOL	None	S 	U 	T 	G 	C 				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		4	6	7				Sandy lean clay (CL), very dark gray	8.1	36	13	24	68.2	
		7	9	12				(CL), reddish brown	10.5					
5		12	17	19				Fat clay with sand (CH), gray	12.5	60	19	41	78.2	
								Bottom of Borehole at 6.5 feet						



BORING LOG

PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**
LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-16**
SHEET NUMBER: **1** of **1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG: **CME 75** TEST HOLE DIAMETER (in): **8**
DRILLING METHOD: **Hollow Stem Auger** TOTAL DEPTH (ft): **6.5**

GROUND WATER DATA:

DATE	TIME	WATER DEPTH (ft)	REMARKS
7/12/2019			Dry

TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE
SYMBOL	None	S ☒	U ☒	T ☒	G ☒	C ☒

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		10	7	7				Lean clay with sand (CL), dark reddish brown	16.1					
		3	4	4					16.1	41	18	23	73.0	
								(CL), light reddish brown						
5		3	7	12					15.3					
								Bottom of Borehole at 6.5 feet						



BORING LOG

PROJECT NO.: STR 2481L
INVOICE NO.: 239609
PROJECT: New K-12 School Petersburg ISD
LOCATION: Petersburg, TX
CLIENT: BGR Architects Inc.
CONTACT: Mr. Jim Melton, AIA

TEST HOLE: B-17
SHEET NUMBER: 1 of 1
DATE STARTED: 7/11/2019
DATE FINISHED: 7/11/2019
DRILLER: Leo K.
LOGGER: Bradley W.
REVIEWED BY: Jobair

DRILL RIG: CME 75			TEST HOLE DIAMETER (in): 8			GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 21.5			DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019		Dry
SYMBOL	None	S ☐	U ☐	T ☒	G ☒	C ☐			

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		11	7	3					14.1	41	17	24	71.2	
		3	3	2				Lean clay with sand (CL), light reddish brown	17.7					
5		3	6	7					17.0	38	14	24	72.8	
		4	7	10					17.3					
10		4	9	14				(CL), pink	16.4	44	18	26	71.3	
15		7	13	17					18.6					
								(CL), yellowish red						
20		11	19	31				Sandy lean clay (SC), yellowish red	17.0	38	18	20	51.2	
								Bottom of Borehole at 21.5 feet						



PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**

LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-18**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/11/2019**
DATE FINISHED: **7/11/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019			Dry
SYMBOL	None									

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		0	1	2					21.6					
		3	4	4				Sandy lean clay (CL), reddish brown	18.9	45	14	31	60.4	
5		4	6	8				(CL), dark gray	20.9					
		5	6	7					18.3	38	14	24	64.2	
10		1	2	2				(CL), pinkish gray	17.0					
15		8	13	19					13.3	35	14	21	48.6	
								Clayey sand (SC), pink						
20		10	24	30					16.2					
								Bottom of Borehole at 21.5 feet						



BORING LOG

PROJECT NO.: STR 2481L
INVOICE NO.: 239609
PROJECT: New K-12 School Petersburg ISD
LOCATION: Petersburg, TX
CLIENT: BGR Architects Inc.
CONTACT: Mr. Jim Melton, AIA

TEST HOLE: B-2
SHEET NUMBER: 1 of 1
DATE STARTED: 7/11/2019
DATE FINISHED: 7/11/2019
DRILLER: Leo K.
LOGGER: Bradley W.
REVIEWED BY: Jobair

DRILL RIG: CME 75							TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:				
DRILLING METHOD: Hollow Stem Auger							TOTAL DEPTH (ft): 21.5				DATE	TIME	WATER DEPTH (ft)	REMARKS	
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019							Dry	
SYMBOL	None	S 	U 	T 	G 	C 									
DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS	
0		4	6	7				Lean clay with sand (CL), reddish gray	6.4						
		6	8	10				(CL), reddish brown	11.5	41	12	 25	75.4		
5		10	8	8				(CL), pink	15.9						
		6	8	10				 Sandy lean clay (SC), pink	14.5	34	15	19	67.7		
10		6	17	22					17.5						
15		10	15	24				 (SC), light reddish brown	17.0	41	17	24	64.5		
20		24	29	31					11.4						
Bottom of Borehole at 21.5 feet															



PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**

LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-3**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019			Dry
SYMBOL	None									

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		6	4	6				Sandy lean clay (CL), gray	17.8	45	16	29	62.7	
		2	3	6				(CL), very dark gray	17.7					
5		4	5	4					16.2	35	14	21	70.1	
		4	6	7					14.8					
10		5	12	16				Lean clay with sand (CL), pink	15.6	42	17	25	73.4	
15		9	15	18				(CL), light reddish brown	13.9					
20		8	25	29				Sandy lean clay (CL), light reddish brown	15.8	35	16	19	56.7	
								Bottom of Borehole at 21.5 feet						



PROJECT NO.: STR 2481L
INVOICE NO.: 239609
PROJECT: New K-12 School Petersburg ISD

LOCATION: Petersburg, TX
CLIENT: BGR Architects Inc.
CONTACT: Mr. Jim Melton, AIA

TEST HOLE: **B-4**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

DATE	TIME	WATER DEPTH (ft)	REMARKS
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TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE
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7/12/2019			Dry
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SYMBOL	None	S	U	T	G	C
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DEPTH (FEET)	SAMPLE	FIELD RESULTS					GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS										
		SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS					
		0-6"	6-12"	12-18"															
0		3	5	5			Lean clay with sand (CL), gray	11.7	37	15	22	74.8							
		6	7	8			(CL), reddish gray	13.8											
5		5	6	8				16.5											
		3	4	6				16.1											
10		4	6	9			(CL), reddish brown	15.7											
15		8	15	19				16.0											
20		8	15	21			Sandy lean clay (CL), reddish brown	17.2											
							Bottom of Borehole at 21.5 feet												



PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**

LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-5**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE: 7/12/2019		TIME:		WATER DEPTH (ft):		REMARKS:	
TYPE/		CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE							
SYMBOL		None	S 	U 	T 	G 	C 							

DEPTH (FEET)	SAMPLE	FIELD RESULTS					GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
		SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		8	10	8					11.3				75.6	
		5	5	9				Lean clay with sand (CL), pinkish gray	12.6					
5		7	12	18				(CL), reddish brown	13.3	36	13	23	70.2	
		6	11	15					9.6					
10		10	11	9					14.4	38	15	23	76.3	
								(CL), pink						
15		23	32	24					9.0					
														
20		11	11	10				Sandy lean clay (CL), pink	14.7	33	15	18	69.7	
								Bottom of Borehole at 21.5 feet						



BORING LOG

PROJECT NO.: **STR 2481L**
 INVOICE NO.: **239609**
 PROJECT: **New K-12 School Petersburg ISD**
 LOCATION: **Petersburg, TX**
 CLIENT: **BGR Architects Inc.**
 CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-6**
 SHEET NUMBER: **1 of 1**
 DATE STARTED: **7/12/2019**
 DATE FINISHED: **7/12/2019**
 DRILLER: **Leo K.**
 LOGGER: **Bradley W.**
 REVIEWED BY: **Jobair**

DRILL RIG: CME 75							TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:					
DRILLING METHOD: Hollow Stem Auger							TOTAL DEPTH (ft): 21.5		DATE	TIME	WATER DEPTH (ft)	REMARKS		
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019				Dry			
SYMBOL	None	S 	U 	T 	G 	C 								
DEPTH (FEET)	FIELD RESULTS						DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)		GRAPHIC LOG	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		2	3	5				Sandy lean clay (CL), gray	17.6					
		5	8	9				(CL), pink	16.8	37	14	23	66.0	
5		4	5	8				(CL), reddish brown	17.5					
		4	4	4					17.3	32	14	18	76.2	
10		4	6	7				Lean clay with sand (CL), pink	14.9					
														
15		3	6	12					15.3	39	15	24	68.2	
														
20		9	17	22				Sandy lean clay (CL), light reddish brown	19.5					
								Bottom of Borehole at 21.5 feet						



PROJECT NO.: **STR 2481L**
INVOICE NO.: **239609**
PROJECT: **New K-12 School Petersburg ISD**

LOCATION: **Petersburg, TX**
CLIENT: **BGR Architects Inc.**
CONTACT: **Mr. Jim Melton, AIA**

TEST HOLE: **B-7**
SHEET NUMBER: **1 of 1**
DATE STARTED: **7/12/2019**
DATE FINISHED: **7/12/2019**
DRILLER: **Leo K.**
LOGGER: **Bradley W.**
REVIEWED BY: **Jobair**

DRILL RIG:	CME 75	TEST HOLE DIAMETER (in):	8
DRILLING METHOD:	Hollow Stem Auger	TOTAL DEPTH (ft):	21.5

GROUND WATER DATA:

DRILLING METHOD: Hollow Stem Auger							DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019			Dry
SYMBOL	None	S 	U 	T 	G 	C 				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		3	4	4					9.3	40	17	23	64.7	
		7	5	4				Sandy lean clay (CL), pinkish gray	13.6					
5		4	6	8				(CL), reddish brown	16.0	36	16	20	68.5	
		7	8	9					12.0					
10		3	2	2					10.7	38	12	26	69.9	
15		17	27	35				(CL), pink	12.1					
20		26	32	38					15.1	39	13	26	59.0	
								Bottom of Borehole at 21.5 feet						



BORING LOG

PROJECT NO.: STR 2481L
 INVOICE NO.: 239609
 PROJECT: New K-12 School Petersburg ISD
 LOCATION: Petersburg, TX
 CLIENT: BGR Architects Inc.
 CONTACT: Mr. Jim Melton, AIA

TEST HOLE: B-8
 SHEET NUMBER: 1 of 1
 DATE STARTED: 7/12/2019
 DATE FINISHED: 7/12/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: Jobair

DRILL RIG: CME 75			TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 21.5				DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/12/2019			Dry
SYMBOL	None	S ☐	U ☐	T ☒	G ☒	C ☐				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS									
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS				
		0-6"	6-12"	12-18"														
0		2	4	5			Sandy lean clay (CL), light gray	15.8	35	15	20	66.2						
		4	8	8			(CL), pink	18.0										
5		3	5	6			(CL), reddish brown	19.0										
		5	5	5				19.7										
10		3	3	6			Lean clay with sand (CL), pink	15.9										
15		8	12	15				13.5										
							Sandy lean clay (CL), pink											
20		6	11	14			(CL), reddish brown	19.6										
								Bottom of Borehole at 21.5 feet										



BORING LOG

PROJECT NO.: **STR 2481L**
 INVOICE NO.: **239609**
 PROJECT: **New K-12 School Petersburg ISD**
 LOCATION: **Petersburg, TX**
 CLIENT: **BGR Architects Inc.**
 CONTACT: **Mr. Jim Melton, AIA**

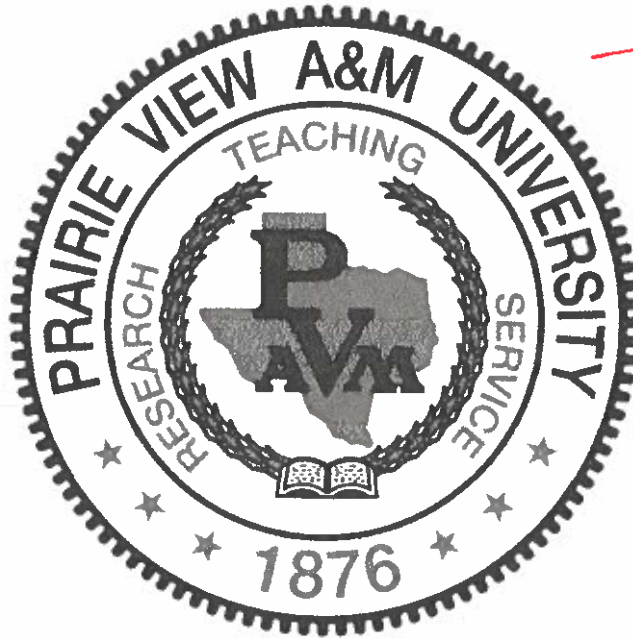
TEST HOLE: **B-9**
 SHEET NUMBER: **1 of 1**
 DATE STARTED: **7/11/2019**
 DATE FINISHED: **7/11/2019**
 DRILLER: **Leo K.**
 LOGGER: **Bradley W.**
 REVIEWED BY: **Jobair**

DRILL RIG: CME 75			TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 21.5				DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	7/11/2019			Dry
SYMBOL	None	S ☒	U ☒	T ☒	G ☒	C ☒				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS	
		0-6"	6-12"	12-18"											
0		4	6	6				Fat clay with sand (CH), reddish gray	9.9	51	17	34	73.4		
		5	6	7				(CH), grayish brown	10.5						
5		6	9	9				Lean clay with sand (CL), grayish brown	12.1	45	14	31	73.2		
		9	15	14					9.8						
10		8	10	14				(CL), pink	11.0	38	12	26	73.6		
15		13	48	48				(CL), reddish brown	11.0						
20		18	25	28				Sandy fat clay (CH), pinkish white	16.8	55	15	40	69.9		
							Bottom of Borehole at 21.5 feet								

ABOVE AVERAGE

Prairie View A&M University



CVEG 4021: Geotechnical Engineering Design Project **Shallow Foundation Design**

Autumn Carter

Shadaria Lynch

Perla Zaldivar

Submitted to:
Dr. J. B. Alam

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Letter of Transmittal

October 13, 2021

Dr. Jobair Bin Alam
Civil & Environmental Engineering
Prairie View A&M University

Dear Dr. Alam,

The attached technical report contains the detailed results of the proposed shallow foundation design for the new K-12 school. The report contains an analysis and recommendation for the building foundation best suited for a building located in Lubbock, Texas. This report consists of the introduction, site location, the soil profile of the site area with the inclusion of boring logs from B-1 to B-18 and the spread footing of the proposed parking areas. If you have any questions or concerns, please do not hesitate to contact us.

Sincerely,
Autumn Carter
Shadaria Lynch
Perla Zaldivar

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Introduction

The engineers that created this document were tasked with recommending a foundation type for a planned skyscraper in Lubbock, Texas. A steel frame is used to construct the structure. The facility's foundation must be constructed for bearing capacity as well as settling. The benefits and downsides of various types of foundations are grouped together, along with justifications for the foundation dimensions chosen.

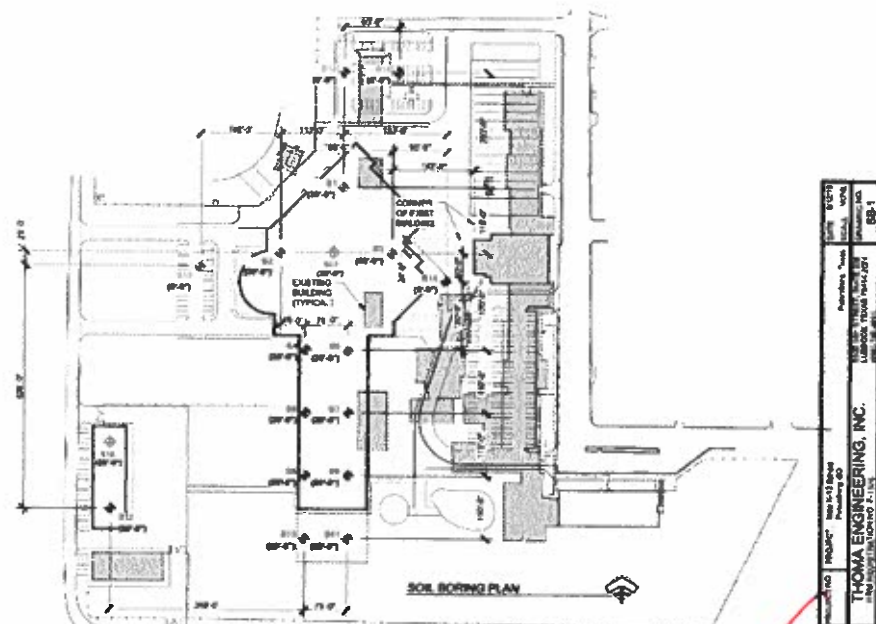
City of Lubbock requires BGR Architects to conduct a geotechnical assessment and design a foundation system. Soil boring information, ground water table position, precise soil information, and design soil parameters are all part of the foundation system. A design for both bearing capacity and settling concerns, as well as a suggestion for the optimal shallow foundation system and a CAD drawing, will be included in the system. These design elements will offer the information that a shallow foundation system requires.

The project's goal is to investigate the subsurface conditions at a given location in order to aid foundation design for proposed constructions and then make general recommendations for the new existing structure. Drilling soil borings to depths of 0-20 feet below current grades within the planned development area, laboratory testing, and the creation of an engineering report were all part of the scope of services.

Chapter 1: Proposed K-12 School Petersburg ISD

1.1 Site Location

The proposed school for Petersburg ISD is located in Lubbock, TX. The site plan for the school is shown in Figure 1, also displaying the location of the borings. The school building will be built of a conventional steel frame. Of all the borings 12 are located under the proposed building at a minimum of 20 ft deep. There are 4 borings located on the proposed parking areas. The soil borings should be taken at a minimum of 5 feet deep. The maximum column load allowed is 50 kips. The foundation will consist of a continuous footing for the perimeter of the building while the steel columns will have a spread footing.



1.2 Soil Profile from Boring Log

The boring log showed that the soil was dry and no ground water present. The boring log contains a detailed description for each boring sample taken. Figure 2 displays the boring log description found for test hole B-1, B-2 and B-3. For B-1 the soil was found to be lean clay with sand (CL) however it varied by color throughout the 20 ft. After 20 ft the soil was found to be sandy lean clay (SC). For B-2 the soil was found to be lean clay with soil to 7.5 ft and sandy lean clay (SC) for the rest of the boring. For B-3 the soil sample was found to be lean clay with sand (CL).

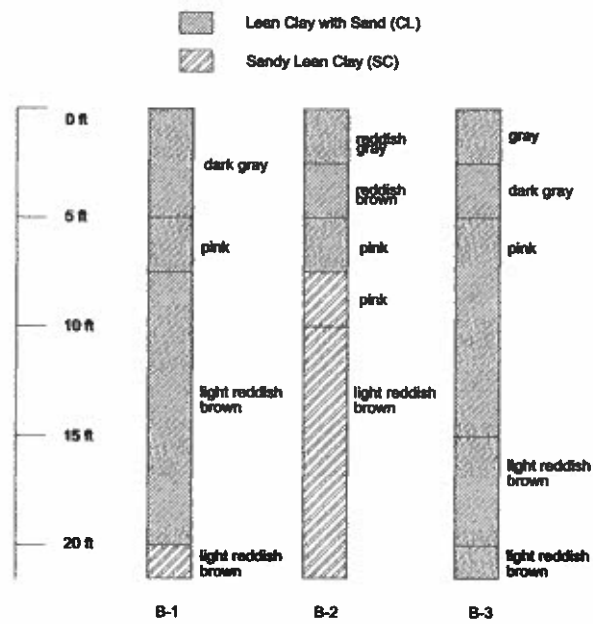


Figure 2. Boring Profile for B-1 to B-3

Figure 3 displays the boring log description found for test hole B-4, B-5 and B-6. All three boring soil samples were found to be a lean clay soil with different variations of colors.

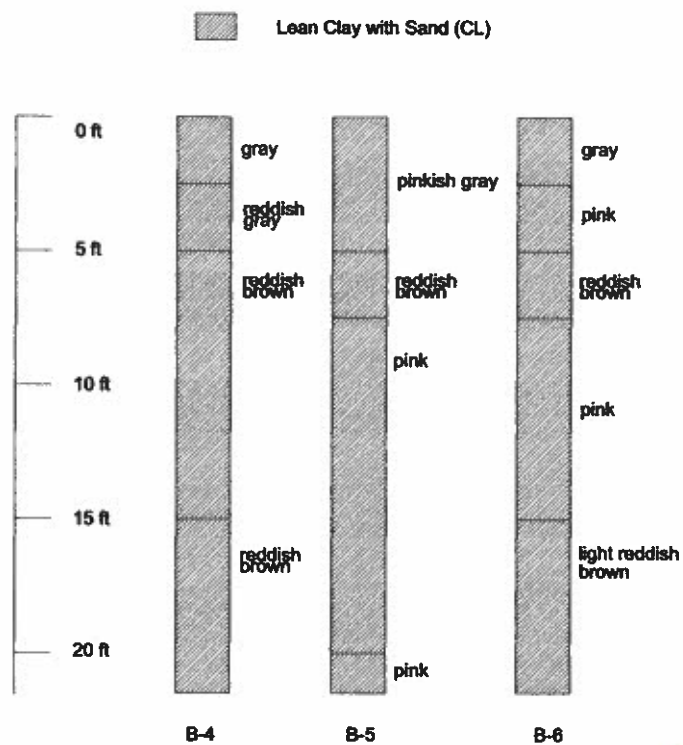


Figure 3. Boring Profile for B-4 to B-6

Figure 4 displays the boring log description found for test hole B-7, B-8 and B-9. Boring 7 and 8 is composed of lean clay with sand. While boring 9 contains lean clay with sand and fat clay with sand

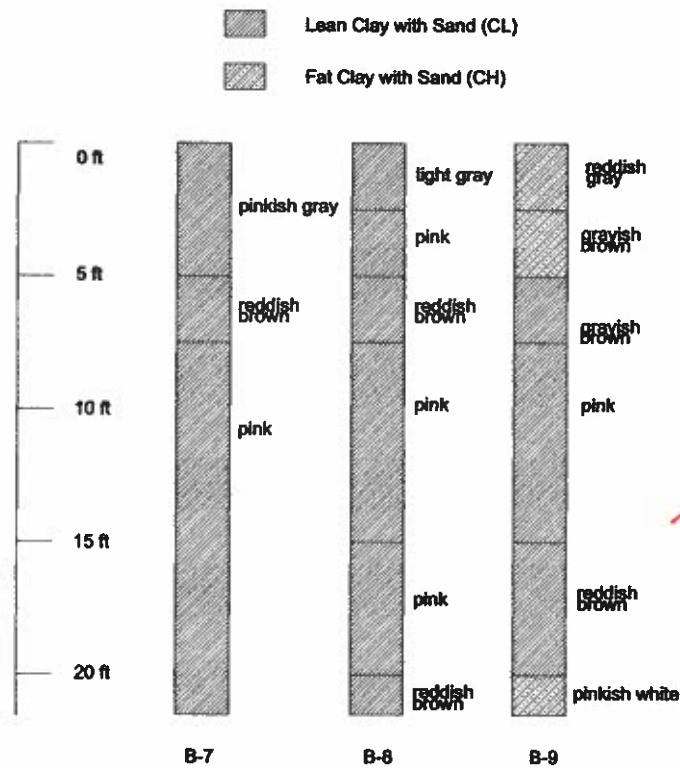


Figure 4. Boring Profile for B-7 to B-9

Figure 5 displays the boring log description found for test hole B-10, B-11 and B-12. All three borings are composed of lean clay with sand with different variations of color.

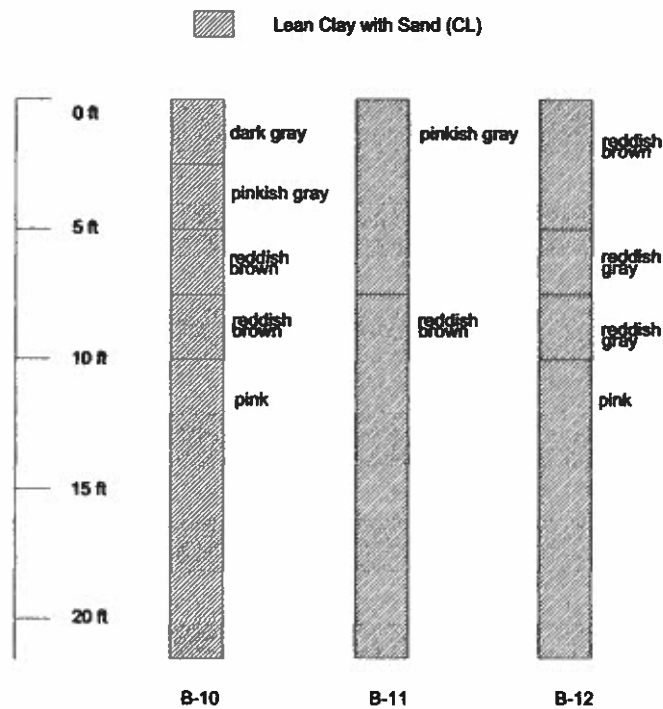


Figure 5. Boring Profile for B-10 to B-12

Figure 6 displays the boring log description found for test hole B-13, B-14 and B-15. Boring 13 is composed of lean clay with sand and clayey sand. While boring 14 contains lean clay with sand. Boring 15 is composed of lean clay with sand and fat clay with sand.

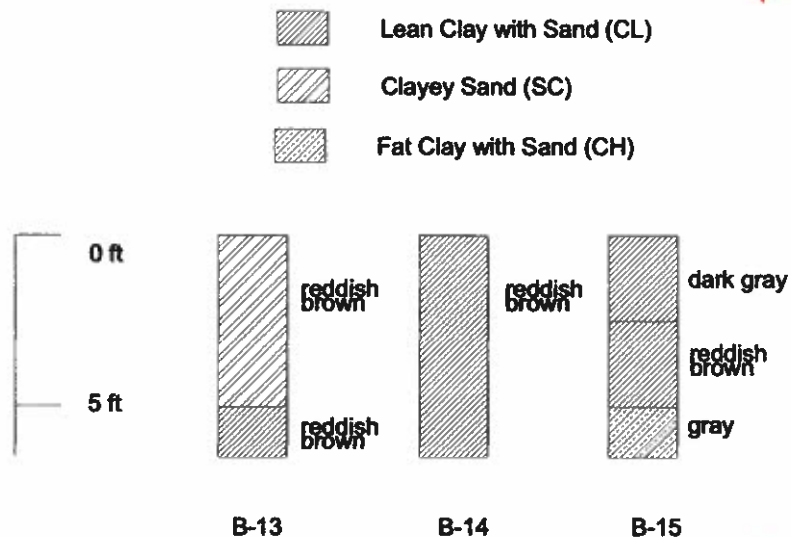


Figure 6. Boring Profile for B-13 to B-15

Figure 6 displays the boring log description found for test hole B-16, B-17 and B-18. Boring 16 is composed of lean clay with sand. While boring 17 and 18 contains lean clay with sand and clayey sand.

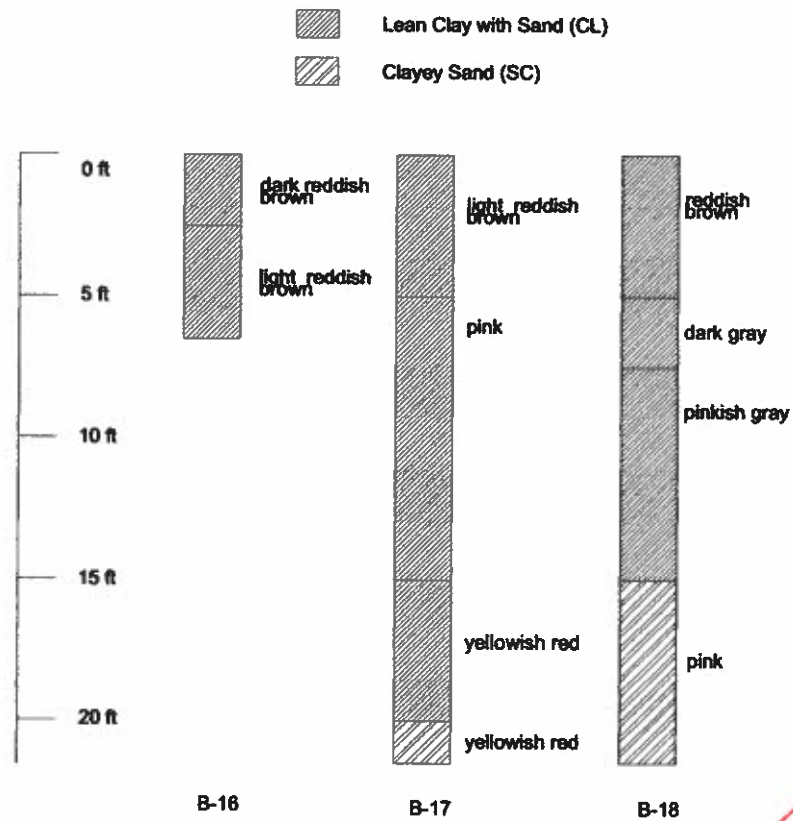


Figure 7. Boring Profile for B-16 to B-18

* you should provide the design parameter obtained from SPT in a tabular format for all borings!

Chapter 2: Foundation Design

2.1 Foundation Selection

The foundation type is chosen based on a number of variables. Majority of the selection process depends on the data that is collected from the boring analysis. Bearing capacity failure, settlement, soil quality, appropriate depth and strength, adverse soil changes, and seismic stresses are only a few of the issues. These elements work together to define the requirements for a long-term foundation design. To avoid frost damage, the foundation must first be deep enough. The foundation design must also meet all regulations to ensure that the foundation is safe from any potential failures. The structure should also be supported in the event of an earthquake or other natural calamity.

2.2 Soil Analysis

Based on all the boring logs the allowable bearing capacity was calculated based on boring log B-12. The standard penetration was found to be 33, with that value the dry unit weight was determined. The unit weight was calculated to be 134.86 lb/ft³. Using that value the effective stress was found as well as the blow count corrected to 60% of the theoretical free-fall hammer energy. From Table 24 for shear strength for cohesive soils, the cohesion (c') was determined to be 2000 psf. The friction angle (φ) was taken to be zero. No water table was found on any boring log therefore no consolidation settlement will occur.

2.3 Ultimate Bearing Capacity

Foundations must satisfy the bearing capacity with no failure in the surrounding soil. In addition, the settlement must be within tolerable limits. The Terzaghi's Bearing Capacity Theory for strip footing:

$$q_u = cN_c + qN_q + \left(\frac{1}{2}\right)BN_r \quad (1)$$

Where,

q_u = Ultimate Bearing Capacity

c = Cohesion of Soil

N_c, N_q, N_r = Terzaghi's Bearing Capacity Factors

B = Width of Square Footing

Ultimate bearing capacity of square foundations:

$$q_u = 1.3cN_c + qN_q + 0.4BN \quad (2)$$

In the Terzaghi's Bearing Capacity Theory equation, cohesion, friction and density are properties that are very important.

2.4 Allowable Bearing Capacity

The allowable bearing capacity is the load per unit area the foundation applies on the underlying soil.

$$q_{all} = q_u / FS \quad (3)$$

The Factor of Safety for shallow foundation ranges from the values 3 to 4. Allowable loading-bearing capacity of shallow foundations requires applying a factor of safety to the gross ultimate bearing capacity. The allowable bearing capacity for the spread footing was found to be 5906.5 lb/ft² for a 3ft by 3ft square. The continuous footing around the perimeter was found to be 4766.5 lb/ft². The allowable bearing capacity for the proposed parking lots was determined to be 5232.2 lb/ft².

did you check - structural load
50 ksf is okay with your design

$$Q_{design} > Q_{imposed} (50 ksf)$$

$$\uparrow$$

$$\boxed{Q_{all} = q_{all} \times A} \Rightarrow \underline{\underline{ok}} \quad (ok)$$

Chapter 3: Conclusion & Recommendation

3.1 Conclusion

Calculations were done using Terzaghi's bearing capacity factors, the unit weight and cohesiveness of the soil, and the depth of the soil to estimate the dimensions of the footing. Since boring logs were taken at separate points on the site and at varying depths at each location, the angle of friction found was influenced, which influenced Terzaghi's bearing capacity factors. This had an impact on the soil's unit weight. The cohesiveness of the soil was altered since the type of soil varied at each place where a boring log was collected, as well as at each depth. The ultimate bearing capacity would vary across the site as a result of these changing circumstances and the unknown dimensions of the square footing, affecting the permissible bearing capacity as well. As a result, having uniformly sized footings is the ideal option. Estimates were needed to estimate the dimensions of the footing that would be effective across the site. To begin, calculations were done for each depth of each boring log to calculate the eventual bearing capacity when a strip foundation was considered. As a result, the allowable bearing capacity for spread footing, continuous footing and parking lot. The square footing dimensions were determined to be 3ft by 3ft.



Calculations

Soil Analysis:

Based on B-12; $N = 33$

From Table 21: 30-50 SPT

$$\gamma_d = 18 \text{ kN/m}^3$$

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

$$18 = \frac{\gamma}{1 + 0.177}$$

$$\gamma = 21.186 \frac{\text{kN}}{\text{m}^3} = 134.86 \frac{\text{lb}}{\text{ft}^3}$$

$$\sigma = \gamma h = \left(134.86 \frac{\text{lb}}{\text{ft}^3} \right) (21.5 \text{ ft}) = 2899.5 \frac{\text{lb}}{\text{ft}^2}$$

$$C_N = \sqrt{\frac{2000}{2899.5}} = 0.83$$

$$N_{60} = N \times C_N = 33(0.83) = 27.4$$

Allowable Bearing Capacity:

Given:

$$c' = 2000 \text{ psf}$$

$$\theta = 0^\circ$$

$$N_c = 5.70$$

$$N_q = 1.0$$

$$N_y = 0$$

$$\gamma = 134.86 \text{ lb/ft}^3$$

$$q = \gamma \cdot D_f$$

$$q = (134.86 \text{ lb/ft}^3)(21.5 \text{ ft}) = 2899.49 \text{ lb/ft}^2$$

Spread Footing (Square)

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma B N_y$$

$$q_u = (1.3)(2000 \text{ psf})(5.70) + (2899.49 \text{ psf})(1) + 0.4(134.86)(B)(0) = 17719.49 \text{ psf}$$

$$q_{all} = q_u / FS$$

$$q_{all} = 17719.49 / 3 = 5906.5 \text{ lb/ft}^2$$

$$q_{all} = Q / A$$

$$A = Q / q_{all}$$

$$B^2 = 50 \text{ kips} \cdot 1000 / 5906.5$$

$$B^2 = 8.465$$

$$B = 3 \text{ ft} \times 3 \text{ ft}$$

Continuous Footing

$$q_u = c'N_c + qN_q + 0.5\gamma BN_\gamma$$

$$q_u = (2000\text{psf})(5.70) + (2899.49\text{psf})(1)$$

$$q_u = 14299.49\text{psf}$$

$$q_{all} = q_u/FS$$

$$q_{all} = 14299.49/3 = 4766.5 \text{ psf}$$

Parking

$$q = \gamma \cdot D_f$$

$$q = (134.86 \text{ lb/ft}^2)(6.5 \text{ ft})$$

$$q = 876.59 \text{ lb/ft}^2$$

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

$$q_u = (1.3)(2000\text{psf})(5.70) + (876.59\text{psf})(1)$$

$$q_u = 15696.6 \text{ psf}$$

$$q_{all} = q_u/FS$$

$$q_{all} = 15696.6/3 = 5232.2 \text{ psf}$$

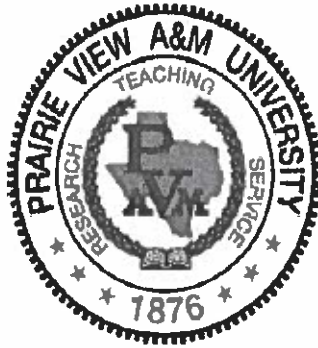

Reference:

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AVERAGE

Geotechnical Foundation Design Project
Lubbock, TX
Project outline

88



CVEG 4100: Geotechnical Engineering Design
Fall 2021

Submitted by:
Paige Hines
Sydney Jones
Michael LeBlanc
Johnathon Chevalier

Submitted to:
Dr. Jobair Bin Alam

Letter of Transmittal

October 13, 2021

Dr. Jobair Bin Alam, P.E.
Civil Engineering Department
Prairie View A&M University

Dear Dr. Alam,

The "New K-12 School Petersburg" findings are documented in the accompanying technical report. The study includes a structural layout that is best suited for a structure in Lubbock, Texas. The report's data was compiled from each and every engineer in the company. The theoretical, hypothesis, venture rundown, and supplement are all included in this report. If you have any questions or issues about the report, please don't hesitate to contact our task director Paige Hines at 808-471-2659 or hines_paige@yahoo.com.

Sincerely,
Paige Hines

Abstract

The engineers on this technical paper were charged with recommending a foundation type for a planned building in Lubbock, Texas. Steel frames are used to construct the structure and the facility's foundation must be built for bearing capacity as well as settling. The information was gathered and briefly examined to determine the benefits and drawbacks of various types of foundations and to justify their choice. ✓

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Introduction

The Standard Penetration Test (SPT) is a testing method for determining subsurface soil geotechnical characteristics. This test is cheap and can correctly determine the density and shear strength characteristics of soil. A conventional, thick-walled sample tube is driven into the earth at the bottom of a borehole to conduct this test. This is accomplished by strikes from a slide hammer mechanism with a specific weight and fall distance. The example tube is pushed 150 mm (6 in.) into the ground for this circumstance, after which the number of blows necessary for the cylinder to enter the soil each 150 mm up to a depth of 18 in (450 mm). Following this, the total number of blows required for the second and third 6 crawls of penetration is recorded as the SPT blow count. The standard penetration obstruction, often known as the N-value, is what this is referred to as. In terms of the N-value, it indicates the density of subsurface soil. The soils' estimated shear strength characteristics may be evaluated using this method.

Objective

The Geotechnical Group's goal was to examine the subsurface characteristics at this location in order to promote foundation plans for the planned buildings and then provide general recommendations for the new existing construction in Lubbock, Texas. Penetrating soil boring to depths of 0 to 20 feet under present assessments inside the projected advancement zone, lab testing, and the creation of an engineer designing report were among the services provided.

3.2.1. Geotechnical Engineering

Criteria

This report briefly presents available project information, outlines the testing procedures, describes the site and subsurface conditions, and presents the following:

1. Description of subsurface conditions and groundwater information
2. Boring logs and laboratory test results
3. Discussion of grading for the site and calculation of cut and fill
4. Site preparation recommendations including structural fill placement and compaction
5. Lateral earth pressure parameters
6. Recommendations for foundations and estimated settlement
7. Discussions of the factors impacting construction and performance of the proposed construction

3.1 New K-12 School Petersburg Description

Eighteen 2 soil borings, B-01 through B-18, were tested to depths of roughly 21.5 feet and 6.5 feet (B-13-B-16) below the existing ground surface during the field research. The borings were drilled with a track-mounted CME 75 boring rig and a Hollow stem drill, all in accordance with ASTM standards. Texas Cone Penetration Tests (TxDOT Designation Tex-132-E) were carried out in the borings at 5-foot intervals, as per the TxDOT geotechnical handbook 2016. The soil samples collected during the field inquiry were transported to the research center, where they were tested to determine material characteristics for evaluation.

Laboratory testing was carried out on chosen samples in line with ASTM standards to assess the subsurface materials' classification, strength, and other engineering properties. The following tests were carried out on the chosen samples:

- Moisture Content (ASTM D 2216)
- Unit Weight (ASTM D 2937)
- Atterberg Limits (ASTM D 4318)
- Percent Passing No. 200 Sieve (ASTM D 1140)
- Unconfined Compression (ASTM D 2166)
- Triaxial Shear Strength (ASTM D 2850)
- One Dimensional Consolidation (ASTM D 2435)

3.1 New K-12 School Petersburg Table Description

Table 3.1a – New K-12 School Petersburg Subsurface Profile for B-1

Test Hole #1 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 5	38	15	23	66.7%	33%	11.0%	CL	Sandy lean Clay (Dark Gary)	
5 - 7.5	35	14	21	74.1%	26%	13.8%	CL	Lean Clay with Sand (Pink)	
7.5 - 20	41	13	28	77.1%	23%	15.5%	CL	Lean Clay with Sand (Light reddish brown)	
20 - 21.5	34	13	21	60.6%	39%	17.5%	CH	Sandy lean Clay (Light reddish brown)	

Table 3.1b – New K-12 School Petersburg Subsurface Profile for B-2

Test Hole #2 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 7.5	41	12	29	75.4%	25%	15.9%	CL	Lean Clay with Sand (Reddish gray)	
7.5 - 10	34	15	19	67.7%	32%	14.5%	SC	Sandy lean Clay (Pink)	
10 - 21.5	41	17	24	64.5%	36%	17.0%	SC	Sandy lean Clay (Light Reddish Brown)	

Table 3.1c -- New K-12 School Petersburg Subsurface Profile for B-3

Test Hole #3 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 5	45	16	29	62.7%	37%	17.8%	CL	Sandy lean Clay (Gray)	
(5 - 15)	42	17	25	73.4%	27%	15.6%	CL	Lean Clay with Sand (Pink)	
20 - 21.5	35	16	19	56.7%	43%	15.8%	CL	Sandy lean Clay (Light Reddish Brown)	

Table 3.1d-- New K-12 School Petersburg Subsurface Profile for B-4

Test Hole #4 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 5	37	15	22	75%	25%	14%	CL	Lean clay with Sand (Gray)	
(5 - 15)	33	12	21	71%	29%	16%	CL	Lean clay with Sand (Reddish Brown)	
15 - 21.5	37	14	23	59%	42%	16%	CL	Sandy Lean Clay (Reddish Brown)	

Table 3.1e- New K-12 School Petersburg Subsurface Profile for B-5

Test Hole #5 Soil Classification										
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification		
0 - 7.5	36	13	23	70%	30%	13%	CL	Lean Clay with Sand		
7.5 - 20	38	15	23	81%	19%	12%	CL	Sandy lean Clay		
20 - 21.5	33	15	18	70%	30%	15%	CL	Sandy lean Clay		

Table 3.1f- New K-12 School Petersburg Subsurface Profile for B-6

Test Hole #6 Soil Classification										
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification		
0 - 7.5	37	14	23	66%	34%	18%	CL	Sandy Lean Clay (Pink)		
7.5 - 15	32	14	18	76%	24%	17%	CL	Lean Clay with Sand (Pink)		
15 - 21.5	39	15	24	68%	32%	20%	CL	Sandy Lean Clay (light reddish brown)		

Table 3.1g – New K-12 School Petersburg Subsurface Profile for B-7

Test Hole #7 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 7.5	36	16	20	69%	32%	12%	CL	Sandy lean Clay	
7.5 - 21.5	39	13	26	59%	41%	15%	CL	Sandy lean Clay	

Table 3.1h– New K-12 School Petersburg Subsurface Profile for B-8

Test Hole #8 Soil Classification									
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)	Coarse Fraction	Water Content	Group Name	Classification	
0 - 7.5	35	15	20	66%	34%	18%	CL	Sandy Lean Clay	
7.5 - 15	29	16	13	79%	21%	20%	CL	Sandy Lean Clay	
15 - 21.5	47	14	33	59%	41%	14%	CL	Sandy Lean Clay	

Table 3.1i– New K-12 School Petersburg Subsurface Profile for B-9

<u>Test Hole #9 Soil Classification</u>									
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>	
<u>0 - 5</u>	<u>51</u>	<u>17</u>	<u>34</u>	<u>73%</u>	<u>27%</u>	<u>11%</u>	<u>CH</u>	<u>Fat Clay with</u> <u>Sand</u>	
<u>5 - 7.5</u>	<u>45</u>	<u>14</u>	<u>31</u>	<u>73%</u>	<u>27%</u>	<u>12%</u>	<u>CL</u>	<u>Lean Clay with</u> <u>Sand</u>	
<u>7.5 -</u> <u>20</u>	<u>38</u>	<u>12</u>	<u>26</u>	<u>74%</u>	<u>26%</u>	<u>11%</u>	<u>CL</u>	<u>Lean Clay with</u> <u>Sand</u>	
<u>20 -</u> <u>21.5</u>	<u>55</u>	<u>15</u>	<u>40</u>	<u>70%</u>	<u>30%</u>	<u>17%</u>	<u>CH</u>	<u>Sandy Fat Clay</u>	

Table 3.1j – New K-12 School Petersburg Subsurface Profile for B-10

<u>Test Hole #10 Soil Classification</u>									
<u>Depth</u>	<u>Liquid Limit</u>	<u>Plastic Limit</u>	<u>Plastic Index</u>	<u>Sieve Analysis (#200)</u>	<u>Coarse Fraction</u>	<u>Water Content</u>	<u>Group Name</u>	<u>Classification</u>	
0 - 7.5	43	16	27	71%	29%	13%	CL	Lean Clay with Sand	
7.5 - 1.5	39	14	25	67%	33%	12%	CL	Sandy Lean Clay	

Table 3.1k – New K-12 School Petersburg Subsurface Profile for B-11

<u>Test Hole #11 Soil Classification</u>									
<u>Depth (ft)</u>	<u>Liquid Limit</u>	<u>Plastic Limit</u>	<u>Plastic Index</u>	<u>Sieve Analysis (#200)</u>	<u>Coarse Fraction</u>	<u>Water Content</u>	<u>Group Name</u>	<u>Classification</u>	
0 - 7.5	31	12	19	69%	31%	13%	CL	Lean Clay with Sand	
7.5 - 20	43	13	30	71%	29%	10%	CL	Lean Clay with Sand	
20 - 21.5	52	21	31	77%	23%	21%	CH	Fat Clay	

Table 3.11– New K-12 School Petersburg Subsurface Profile for B-12

<u>Test Hole #12 Soil Classification</u>								
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>
<u>0 - 7.5</u>	<u>40</u>	<u>12</u>	<u>28</u>	<u>68%</u>	<u>32%</u>	<u>22%</u>	<u>CL</u>	<u>Lean Clay with</u> <u>Sand</u>
<u>7.5 -</u> <u>21.5</u>	<u>35</u>	<u>15</u>	<u>20</u>	<u>61%</u>	<u>39%</u>	<u>15%</u>	<u>CL</u>	<u>Sandy lean Clay</u>

Table 3.1m – New K-12 School Petersburg Subsurface Profile for B-13

Test Hole #13 Soil Classification									
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>	
<u>0 - 5</u>	<u>38</u>	<u>16</u>	<u>22</u>	<u>44%</u>	<u>56%</u>	<u>5%</u>	<u>SC</u>	<u>Clayey Sand</u>	
<u>5 - 6.5</u>	<u>45</u>	<u>14</u>	<u>31</u>	<u>74%</u>	<u>26%</u>	<u>15%</u>	<u>CL</u>	<u>Lean Clay with Sand</u>	

Table 3.1n – New K-12 School Petersburg Subsurface Profile for B-14

<u>Test Hole #14 Soil Classification</u>								
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>
<u>0 - 6.5</u>	<u>38</u>	<u>12</u>	<u>26</u>	<u>75%</u>	<u>25%</u>	<u>14%</u>	<u>CL</u>	<u>Lean Clay with Sand</u>

Table 3.1o – New K-12 School Petersburg Subsurface Profile for B-15

<u>Test Hole #15 Soil Classification</u>								
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>
<u>0 - 5</u>	<u>36</u>	<u>13</u>	<u>23</u>	<u>68%</u>	<u>32%</u>	<u>8%</u>	<u>CL</u>	<u>Sandy lean Clay</u>
<u>5 - 6.5</u>	<u>60</u>	<u>19</u>	<u>41</u>	<u>78%</u>	<u>22%</u>	<u>13%</u>	<u>CH</u>	<u>Fat Clay with Sand</u>

Table 3.1p – New K-12 School Petersburg Subsurface Profile for B-16

<u>Test Hole #16 Soil Classification</u>									
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>	
<u>0 - 6.5</u>	<u>41</u>	<u>18</u>	<u>23</u>	<u>73%</u>	<u>27%</u>	<u>16%</u>	<u>CL</u>	<u>Lean Clay with San</u>	

Table 3.1q – New K-12 School Petersburg Subsurface Profile for B-17

<u>Test Hole #17 Soil Classification</u>									
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>	
<u>0 - 5</u>	<u>41</u>	<u>17</u>	<u>24</u>	<u>71%</u>	<u>29%</u>	<u>14%</u>	<u>CL</u>	<u>Lean Clay with San</u>	
<u>7.5 -</u> <u>20</u>	<u>44</u>	<u>18</u>	<u>26</u>	<u>71%</u>	<u>29%</u>	<u>12%</u>	<u>CL</u>	<u>Lean Clay with San</u>	
<u>20 -</u> <u>21.5</u>	<u>38</u>	<u>18</u>	<u>20</u>	<u>51%</u>	<u>49%</u>	<u>17%</u>	<u>SC</u>	<u>Sandy Lean Clay</u>	

Table 3.1r – New K-12 School Petersburg Subsurface Profile for B-18

<u>Test Hole #18 Soil Classification</u>									
<u>Depth</u> <u>(ft)</u>	<u>Liquid</u> <u>Limit</u>	<u>Plastic</u> <u>Limit</u>	<u>Plastic</u> <u>Index</u>	<u>Sieve</u> <u>Analysis</u> <u>(#200)</u>	<u>Coarse</u> <u>Fraction</u>	<u>Water</u> <u>Content</u>	<u>Group</u> <u>Name</u>	<u>Classification</u>	
<u>0 - 5</u>	<u>43</u>	<u>16</u>	<u>27</u>	<u>71%</u>	<u>29%</u>	<u>19%</u>	<u>CL</u>	<u>Sandy Lean Cla</u>	
<u>(5 - 15)</u>	<u>38</u>	<u>14</u>	<u>24</u>	<u>64%</u>	<u>36%</u>	<u>18%</u>	<u>CL</u>	<u>Sandy lean Clay</u>	
<u>15 -</u> <u>21.5</u>	<u>35</u>	<u>14</u>	<u>21</u>	<u>49%</u>	<u>51%</u>	<u>13%</u>	<u>SC</u>	<u>Clayey Sand</u>	

3.1.2 New K-12 School Petersburg Subsurface Boring logs

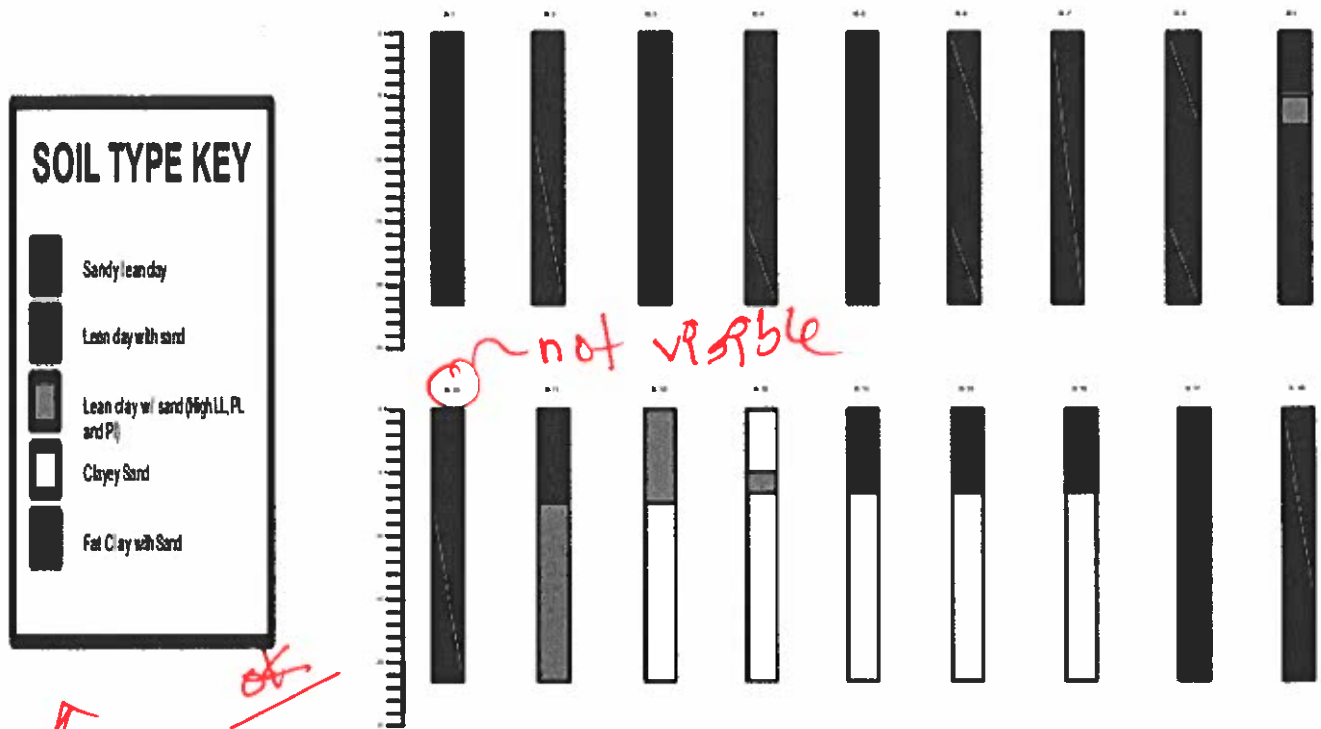
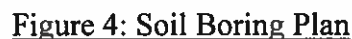


Figure 3.1.2a: Soil Boring Plan

Site Location and Description

The figure beneath shows the structure site with comparing measurements of the boring examination.



Groundwater level was not found in the borings during the hour of exhausting exercises. It should be perceived that the groundwater levels were wanted to be recorded during the entering and after exhausting fulfillment. It is possible that periodic assortments (temperature, precipitation, etc) will cause changes in the groundwater level. Also, perched water might be knowledgeable about sporadic zones inside the overburden. The groundwater levels presented in this report, expecting to be any, are the levels that were assessed at the hour of our field works out. It is recommended that the authoritative specialist choose the veritable groundwater levels at the site at the hour of the improvement activities to choose the impact, accepting any, on the advancement frameworks.

The ESA is ordinarily seen as the underlying stage during the time spent normal due consistency. Before purchasing a land bundle, an owner should promise himself that the envisioned progression of the land is truly possible with its dirt conditions. This being expressed, the owner volunteers' geotechnical engineers to analyze the dirt through key borings to test the dirt and

guarantee that it is sensible. These are key motivations behind why associations and advancing foundations habitually require a Phase I ESA. Driving an ESA limits the obligation of the owner or advance trained professional and outfits them with a sensation of statement for the idea of their domain. Norms for Performing a Phase I Site Assessment have been made by the EPA. These norms include:

- Evaluating stockpiling, taking care of, treatment, and removal of materials and waste
- Investigating site for proof of underground stockpiling tanks or spills
- Researching history of the office, soil type, and ground and surface water

3.2.1. Foundation Design

1.) Selection of Foundation

The suitable establishment is chosen for each chose office dependent on specific components. Perceive the establishment type dependent on satisfactory and significant information from subsurface investigation

Determination of Foundation Type :

1. Quality: The establishment should be a satisfactory quality with the goal that it isn't exposed to disintegration, for example, from sulfate assault.
2. Satisfactory Strength: The establishment should be planned with adequate strength that is doesn't crack or fall to pieces under the applied superstructure loads. The establishment should likewise be appropriately built in conformance with the plan details
3. Unfavorable Soil Changes: The establishment should have the option to oppose long haul unfriendly soil changes.
4. Seismic Forces: The establishment should have the option to help the design during a tremor with-out exorbitant settlement or horizontal development.
5. Satisfactory Depth: Foundation should have a sufficient profundity to forestall ice harm. For Such establishments as scaffold wharfs, the profundity of the establishment should be adequate to forestall subverting by scour.
6. Bearing Capacity Failure: The Foundation should be protected against a direction limit disappointment.
7. Settlement: Foundation should not settle to such degree that it harms the construction.

Terzaghi hypothesized that the dirt under the balance would create a triangle of tension. The bearing limit of the dirt is created in a balance because of three properties of soil:

- i. Cohesion
- ii. Friction
- iii. Density

The terms utilized in the Terzaghi bearing cutoff condition are an authoritative bearing breaking point, the connection term, the additional charge term, and the thickness term. An authoritative bearing restriction of an establishment is the stack past which an establishment would miss the mark and not, now be significant. Attachment (c) is a substance cycle. Soil particles will overall stick to each other on account of electrical charges present in mud particles. As opposed to connection, contact is an actual cycle. The higher the scouring between particles, the higher the restriction of the dirt to pass on balance loads. Generally, sands and silt secure grinding. By and large, soils are seen as grating less. The pounding of a dirt is addressed by the grinding point = 0; where B is the width of the equilibrium, and the place of the dirt strain triangle is given by a conclusive bearing cutoff.

Calculations

Ultimate Bearing Capacity

The Ultimate Bearing Capacity is calculated by using the Terzaghi Bearing Capacity factors which depend on the internal angle of friction of the soil. Ultimate Bearing Capacity (Q_{ult}) for a square footing with a width B is calculated as,

$$Q_{ult} = 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma$$

Whereas,

$Q_{ultimate}$ = Ultimate bearing capacity
 C = cohesion of soil

N_c, N_q, N_γ = Terzaghi's bearing capacity factors

γ_1 = effective unit weight of soil above soil of foundation

γ_2 = effective unit weight of soil below foundation

D_f = depth of footing, or distance from ground surface to base of footing

B = width of square footing

Given:

$$\gamma_1 = 125 \frac{lb}{ft^3}$$

$$\gamma_2 = 125 \frac{lb}{ft^3}$$

$$D = 21.5 ft$$

$$C = 1000 \frac{lb}{ft^2} \text{ for clay.}$$

$$\text{Friction angle} = 0$$

q = bearing pressure
 Q = load.

Ultimate bearing capacity is therefore,

$$\begin{aligned} Q_{ultimate} &= 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma \\ &= 1.3 * (1000) * (5.7) + 125 \frac{lb}{ft^3} * (21.5) * (1) \\ &= 10,097.5 \frac{lb}{ft^2} \end{aligned}$$

Parking lot(shallow foundation)

$$\begin{aligned} \underline{Q_{ultimate}} &= 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma \\ &= 1.3 * (1000) * (5.7) + 125 \frac{lb}{ft^3} * (6.5) * (1) \\ &= 8222.5 \frac{lb}{ft^2} \end{aligned}$$

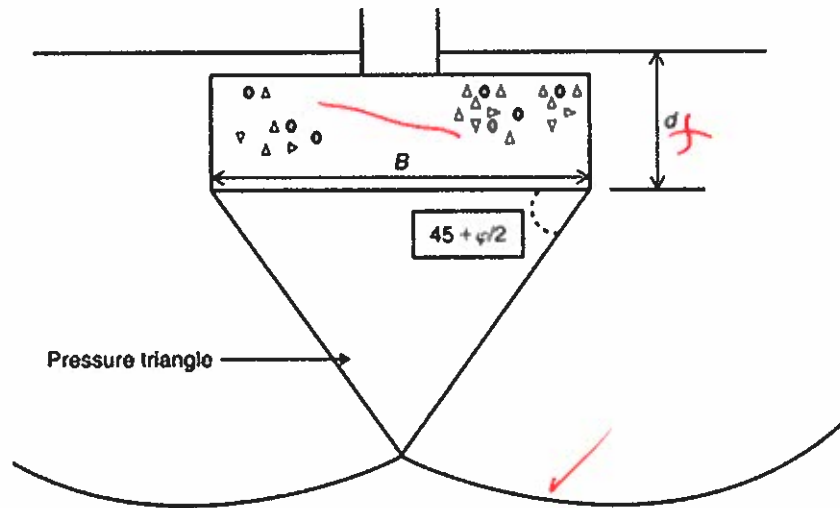


Figure 3.2.1a: Ultimate Bearing Capacity

Allowable Bearing Capacity

Allowable bearing capacity (Q_a) refers to the loading per unit area that the soil is able to support without unsafe movement. It is also referred to as the design bearing capacity. A factor of safety of 2.5 to 3 is commonly applied to the value of $q_{ultimate}$. Care must be taken to ensure that a footing design is safe with regard to:

1. Foundation failure (collapse)
2. Excessive settlement

Allowable Bearing Capacity:

$$\begin{aligned} Q_a &= \frac{Q_{ultimate}}{3} \\ Q_a &= 3,365.83 \text{ lb./ft}^2 \\ Q_a &= 2740.83 \text{ lb/ft}^2 \end{aligned}$$

The allowable bearing capacity of the soil is determined to be 4.08 ksf for a 3.5ft by 3.5ft footing. This value will be used in ensuing foundation designs of compactness of the soils.

Primary Consolidation Settlement

Because there is no water, there is no consolidation settlement.

Results & Discussion

To choose the elements of the equilibrium, counts were made using Terzaghi's bearing cutoff factors, the unit weight and attachment of the dirt, and the significance of the dirt. Since exhausting logs were taken at various regions on the site similarly as at different profundities at each space, this affected the resource chose, thusly impacting Terzaghi's bearing cutoff factors. This in like manner impacted the unit weight of the dirt. Since the sort of soil was different at each point where an exhausting log was taken similarly as at each significance, this impacted the union of the dirt. Considering these changing components and the dark elements of the square equilibrium, a conclusive bearing cutoff would move over the site, in this way changing the permissible bearing breaking point over the site as well. In any case, having different footings with various measurements isn't useful or monetarily incredible. Henceforth, having footings with uniform measurements is the most ideal decision. To choose the components of the equilibrium that would be practical over the site, appraisals ought to have been made. First thing, calculations were made for each significance of each exhausting log to choose a conclusive bearing breaking point concerning a strip foundation. Considering this, the most un-outrageous bearing breaking point was picked as a cautious advance not to misjudge our authoritative bearing cutoff. Considering this, the components in idea for the most decreased outrageous bearing cutoff regarding a strip foundation at that exact significance and exhausting log were used in figuring for a square foundation. From that point, the elements of 3.5ft by not set in stone.

Conclusion

Finally, this event provided an opportunity to learn about alternative geotechnical design cycles. The Geotechnical Group's mission was to examine the underlying characteristics at this location in order to promote the development of a design for the proposed structures and then make general recommendations for the new existing construction in Lubbock, Texas. Penetrating soil borings to depths of 0 to 20 feet beneath present assessments within the planned development area, lab testing, and the drafting of a designing report were all part of the scope of services. In the end, this group had the ability to apply geotechnical design methods to this project efficiently.

Test Hole #1 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	38	15	23	66.7%
5 - 7.5	35	14	21	74.1%
7.5 - 20	41	13	28	77.1%
20 - 21.5	34	13	21	60.6%

Test Hole #2 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	41	12	29	75.4%
7.5 - 10	34	15	19	67.7%
10 - 21.5	41	17	24	64.5%

Test Hole #3 Soil Classification

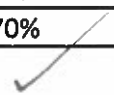
Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	45	16	29	62.7%
(5 - 15)	42	17	25	73.4%
20 - 21.5	35	16	19	56.7%

Test Hole #4 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	37	15	22	75%
(5 - 15)	33	12	21	71%
15 - 21.5	37	14	23	59%

Test Hole #5 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	36	13	23	70%
7.5 - 20	38	15	23	81%
20 - 21.5	33	15	18	70%



Test Hole #6 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	37	14	23	66%
7.5 - 15	32	14	18	76%
15 - 21.5	39	15	24	68%

Test Hole #7 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	36	16	20	69%
7.5 - 21.5	39	13	26	59%

Test Hole #8 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	35	15	20	66%
7.5 - 15	29	16	13	79%
15 - 21.5	47	14	33	59%

Test Hole #9 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	51	17	34	73%
5 - 7.5	45	14	31	73%
7.5 - 20	38	12	26	74%
20 - 21.5	55	15	40	70%

Test Hole #10 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	43	16	27	71%
7.5 - 21.5	39	14	25	67%

Test Hole #11 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	31	12	19	69%
7.5 - 20	43	13	30	71%
20 - 21.5	52	21	31	77%

Test Hole #12 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 7.5	40	12	28	68%
7.5 - 21.5	35	15	20	61%

Test Hole #13 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	38	16	22	44%
5 - 6.5	45	14	31	74%

Test Hole #14 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 6.5	38	12	26	75%

Test Hole #15 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	36	13	23	68%
5 - 6.5	60	19	41	78%

Test Hole #16 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 6.5	41	18	23	73%

Test Hole #17 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
0 - 5	41	17	24	71%
7.5 - 20	44	18	26	71%
20 - 21.5	38	18	20	51%

Test Hole #18 Soil Classification

Depth (ft)	Liquid Limit	Plastic Limit	Plastic Index	Sieve Analysis (#200)
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0 - 5	43	16	27	71%
(5 - 15)	38	14	24	64%
15 - 21.5	35	14	21	49%

Coarse Fraction	Water Content	Group Name	Classification
33%	11.0%	CL	Sandy lean Clay (Dark Gary)
26%	13.8%	CL	Lean Clay with Sand (Pink)
23%	15.5%	CL	Lean Clay with Sand (Light reddish brown)
39%	17.5%	CH	Sandy lean Clay (Light reddish brown)

Coarse Fraction	Water Content	Group Name	Classification
25%	15.9%	CL	Lean Clay with Sand (Reddish gray)
32%	14.5%	SC	Sandy lean Clay (Pink)
36%	17.0%	SC	Sandy lean Clay (Light Reddish Brown)

Coarse Fraction	Water Content	Group Name	Classification
37%	17.8%	CL	Sandy lean Clay (Gray)
27%	15.6%	CL	Lean Clay with Sand (Pink)
43%	15.8%	CL	Sandy lean Clay (Light Reddish Brown)

Coarse Fraction	Water Content	Group Name	Classification
25%	14%	CL	Lean clay with Sand (Gray)
29%	16%	CL	Lean clay with Sand (Reddish Brown)
42%	16%	CL	Sandy Lean Clay (Reddish Brown)

Coarse Fraction	Water Content	Group Name	Classification
30%	13%	CL	Lean Clay with Sand
19%	12%	CL	Sandy lean Clay
30%	15%	CL	Sandy lean Clay

Coarse Fraction	Water Content	Group Name	Classification
34%	18%	CL	Sandy Lean Clay (Pink)
24%	17%	CL	Lean Clay with Sand (Pink)
32%	20%	CL	Sandy Lean Clay (light reddish brown)

Coarse Fraction	Water Content	Group Name	Classification
32%	12%	CL	Sandy lean Clay
41%	15%	CL	Sandy lean Clay

Coarse Fraction	Water Content	Group Name	Classification
34%	18%	CL	Sandy Lean Clay
21%	20%	CL	Sandy Lean Clay
41%	14%	CL	Sandy Lean Clay

Coarse Fraction	Water Content	Group Name	Classification
27%	11%	CH	Fat Clay with Sand
27%	12%	CL	Lean Clay with Sand
26%	11%	CL	Lean Clay with Sand
30%	17%	CH	Sandy Fat Clay

Coarse Fraction	Water Content	Group Name	Classification
29%	13%	CL	Lean Clay with Sand
33%	12%	CL	Sandy Lean Clay

Coarse Fraction	Water Content	Group Name	Classification
31%	13%	CL	Lean Clay with Sand
29%	10%	CL	Lean Clay with Sand
23%	21%	CH	Fat Clay

Coarse Fraction	Water Content	Group Name	Classification
32%	22%	CL	Lean Clay with Sand
39%	15%	CL	Sandy lean Clay

Coarse Fraction	Water Content	Group Name	Classification
56%	5%	SC	Clayey Sand
26%	15%	CL	Lean Clay with Sand

Coarse Fraction	Water Content	Group Name	Classification
25%	14%	CL	Lean Clay with Sand

Coarse Fraction	Water Content	Group Name	Classification
32%	8%	CL	Sandy lean Clay
22%	13%	CH	Fat Clay with Sand

Coarse Fraction	Water Content	Group Name	Classification
27%	16%	CL	Lean Clay with Sand

Coarse Fraction	Water Content	Group Name	Classification
29%	14%	CL	Lean Clay with Sand
29%	12%	CL	Lean Clay with Sand
49%	17%	SC	Sandy Lean Clay

Coarse Fraction	Water Content	Group Name	Classification
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29%	19%	CL	Sandy Lean Clay
36%	18%	CL	Sandy lean Clay
51%	13%	SC	Clayey Sand

Reference:

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BELOW AVERAGE

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4100: Geotechnical Engineering Design

Section: P81

Title: Geotech Project 1 Report

Submitted By: M.A.R.S Engineering

Abram Auguste, Alex Martinez, Caleb Ross, Nathaniel Smith

Submitted To: Dr. Alam, Md Jobair Bin Ph.D., P.E.

Due Date: October 13, 2021 NLT 10:00 A.M.

Fall 2019

ABET Criteria 3(c) and 3(i)

?

Letter of Transmittal

October 12, 2021

Dr. Jobair Bin Alam

Civil Engineering Department

Prairie View A&M University

Dear Dr. Alam,

This report describes a design for a project done by M.A.R.S. Engineering. The report contains the detailed analysis and recommendations for the building foundation and parking cross-section for the project "New K-12 School Petersburg ISD". The report contains a shallow foundation design best suited for the proposed building in Petersburg, Texas. All the information in the report was gathered from EIT's and engineers involved in the project. This report also consists of different sections that will analyze some differently significant parts of the project. Please feel free to contact our project manager if you have any questions or concerns regarding the report (857-342-0981).



Thank you,

M.A.R.S. Engineering

Abstract

The engineers of this project were tasked with providing a foundation type that best fit the proposed building in Lubbock, Texas. The buildings will be constructed with a conventional steel-framed building structural system. The building is anticipated to have a foundation that will consist of continuous footing around the building and spread footing under the isolated steel columns. The foundation of the project must be designed for bearing capacity and settlement. Comparing the different types of foundations will help decide if the selection and dimensions are both good fits for the project's structure.

Table of contents?

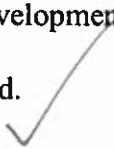
Introduction

The test that we will be conducting is the Standard Penetration Test (SPT). The Standard Penetration Test is a testing method that is used to determine the geotechnical properties of subsurface soils. The test compared to others is inexpensive and can estimate the density and shear strength parameters of soil accurately. The test uses a thick-walled sample tube, with an outside diameter of 50.8 mm and an inside diameter of 35 mm, and a length of around 650 mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a mass of 63.5 kg (140 lb) falling through a distance of 760 mm (30 in). The sample tube is driven 150 mm into the ground and then the number of blows needed for the tube to penetrate each 150 mm (6 in) up to a depth of 450 mm (18 in) is recorded. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance" or the "N-value". In cases where 50 blows are insufficient to advance it through a 150 mm (6 in) interval the penetration after 50 blows are recorded. The blow count provides an indication of the density of the ground, and it is used in many empirical geotechnical engineering formulae. In regard to the N-value, it provides an indication of the density of subsurface soil. Using this, the approximate shear strength properties of the soils can be estimated for the project.

show figure, project location
site area.

Objective

The objective of this project was to prepare a comprehensive geotechnical investigation and to prepare a written report of the analysis and recommend a foundation that would best suit the building design for the proposed structure near Lubbock, Texas. The things that need to be done will be drilling soil borings at a depth of a minimum of 0 to 20 feet below the existing grades within the proposed development area and laboratory testing and preparation of an engineering report will be conducted.



Geotechnical Engineering

Criteria

The contents within this report presents-

- Soil boring information and sub-surface soil conditions
- Detail soil information and design soil parameters
- Design of foundation for both bearing capacity and settlement consideration.
- Recommendation of best shallow foundation system providing all details, calculations, and reasons for decision.
- Detail of foundation in CAD Drawing

New K-12 School Petersburg Description

The project contains samples of 18 soil borings, B-1 through B-18, with depths around 21.5 ft and 6.5 ft below the ground surface. The boreholes were drilled by a CME 75 Hollow stem auger following the ASTM procedures. The samples from the project site were taken to a lab and the samples that were selected were tested to analyze material properties

Texas Cone Penetration tests (TxDOT Designation Tex-132-E) were performed in accordance with TxDOT geotechnical manual 2016, in the borings at approximately 5-foot intervals.

Laboratory testing was accomplished generally in accordance with ASTM procedures and performed on selected samples to evaluate the classification, strength and other engineering characteristics of the subsurface materials. The tests on the selected samples included:

- Moisture Content (ASTM D 2216)

- Unit Weight (ASTM D 2937)
- Atterberg Limits (ASTM D 4318)
- Percent Passing No. 200 Sieve (ASTM D 1140)
- Unconfined Compression (ASTM D 2166)
- Triaxial Shear Strength (ASTM D 2850)
- One Dimensional Consolidation (ASTM D 2435)



Table 3.1a – New K-12 School Petersburg Subsurface Profile for B-1 through B-18

table title should be on the page
where the tables are.

	Depth (ft.)	N	Stress (σ')	CN	N60	Soil Classification
Boring 1	0	18	0	-	-	Sandy Lean Clay
	2.5	18	287.5	2.637521894	47.47539408	Sandy Lean Clay
	5	35	575	1.865009616	65.27533658	Lean Clay with Sand, Pink
	7.5	13	862.5	1.522773975	19.79606168	Lean Clay with Sand, Light Reddish Brown
	10	34	1150	1.318760947	44.83787219	Lean Clay with Sand, Light Reddish Brown
	15	41	1725	1.076763804	44.14731597	Lean Clay with Sand, Light Reddish Brown
	20	53	2300	0.9325048082	49.42275484	Sandy Lean Clay (SC), Light Reddish Brown
Boring 2	0	13	0	-	-	Lean Clay with Sand (CL), reddish gray
	2.5	18	287.5	2.637521894	47.47539408	CL, reddish brown
	5	16	575	1.865009616	29.84015386	CL, pink
	7.5	18	862.5	1.522773975	27.40993155	Sandy Lean Clay (CL), pink
	10	39	1150	1.318760947	51.43167692	Sandy Lean Clay (CL), light reddish brown
	15	39	1725	1.076763804	41.99378836	Sandy Lean Clay (CL), light reddish brown
	20	60	2300	0.9325048082	55.95028849	Sandy Lean Clay (CL), light reddish brown
Boring 3	0	10	0	-	-	Sandy Lean Clay (CL), gray
	2.5	9	287.5	2.637521894	23.73769704	CL, very dark gray
	5	9	575	1.865009616	16.78508655	Lean Clay with Sand (CL), Pink
	7.5	13	862.5	1.522773975	19.79606168	Lean Clay with Sand (CL), Pink
	10	28	1150	1.318760947	36.92530651	Lean Clay with Sand (CL), Pink
	15	33	1725	1.076763804	35.53320554	CL, light reddish brown
	20	54	2300	0.9325048082	50.35525964	Sandy Lean Clay (CL), light reddish brown
Boring 4	0	10	0	-	-	Lean Clay with Sand (CL), gray
	2.5	15	287.5	2.637521894	39.5628284	CL, reddish gray
	5	14	575	1.865009616	26.11013463	CL, reddish brown
	7.5	10	862.5	1.522773975	15.22773975	CL, reddish brown
	10	15	1150	1.318760947	19.7814142	CL, reddish brown
	15	34	1725	1.076763804	36.60996934	Sandy Lean Clay
	20	36	2300	0.9325048082	33.5701731	Sandy Lean Clay
Boring 5	0	18	0	-	-	Lean Clay with Sand (CL), pinkish gray
	2.5	14	287.5	2.637521894	36.92530651	Lean Clay with Sand (CL), pinkish gray
	5	30	575	1.865009616	55.95028849	CL, reddish brown
	7.5	26	862.5	1.522773975	39.59212336	CL, pink
	10	20	1150	1.318760947	26.37521894	CL, pink
	15	56	1725	1.076763804	60.29877303	CL, pink
	20	21	2300	0.9325048082	19.58260097	Sandy Lean Clay
Boring 6	0	8	0	-	-	Sandy Lean Clay (CL), gray
	2.5	17	287.5	2.637521894	44.83787219	CL, pink
	5	13	575	1.865009616	24.24512501	CL, reddish brown
	7.5	8	862.5	1.522773975	12.1821918	Lean Clay with Sand (CL), pink
	10	13	1150	1.318760947	17.14389231	Lean Clay with Sand (CL), pink
	15	18	1725	1.076763804	19.38174847	Sandy Lean Clay
	20	39	2300	0.9325048082	36.36768752	Sandy Lean Clay

Boring 8	0	9	0	-	-	Sandy Lean Clay (CL), light gray
	2.5	16	287.5	2.637521894	42.2003503	CL, pink
	5	11	575	1.865009616	20.51510578	CL, reddish brown
	7.5	10	862.5	1.522773975	15.22773975	Lean Clay with Sand (CL), pink
	10	9	1150	1.318760947	11.86884852	Lean Clay with Sand (CL), pink
	15	27	1725	1.076763804	29.07262271	Sandy Lean Clay (CL), pink
	20	25	2300	0.9325048082	23.31262021	CL, reddish brown
Boring 9	0	12	0	-	-	Fat Clay with Sand (CH), reddish gray
	2.5	13	287.5	2.637521894	34.28778462	CH, grayish brown
	5	18	575	1.865009616	33.5701731	Lean Clay with Sand (CL), grayish brown
	7.5	29	862.5	1.522773975	44.16044528	CL, pink
	10	24	1150	1.318760947	31.65026272	CL, pink
	15	96	1725	1.076763804	103.3693252	CL, reddish brown
	20	53	2300	0.9325048082	49.42275484	Sandy Fat Clay (CH), pinkish white

	Depth (ft.)	N	Stress (σ')	CN	N60	Soil Classification
Boring 10	0	10	0	-	-	Lean Clay with Sand (CL), very dark gray
	2.5	7	287.5	2.637521894	18.46265326	CL, pinkish gray
	5	14	575	1.865009616	26.11013463	CL, reddish brown
	7.5	31	862.5	1.522773975	47.20599323	Sandy Lean Clay (CL), reddish brown
	10	28	1150	1.318760947	36.92530651	CL, pink
	15	54	1725	1.076763804	58.14524542	CL, pink
	20	69	2300	0.9325048082	64.34283177	CL, pink

Boring 11	0	14	0	-	-	Lean Clay with Sand (CL), pinkish gray
	2.5	13	287.5	2.637521894	34.28778462	Lean Clay with Sand (CL), pinkish gray
	5	18	575	1.865009616	33.5701731	Lean Clay with Sand (CL), pinkish gray
	7.5	35	862.5	1.522773975	53.29708913	CL, reddish brown
	10	40	1150	1.318760947	52.75043787	CL, reddish brown
	15	57	1725	1.076763804	61.37553683	CL, reddish brown
	20	59	2300	0.9325048082	55.01778369	CL, reddish brown

Boring 12	0	3	0	-	-	Lean Clay with Sand (CL), reddish brown
	2.5	9	287.5	2.637521894	23.73769704	Lean Clay with Sand (CL), reddish brown
	5	7	575	1.865009616	13.05506732	CL, reddish gray
	7.5	7	862.5	1.522773975	10.65941783	Sandy Lean Clay (CL), reddish gray
	10	25	1150	1.318760947	32.96902367	CL, pink
	15	29	1725	1.076763804	31.22615032	CL, pink
	20	33	2300	0.9325048082	30.77265867	CL, pink

Boring 13	0	11	0	-	-	Clayey Sand (SC), reddish brown
	2.5	14	287.5	2.637521894	36.92530651	Clayey Sand (SC), reddish brown
	5	25	575	1.865009616	46.62524041	Lean Clay with Sand (CL), reddish brown

Boring 14	0	8	0	-	-	Lean Clay with Sand (CL), reddish brown
	2.5	8	287.5	2.637521894	21.10017515	Lean Clay with Sand (CL), reddish brown
	5	25	575	1.865009616	46.62524041	Lean Clay with Sand (CL), reddish brown

Boring 15	0	13	0	-	-	Sandy Lean Clay (CL), very dark gray
	2.5	21	287.5	2.637521894	55.38795977	CL, reddish brown
	5	36	575	1.865009616	67.14034619	Fat Clay with Sand (CH), gray

Boring 16	0	14	0	-	-	Lean Clay with Sand (CL), dark reddish brown
	2.5	8	287.5	2.637521894	21.10017515	CL, light reddish brown
	5	19	575	1.865009616	35.43518271	CL, light reddish brown

Boring 17	0	10	0	-	-	Lean Clay with Sand (CL), light reddish brown
	2.5	5	287.5	2.637521894	13.18760947	Lean Clay with Sand (CL), light reddish brown
	5	13	575	1.865009616	24.24512501	CL, pink
	7.5	17	862.5	1.522773975	25.88715758	CL, pink
	10	23	1150	1.318760947	30.33150178	CL, pink
	15	30	1725	1.076763804	32.30291412	CL, yellowish red
	20	50	2300	0.9325048082	46.62524041	Sandy Lean Clay (CL), yellowish red

Boring 18	0	3	0	-	-	Sandy Lean Clay (CL), reddish brown
	2.5	8	287.5	2.637521894	21.10017515	Sandy Lean Clay (CL), reddish brown
	5	14	575	1.865009616	26.11013463	CL, dark gray
	7.5	13	862.5	1.522773975	19.79606168	CL, pinkish gray
	10	4	1150	1.318760947	5.275043787	CL, pinkish gray
	15	32	1725	1.076763804	34.45644173	Clayey Sand (SC), pink
	20	54	2300	0.9325048082	50.35525964	Clayey Sand (SC), pink

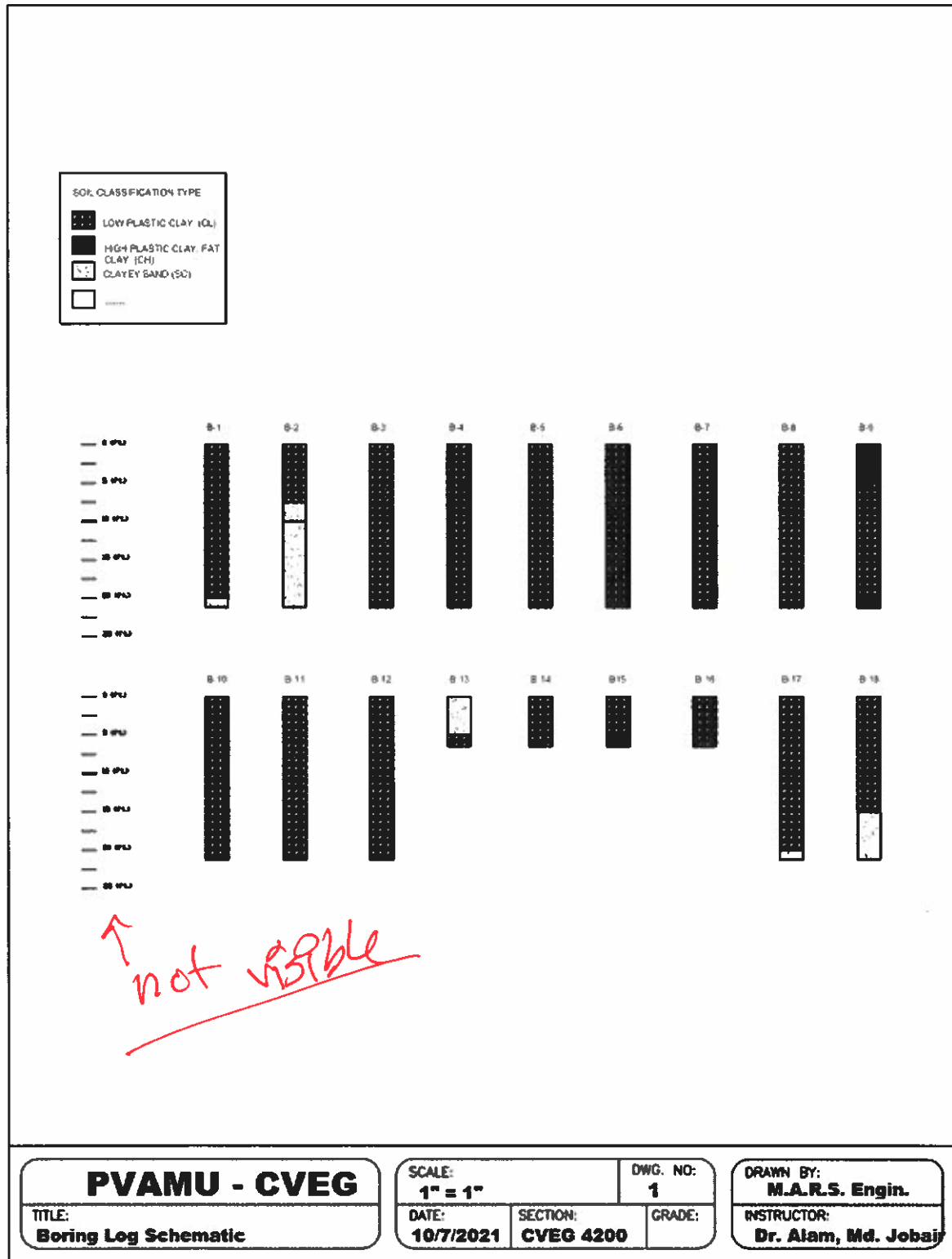


Figure 3.1c: Boring Log Schematic

3.1.4 Site and Subsurface Conditions

Site Location and Description

At the time of exploration activities, the site was existing and was generally level and exhibiting.

3.1.3 Groundwater Information

↑ font, size of text ✓
↓ must be consistent

The level of the groundwater was not observed in the boring log process during the time when the drilling operations were. It can be inferred that the groundwater levels were supposed to be recorded during the time of the drilling and upon completion of the drilling. It can also be inferred that fluctuations in the groundwater level could be affected by natural variations such as rainfall, temperature, humidity, etc.. Also, perched water could be encountered in discontinuous zones within the overburden. The groundwater levels presented in this report, assuming that any are present, are the levels that were measured during the time of our field activities. One recommendation would be to determine the actual levels of groundwater at the location of the site during the time of the construction activities to determine the impact on the construction process.

Environmental Site Assessment

The Environmental Site Assessment or ESA is usually considered to be the first step in buying a piece of land. Before a piece of land can be purchased, the owner must assure himself/herself that the future development of the land would even be feasible given the present soil conditions. In order to move forward in development, geotechnical engineers would be hired to check and analyze the soil. They would do so through preliminary borings in order to make sure that the soil is able to withstand the development process. This is why many institutions often require a Phase I ESA to be conducted. Conducting an ESA lifts some of the responsibility off of the land buyer/owner when it comes to their land quality and provides them with a confirmation that their land is suitable or not.

Standards for Performing a Phase I Site Assessment have been created by the EPA. These standards include:

- Researching the history of the facility, the soil type, and ground and surface water
- Evaluating the storage, handling, treatment, and disposal of the materials and the waste
- Investigating the site for any evidence of underground storage tanks or spills

3.2.1. Foundation Design

1.) Selection of Foundation

The appropriate foundation is selected for each selected facility based on certain factors. It is important to recognize the foundation type based on adequate and meaningful data from subsurface exploration

Selection of Foundation Type

The selection of a specific type of foundation is based on the following factors below:

Adequate Depth: the foundation must have an adequate depth to prevent frost damage. For other foundations like bridge piers, the foundation depth must be adequate in order to prevent damage by scour.

Adequate Strength: The foundation must be designed with adequate strength so that it does not fracture or break apart due to the applied loads of the structure. The foundation must also be designed and constructed properly with the design specifications taken into account.

Adverse Soil Changes: The soil foundation must be able to resist long term adverse changes.

Bearing Capacity Failure: The soil foundation must be safe against a bearing capacity failure.

Seismic Forces: The soil foundation must be able to support the structure on top of it during the time of an earthquake without excessive lateral or settlement movement.

Settlement: The soil foundation must not settle to a point that it damages the structure.

Quality: The foundation must be of an adequate quality so that it is not subjected to deterioration.

Soil Bearing Capacity

Terzaghi theorized that the soil underneath the footing would generate a triangle of pressure. The bearing capacity of the soil is developed in a footing due to three properties of soil:

1. Cohesion

2. Friction ✓

3. Density ✓

The terms used in the Terzaghi bearing capacity equation are the ultimate bearing capacity, the cohesion term, the surcharge term, and the density term. The ultimate bearing capacity (q_{ult}) of a foundation is the load beyond which a foundation would fail and no longer be useful. Cohesion (c) is a chemical process. Clay particles tend to adhere to each other due to electrical charges present in clay particles. Unlike cohesion, friction is a physical process. The higher the friction between particles, the higher the capacity of the soil to carry footing loads. Usually, sands and silts inherit friction. For all practical purposes, clays are considered to be friction-free. The friction of a soil is represented by the friction angle $= 0$; where B is the width of the footing, and the angle of the soil pressure triangle is given by the **ultimate bearing capacity**.

Ultimate Bearing Capacity

The Ultimate Bearing Capacity is calculated by using the Terzaghi Bearing Capacity factors which depend on the internal angle of friction of the soil. Ultimate Bearing Capacity (q_{ult}) for a square footing with a width B is calculated as,

$$Q_{ult} = 1.3cN_c + Y_1 D_f N_q + 0.4 Y_2 B N_\gamma$$

↳ q_u

$q = \text{pressure}$
 $Q = \text{load}$

Where,

Q_{ult} = Ultimate bearing capacity ✓

C = cohesion of soil

N_c, N_q, N_γ = Terzaghi's bearing capacity factors ✓

γ_1 = effective unit weight of soil above soil of foundation

γ_2 = effective unit weight of soil below foundation

D_f = depth of footing, or distance from ground surface to base of footing

B = width of square footing

Given:

$$\gamma_1 = 125 \text{ lb/ft}^3$$

$$\gamma_2 = 125 \text{ lb/ft}^3$$

$$D = 21.5 \text{ ft}$$

$$C = 1000 \text{ lb/ft}^2 \text{ for clay. Friction angle} = 0$$

Ultimate bearing capacity is therefore,

$$Q_{ult} = 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma$$

$$\begin{aligned} C &= 1.3 (1000) (5.7) + 125 \text{ lb/ft}^3 (21.5) (1) \\ q &= 10,097.5 \text{ lb/ft}^2 \end{aligned}$$

Parking lot (shallow foundation)

$$Q_{ult} = 1.3cN_c + \gamma_1 D_f N_q + 0.4\gamma_2 B N_\gamma$$

$$\begin{aligned} C &= 1.3 (1000) (5.7) + 125 \text{ lb/ft}^3 (6.5) (1) \\ q &= 8222.5 \text{ lb/ft}^2 \end{aligned}$$

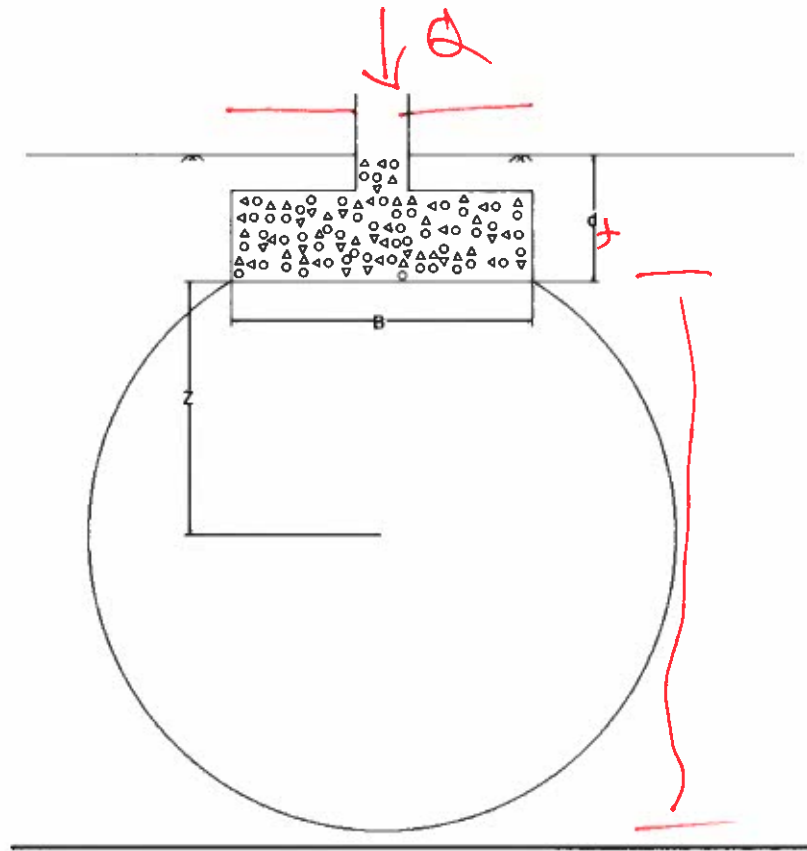


Figure 3.1d: Ultimate Bearing Capacity

Allowable Bearing Capacity

Allowable bearing capacity (q_a) refers to the loading per unit area that the soil is able to support without unsafe movement. It is also referred to as the design bearing capacity. A factor of safety of 2.5 to 3 is commonly applied to the value of q_{ult} . Care must be taken to ensure that a footing design is safe with regard to:

1. Foundation failure (collapse)
2. Excessive settlement

Allowable Bearing Capacity:

$$Q_a = q_{ult} / 3$$

$$Q_a = 3,365.83 \text{ lb./ft}^2$$

$$Q_a = 2740.83 \text{ lb/ft}^2$$

The allowable bearing capacity of the soil is determined to be 4.08 ksf for a 3.5ft by 3.5ft footing. This value will be used in ensuing foundation designs of compactness of the soils.

Primary Consolidation Settlement

Because there is no water, there is no consolidation settlement.

Results & Discussion

In order to determine the dimensions of the footing, the ultimate bearing capacity has to be calculated using the Terzaghi's bearing capacity factors, which depend on the internal angle of friction of the soil. To get the Ultimate Bearing Capacity the unit weight, cohesion of the soil, and the depth of the soil are needed to be known. When boring logs are taken at various locations on the site at different depths the angle of friction determined can be affected. If the angle of friction is affected, the Terzaghi's bearing capacity factors are affected too. When the type of soil is different at each point where a boring log was taken this also affects the unit weight of the soil and the cohesion of the soil. Since dimension of the footing and other things are not known, the

ultimate bearing capacity would not be consistent throughout the project. This would also change the allowable bearing capacity as well. Having footing with uniform dimensions would be more efficient and effective; but In order to determine the dimensions of the footing that would be effective across the site, calculations are needed to be done. Calculations were made for each depth of each boring log to determine the ultimate bearing capacity for a strip foundation. Based on this calculation, the lowest ultimate bearing capacity was taken to overestimate our ultimate bearing capacity. Based on this, the dimensions of a foundation is determined.

Conclusion

In conclusion, this group was able to learn various processes in the field of geotechnical engineering. The objective of the Geotechnical Group was to explore the subsurface conditions at this site to facilitate foundation design for the proposed structures and then provide general recommendations for the new existing building for Lubbock, Texas. scope of services included drilling soil borings to depths of 0 to 20 feet below the existing grades within the proposed development area, laboratory testing and preparation of an engineering report. All in all, this group was able to successfully apply geotechnical engineering practices to this project.

Reference!

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**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Title of Assignment: Project Report 2

TOPICS COVERED IN Project 2

1. Deep Foundation Design

**NOTE: Pages L1 through L7 should be repeated for each Report and
Similarly for all the other assignments in the course binder**

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

SAMPLE PROJECT QUESTIONS



Design Project 2

Description:

The soil boring logs for a project are provided with all the necessary soil properties. Estimate the bearing capacity of the soil if driven pile is considered as foundation system. Each of the boring logs are 20 ft. deep. Due to budget constraints, piles will be driven maximum 20 ft. Additionally, the pile diameter (for circular pile) cannot be more than 15 inches, and for square section pile, the maximum cross-sectional dimension should not be more than 15" by 15". Based on the given condition and soil properties, proportion the pile dimension and find the allowable bearing capacity in a most economical way for both circular and square section pile. Use reasonable factor of safety. **Develop capacity curves**, and recommend the allowable structural column loads that the pile can carry for all the borings for different pile section dimension.

Schedule:

Final Report Due: November 24, 2021 (before the class starts)

Project Presentation: November 24, 2021 (During Class time)

Note:

A professional comprehensive report is expected. Put detailed information, justification, drawings, necessary graphs, and other details in the report.

It is a group project, teamwork is necessary to complete the project.



BORING LOG

PROJECT NO.: STR 2450L
INVOICE NO.: 239386
PROJECT: New Building

LOCATION: McKinney, Texas
CLIENT: PVAMU
CONTACT: DR. Alam

TEST HOLE: B-1
SHEET NUMBER: 1 of 1
DATE STARTED: 6/4/2019
DATE FINISHED: 6/4/2019
DRILLER: Leo K.
LOGGER: Bradley W.
REVIEWED BY: B. Caro

DRILL RIG: CME-75			TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 20				DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/4/2019	4:30:00 PM	17.5	
SYMBOL	N/A	S ☐	U ☐	T ☒	G ☒	C ☐				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		1	1	4					35.5	82	25	57	97.3	
		3	4	7				Fat clay (CH), very dark gray	22.4					
5		3	5	6					19.0					
		4	8	10				(CH), light brown						
		4	7	9					17.5	42	15	27	92.4	
10									19.9					
15		5	10	11				Lean clay (CL), light brown	19.8					
		8	12	19										
									19.8					
20								Bottom of Borehole at 20 feet						



BORING LOG

PROJECT NO.: STR 2450L
 INVOICE NO.: 239386
 PROJECT: New Building

LOCATION: McKinney, Texas
 CLIENT: PVAMU
 CONTACT: DR. Alam

TEST HOLE: B-2
 SHEET NUMBER: 1 of 1
 DATE STARTED: 6/4/2019
 DATE FINISHED: 6/4/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: B. Caro

DRILL RIG: CME-75			TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 20				DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/5/2019	9:30:00 AM	13	
SYMBOL	N/A	S	U	T	G	C	6/4/2019	6:14:00 PM	18.5	

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		0	2	3										
		2	4	5				Fat clay (CH), very dark gray	23.0	69	21	48	93.0	
		3	4	8										
5		3	7	8										
		3	7	8										
		3	7	8										
10		3	7	8				(CH), brown	22.4	50	16	34	91.0	
		3	7	8										
		4	4	6										
15		4	4	6										
		4	4	6										
		8	19	28			(CH), light brown							
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BORING LOG

PROJECT NO.: STR 2450L
 INVOICE NO.: 239386
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LOCATION: McKinney, Texas
 CLIENT: PVAMU
 CONTACT: DR. Alam

TEST HOLE: B-3
 SHEET NUMBER: 1 of 1
 DATE STARTED: 6/4/2019
 DATE FINISHED: 6/4/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: B. Caro

DRILL RIG: CME-75							TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:					
DRILLING METHOD: Hollow Stem Auger							TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS		
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/4/2019	7:30:00 PM	17.5					
SYMBOL	N/A	S 	U 	T 	G 	C 								
DEPTH (FEET)	FIELD RESULTS						DESCRIPTION	LABORATORY RESULTS						
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)		GRAPHIC LOG	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		1	2	4				Fat clay (CH), very dark gray	30.7					
		2	5	8					19.0	61	20	41	97.7	
5		3	8	9					17.3					
		4	6	8					15.3				94.5	
10		3	5	8					21.9	70	22	48	98.5	
								(CH), light brown						
15		4	5	6					22.6				93.8	
		8	21	37					17.9	58	20	38	91.4	
20								Bottom of Borehole at 20 feet						



BORING LOG

PROJECT NO.: STR 2450L
 INVOICE NO.: 239386
 PROJECT: New Building

LOCATION: McKinney, Texas
 CLIENT: PVAMU
 CONTACT: DR. Alam

TEST HOLE: B-4
 SHEET NUMBER: 1 of 1
 DATE STARTED: 6/5/2019
 DATE FINISHED: 6/5/2019
 DRILLER: Leo K.
 LOGGER: Bradley W.
 REVIEWED BY: B. Caro

DRILL RIG: CME-75			TEST HOLE DIAMETER (in): 8				GROUND WATER DATA:			
DRILLING METHOD: Hollow Stem Auger			TOTAL DEPTH (ft): 20				DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/5/2019	9:15:00 AM	14	
SYMBOL	N/A	S	U	T	G	C				

DEPTH (FEET)	FIELD RESULTS						GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)			MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		0	2	3					34.6					
		3	6	8				Fat clay (CH), very dark gray	20.0					
5		3	6	9				(CH), light brown	17.2					
		4	7	9					17.3	35	13	22	86.2	
10														
15		5	8	10				(CL), yellowish brown						
		9	23	30				Fat clay (CH), yellowish brown	18.3	54	20	34	86.5	
20								Bottom of Borehole at 20 feet						

ABOVE AVERAGE

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4100: Geotechnical Engineering Design

Section: P81

Title: Geotech Project 2 Report

Submitted By: M.A.R.S Engineering

Abram Auguste, Alex Martinez, Caleb Ross, Nathaniel Smith

Submitted To: Dr. Alam, Md Jobair Bin Ph.D., P.E.

Due Date: November 24, 2021 NLT 10:00 A.M.

Fall 2021

ABET Criteria 3(c) and 3(i)

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Letter of Transmittal

November 24, 2021

Dr. Jobair Bin Alam

Civil Engineering Department

Prairie View A&M University

Dear Dr. Alam,

This report describes a design for a project done by M.A.R.S. Engineering. The report contains the detailed analysis and recommendations for the allowable loads on structural columns that each pile section can take for the different pile section dimensions. All the information in the report was gathered from EIT's and engineers involved in the project. This report also consists of different sections that will analyze some differently significant parts of the project. Please feel free to contact our project manager if you have any questions or concerns regarding the report (857-342-0981).

Thank you,

M.A.R.S. Engineering



Abstract

The engineers of this project were tasked with providing a foundation type that best fit the proposed building in Lubbock, Texas. The buildings will be constructed with a conventional steel-framed building structural system. The building is anticipated to have a foundation that will consist of continuous footing around the building and spread footing under the isolated steel columns. The foundation of the project must be designed for bearing capacity and settlement. Comparing the different types of foundations will help decide if the selection and dimensions are both good fits for the project's structure.



Introduction

The test that we will be conducting is the Standard Penetration Test (SPT). The Standard Penetration Test is a testing method that is used to determine the geotechnical properties of subsurface soils. The test compared to others is inexpensive and can estimate the density and shear strength parameters of soil accurately. The test uses a thick-walled sample tube, with an outside diameter of 50.8 mm and an inside diameter of 35 mm, and a length of around 650 mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a mass of 63.5 kg (140 lb) falling through a distance of 760 mm (30 in). The sample tube is driven 150 mm into the ground and then the number of blows needed for the tube to penetrate each 150 mm (6 in) up to a depth of 450 mm (18 in) is recorded. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance" or the "N-value". In cases where 50 blows are insufficient to advance it through a 150 mm (6 in) interval the penetration after 50 blows are recorded. The blow count provides an indication of the density of the ground, and it is used in many empirical geotechnical engineering formulae. In regard to the N-value, it provides an indication of the density of subsurface soil. Using this, the approximate shear strength properties of the soils can be estimated for the project.



Objective

The objective of this project was to analyze the given boring logs and to develop capacity curves for both square and circular dimensions. Also to prepare a comprehensive geotechnical investigation and to prepare a written report of the analysis and recommend the allowable structural column loads that the pile can carry for all the borings for different pile section dimensions. The things that need to be done will be drilling soil borings at a depth of a maximum of 20 feet below the existing grades within the proposed development area and laboratory testing and preparation of an engineering report will be conducted.

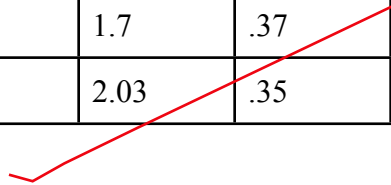
Circular Pile: $A_{\text{circular pile}} = 1.23 \text{ ft}^2$; $P = 3.93 \text{ ft}$.



Square Section Pile: $A_{\text{square pile}} = 1.56 \text{ ft}^2$; $P = 5 \text{ ft}$.

Table 1a: Boring 1 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	6088.5	0	6088.5
2.5	11	1500	.75	.62	16,605	9137.3	25,742.3
5	11	1500	.75	.62	16,605	9137.3	25,742.3
7.5	18	3000	1.5	.39	33,210	11,495.3	44,705
10	16	2500	1.25	.42	27,675	10,316.3	37,991.3
15	21	3400	1.7	.37	37,638	24,719.7	62,357.7
18.75	31	4050	2.03	.35	44,833.5	20,890.4	65,723.9



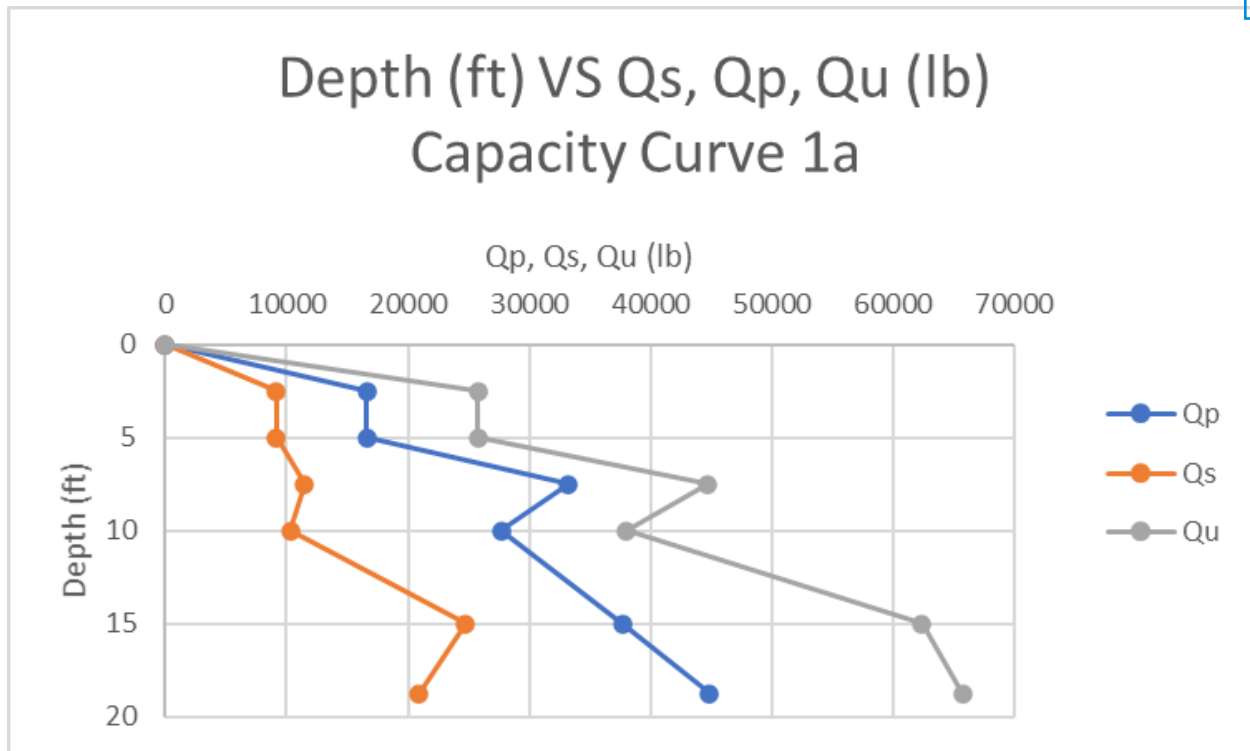
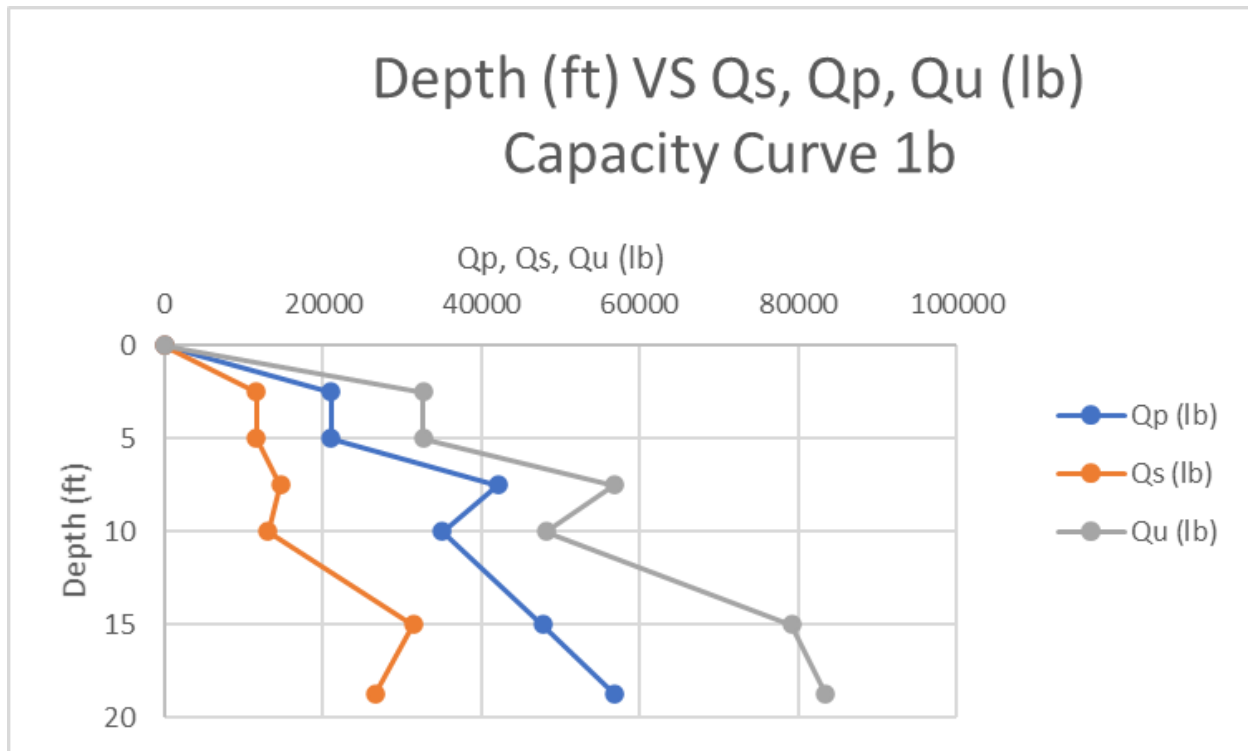


Table 1b: Boring 1 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	7722	0	7722
2.5	11	1500	.75	.62	21,060	11,625	32,685
5	11	1500	.75	.62	21,060	11,625	32,685
7.5	18	3000	1.5	.39	42,120	14,625	56,745
10	16	2500	1.25	.42	35,100	13,125	48,225
15	21	3400	1.7	.37	47,736	31,450	79,186
18.75	31	4050	2.03	.35	56,862	26,578.1	83,440.1



CALCULATIONS FOR BEARING CAPACITY ALLOWABLE:

$$Q_{s,1} = P_{\text{Circular}} \times \sum_1^7 (f_n \times \Delta L) = 3.93 \text{ ft.} \times \left[71,698.13 \frac{\text{lbs}}{\text{ft.}} \right] = 281,773.6 \text{ lbs}$$

$$Q_{p,1} = 9 \times C_u \times A_{\text{circular pile}} = 9 \times \left[4,050 \frac{\text{lbs}}{\text{ft}^2} \right] \times 1.23 \text{ ft}^2 = 44,833.5 \text{ lbs}$$

$$Q_{s,1} = P_{\text{Square}} \times \sum_1^7 (f_n \times \Delta L) = 3.93 \text{ ft.} \times \left[71,698.13 \frac{\text{lbs}}{\text{ft.}} \right] = 358,490.6 \text{ lbs}$$

$$Q_{p,1} = 9 \times C_u \times A_{\text{square pile}} = 9 \times \left[4,050 \frac{\text{lbs}}{\text{ft}^2} \right] \times 1.56 \text{ ft}^2 = 56,862 \text{ lbs}$$

$$Q_{u,\text{Square}} = Q_p + Q_s = 56,862 \text{ lbs} + 358,490.6 \text{ lbs} = 415,352.6 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{415,352.6 \text{ lbs}}{3} = 138,450.87 \text{ lbs}$$

EXPLAIN THE Q- ALLOWABLE :

The Q allowable for boring log 1 was calculated to be 138,450.87 pounds. This means the allowable structural column load can not surpass 138,450.87 lbs or failure will occur.

Table 2a: Boring 2 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	6088.5	0	6088.5
2.5	9	1200	.6	.62	13,284	7309.8	20,593.8
5	12	1650	.83	.54	18,265.5	8754.1	27,019.6
7.5	15	2000	1	.48	22,140	9432	31,572
15	10	1400	.7	.58	15,498	23,933.7	39,431.7
18.75	47	5000	2.5	.34	55,350	25,053.8	80,403.3

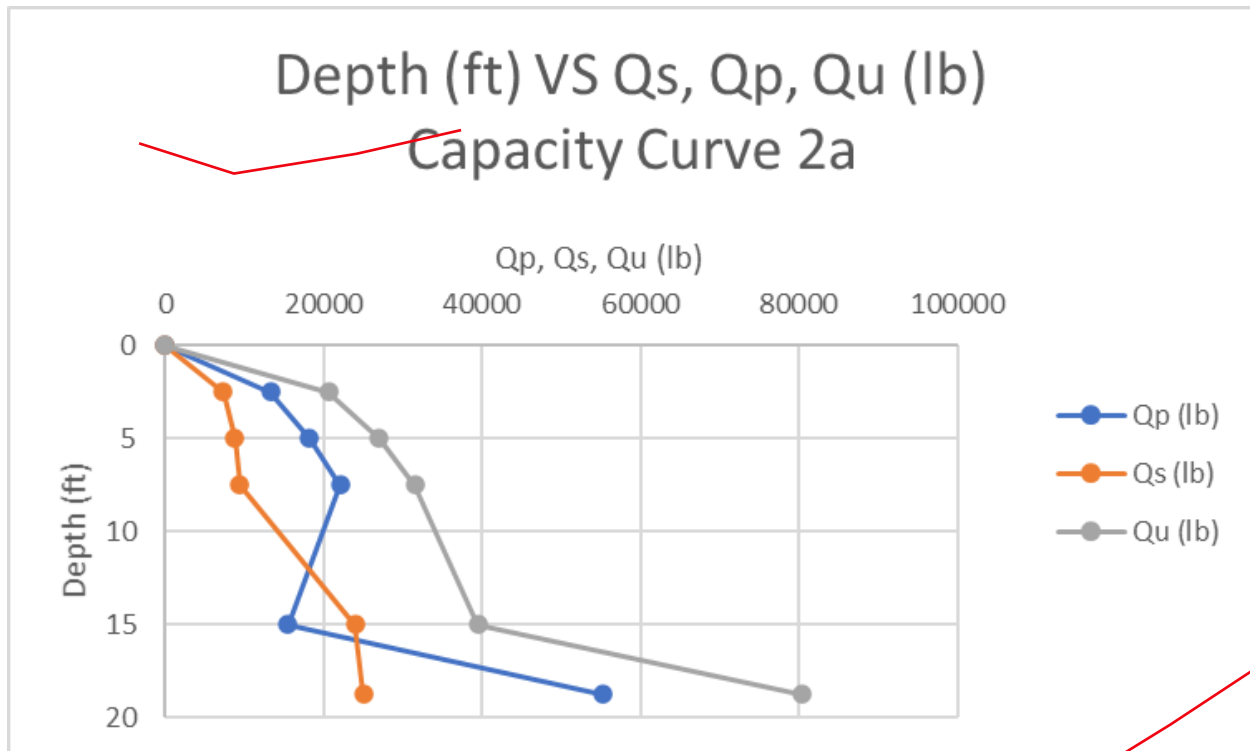
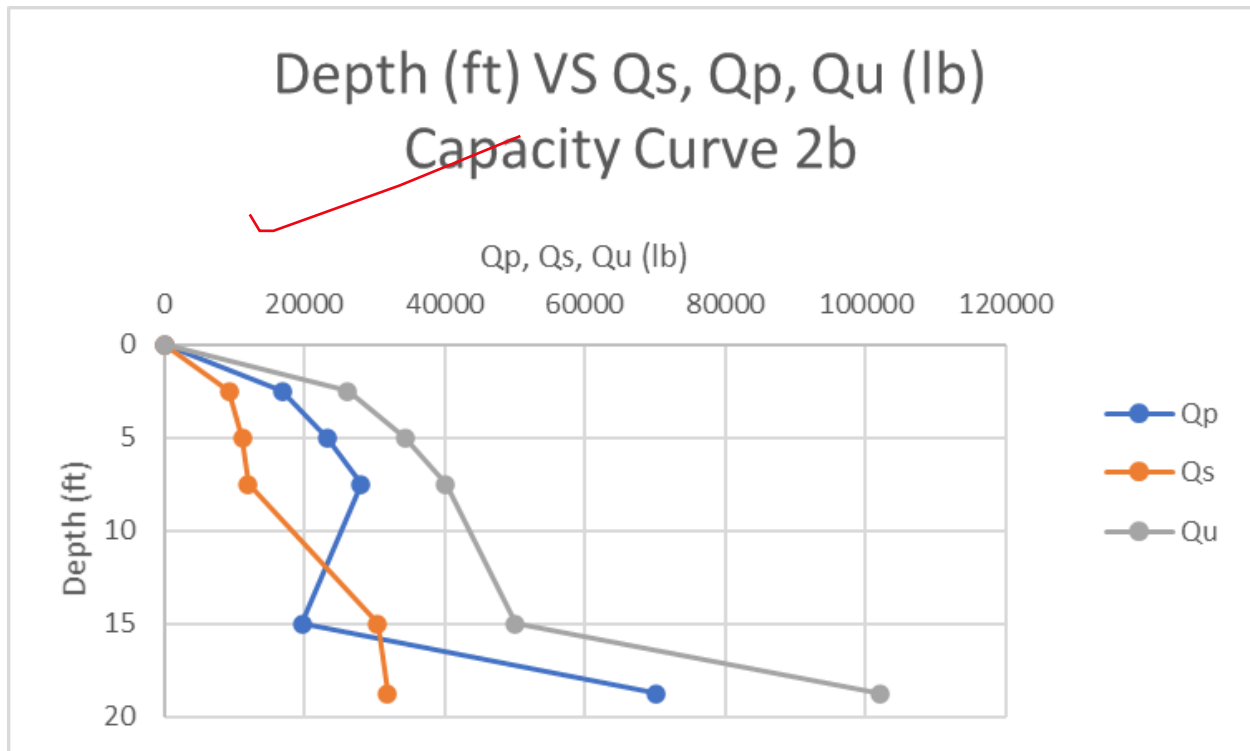


Table 2b: Boring 2 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	7722	0	7722
2.5	9	1200	.6	.62	16,848	9300	26,148
5	12	1650	.83	.54	23,166	11,137.5	34,303.5
7.5	15	2000	1	.48	28,080	12,000	40,080
15	10	1400	.7	.58	19,656	30,450	50,106
18.75	47	5000	2.5	.34	70,200	31,875	102,075



CALCULATIONS FOR BEARING CAPACITY ALLOWABLE:

$$Q_{s,2} = P_{\text{Circular}} \times \sum_1^7 (f_n \times \Delta L) = 3.93 \text{ ft.} \times [57,570 \frac{\text{lbs}}{\text{ft.}}] = 226,250.1 \text{ lbs}$$

$$Q_{s,2} = P_{\text{Square}} \times \sum_1^7 (f_n \times \Delta L) = 5 \text{ ft.} \times [57,570 \frac{\text{lbs}}{\text{ft.}}] = 287,850 \text{ lbs}$$

$$Q_{p,2} = 9 \times C_u \times A_{\text{circular pile}} = 9 \times [5,000 \frac{\text{lbs}}{\text{ft}^2}] \times 1.23 \text{ ft}^2 = 55,350 \text{ lbs}$$

$$Q_{p,2} = 9 \times C_u \times A_{\text{square pile}} = 9 \times \left[5,000 \frac{\text{lbs}}{\text{ft}^2} \right] \times 1.56 \text{ft}^2 = 70,200 \text{ lbs}$$

$$Q_{u,\text{Square}} = Q_p + Q_s = 70,200 \text{ lbs} + 287,850 \text{ lbs} = 358,050 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{358,050 \text{ lbs}}{3} = 119,350 \text{ lbs}$$

EXPLAIN THE Q- ALLOWABLE:

The Q allowable for boring log 2 was calculated to be 119,350 pounds. This means the allowable structural column load can not surpass 119,350 lbs or failure will occur.

Table 3a: Boring 3 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	6	700	.35	.78	7749	0	7749
2.5	13	1800	.9	.51	19,926	9019.4	28,945.4
5	17	2550	1.28	.42	28,228.5	10,522.6	38,751.1
7.5	14	1900	.95	.52	21,033	9707.1	30,740.1
10	13	1800	.9	.51	19,926	9019.4	28,945.4
15	11	1500	.75	.62	16,605	18,274.5	34,879.5
18.75	58	6000	3	.34	66,420	30,064.5	36,484.5

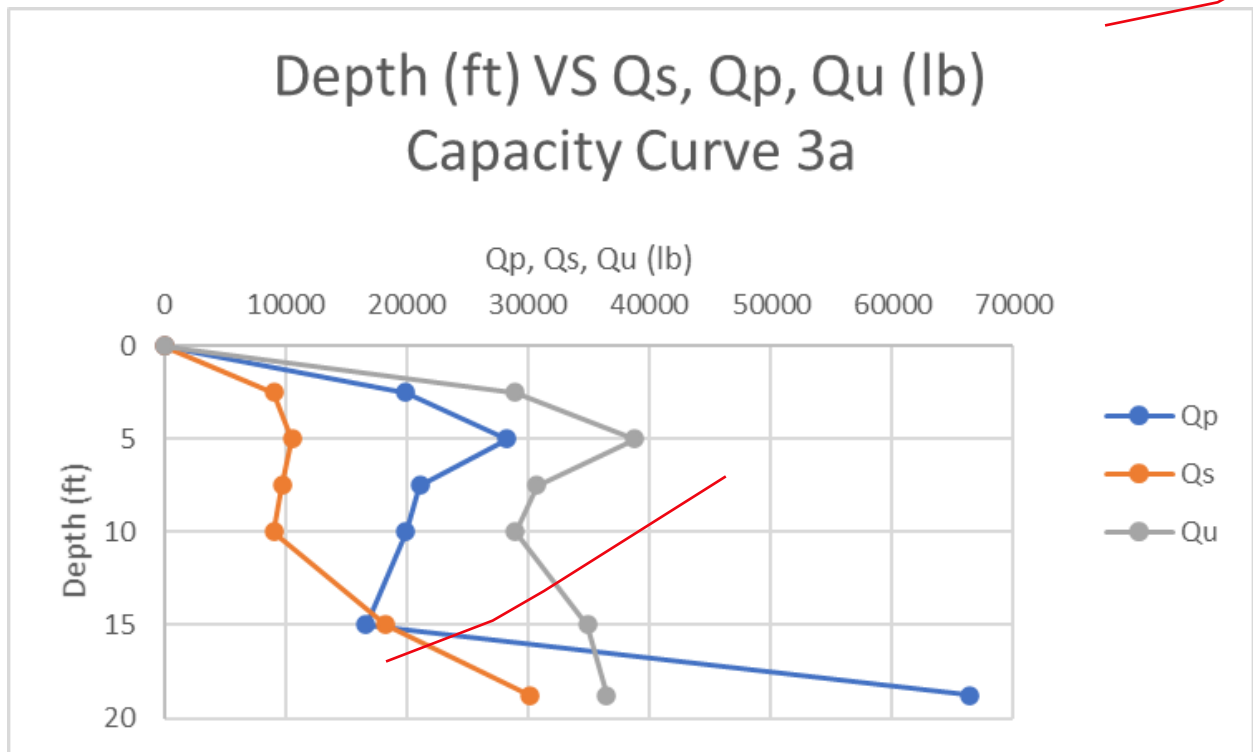
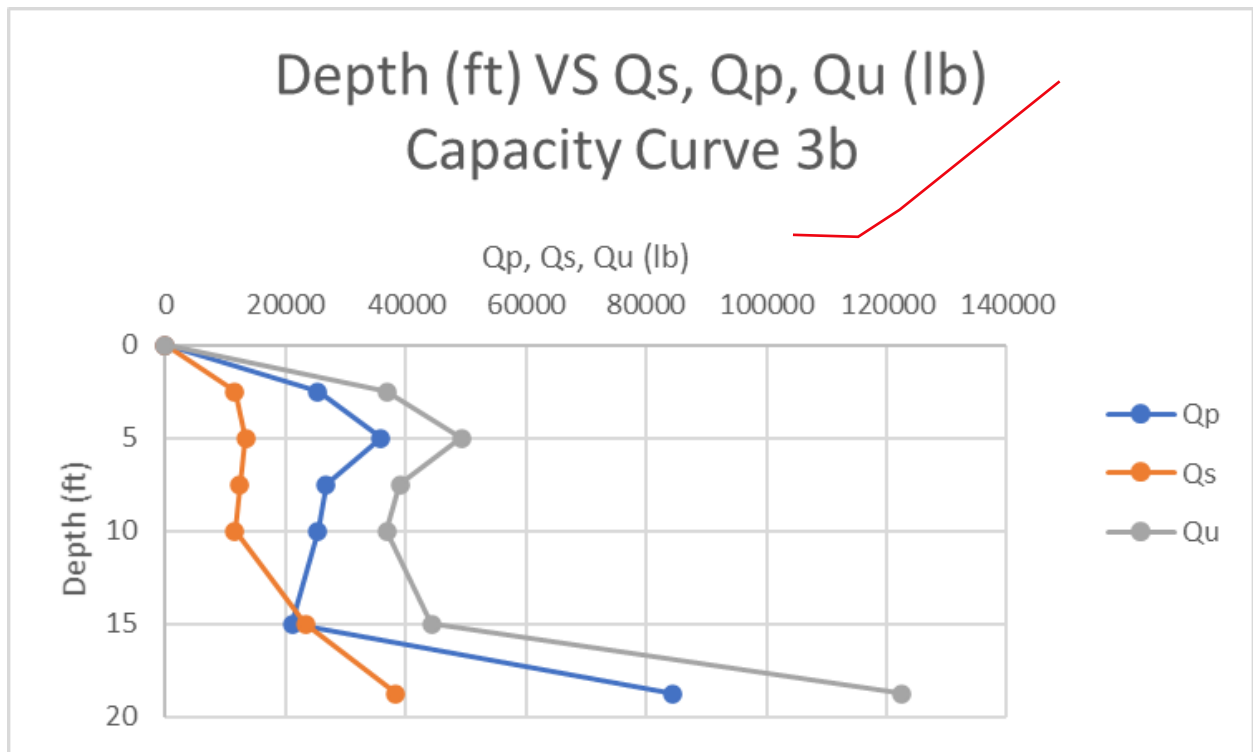


Table 3b: Boring 3 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	6	700	.35	.78	9828	0	9828
2.5	13	1800	.9	.51	25,272	11,475	36,747
5	17	2550	1.28	.42	35,802	13,387.5	49,189.5
7.5	14	1900	.95	.52	26,676	12,350	39,026
10	13	1800	.9	.51	25,272	11,475	36,747
15	11	1500	.75	.62	21,060	23,250	44,310
18.75	58	6000	3	.34	84,240	38,250	122,490



CALCULATIONS FOR BEARING CAPACITY ALLOWABLE:

$$Q_{s,3} = P_{\text{Circular}} \times \sum_1^7 (f_n \times \Delta L) = 3.93 \text{ ft.} \times [76,440 \frac{\text{lbs}}{\text{ft.}}] = 300,409.2 \text{ lbs}$$

$$Q_{s,3} = P_{\text{Square}} \times \sum_1^7 (f_n \times \Delta L) = 5 \text{ ft.} \times [76,440 \frac{\text{lbs}}{\text{ft.}}] = 382,200 \text{ lbs}$$

$$Q_{p,3} = 9 \times C_u \times A_{\text{circular pile}} = 9 \times [6,000 \frac{\text{lbs}}{\text{ft}^2}] \times 1.23 \text{ ft}^2 = 66,420 \text{ lbs}$$

$$Q_{p,3} = 9 \times C_u \times A_{\text{square pile}} = 9 \times [6,000 \frac{\text{lbs}}{\text{ft}^2}] \times 1.56 \text{ ft}^2 = 84,240 \text{ lbs}$$

$$Q_{u,\text{Square}} = Q_p + Q_s = 84,240 \text{ lbs} + 382,200 \text{ lbs} = 466,440 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{466,440 \text{ lb}}{3} = 155,480 \text{ lbs}$$

EXPLAIN THE Q- ALLOWABLE:

The Q allowable for boring log 3 was calculated to be 155,480 pounds. This means the allowable structural column load can not surpass 155,480 lbs or failure will occur.

Table 4a: Boring 4 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	6088.5	0	6088.5
2.5	14	1900	.95	.52	21,033	9707.1	30,740.1
5	15	2000	1	.48	22,140	9432	31,572
7.5	16	2500	1.25	.42	27,675	10,316.3	37,991.3
15	18	3050	1.53	.41	33,763.5	36,858.5	70,622
18.75	53	5800	2.9	.34	64,206	29,062	93,268

Depth (ft) VS Qs, Qp, Qu (lb) Capacity Curve 4a

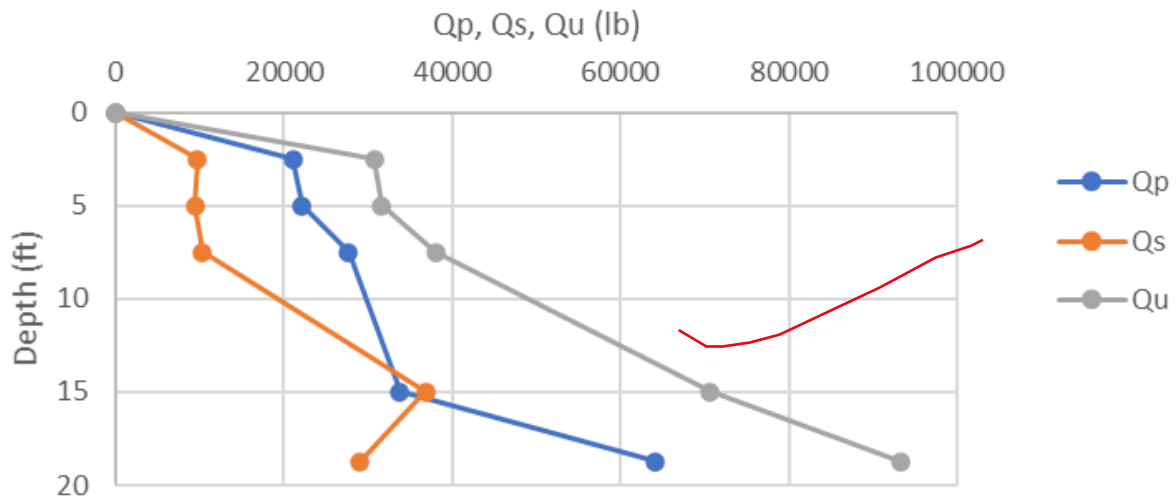
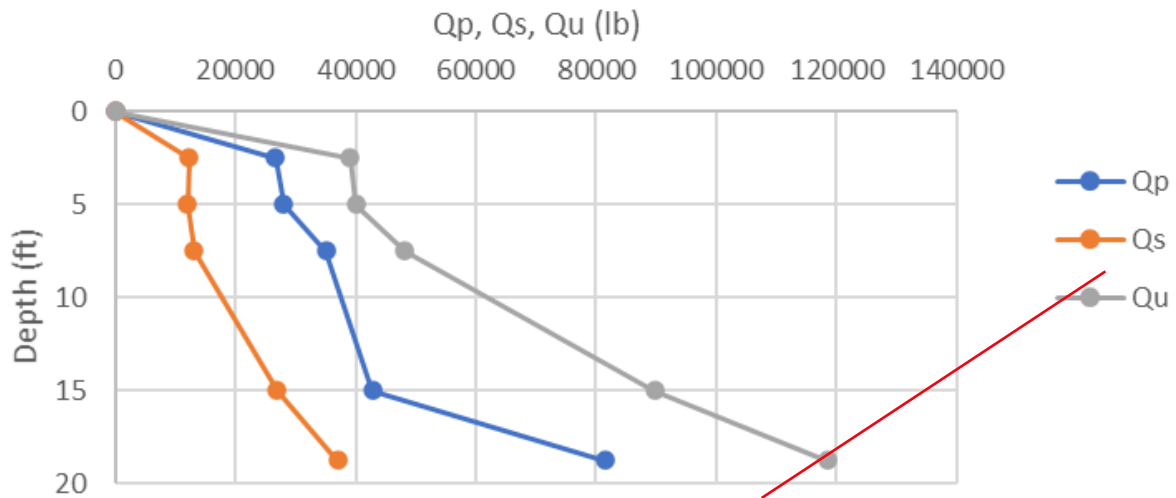


Table 4b: Boring 4 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)
0	5	550	.275	.92	7722	0	7722
2.5	14	1900	.95	.52	26,676	12,350	39,026
5	15	2000	1	.48	28,080	12,000	40,080
7.5	16	2500	1.25	.42	35,100	13,125	48,225
15	18	3050	1.53	.41	42,822	26,893.8	89,715
18.75	53	5800	2.9	.34	81,432	36,975	118,407

Depth (ft) VS Qs, Qp, Qu (lb) Capacity Curve 4b



CALCULATIONS FOR BEARING CAPACITY ALLOWABLE:

$$Q_{s,4} = P_{\text{Circular}} \times \sum_1^7 (f_n \times \Delta L) = 3.93 \text{ ft.} \times [70,877.5 \frac{\text{lbs}}{\text{ft.}}] = 278,548.6 \text{ lbs}$$

$$Q_{s,4} = P_{\text{Square}} \times \sum_1^7 (f_n \times \Delta L) = 5 \text{ ft.} \times [70,877.5 \frac{\text{lbs}}{\text{ft.}}] = 354,387.5 \text{ lbs}$$

$$Q_{p,4} = 9 \times C_u \times A_{\text{circular pile}} = 9 \times [5,800 \frac{\text{lbs}}{\text{ft}^2}] \times 1.23 \text{ ft}^2 = 64,206 \text{ lbs}$$

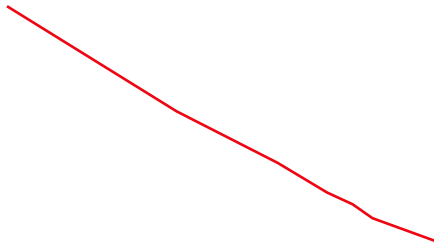
$$Q_{p,4} = 9 \times C_u \times A_{\text{square pile}} = 9 \times \left[5,800 \frac{\text{lbs}}{\text{ft}^2} \right] \times 1.56 \text{ft}^2 = 81,432 \text{ lbs}$$

$$Q_{u,\text{Square}} = Q_p + Q_s = 81,432 \text{ lbs} + 354,387.5 \text{ lbs} = 435,819.5 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{435,819.5 \text{ lbs}}{3} = \underline{145,273.17 \text{ lbs}}$$

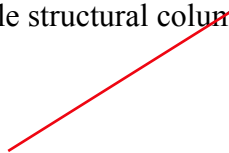
EXPLAIN THE Q- ALLOWABLE:

The Q allowable for boring log 4 was calculated to be 145,273.17 pounds. This means the allowable structural column load can not surpass 145,273.17 lbs or failure will occur.



RESULTS and DISCUSSION

In the project the SPT test was used to determine the properties of the subsurface soils. It was required to analyze the given boring logs and to develop capacity curves for both square and circular dimensions. The diameter of the circular pile could not be more than 15” and the square section pile could not have a cross-section longer than 15” (15”x15”). With the given conditions like soil properties, and pile dimension, the allowable bearing capacity for both the circular and square section piles using a reasonable factor of safety had to be determined in the most economical way. also the allowable structural column loads the piles can withstand for all the borings has to be calculated.



In the beginning of the analysis the area (A) and perimeter (p) had to be determine for both the circle and square pile:

Circular Pile: $A_{\text{circular pile}} = \pi r^2 = 1.23 \text{ ft}^2$

Square Section Pile: $A_{\text{square pile}} = bh = 1.56 \text{ ft}^2$

Circular Pile: $p_{\text{circular pile}} = 2\pi r = 3.93 \text{ ft.}$

Square Section Pile: $p_{\text{square pile}} = S \times 4 = 5 \text{ ft.}$

The area and perimeter are both constant for all boring logs.

The bearing capacity (Q_u) is calculated by adding the point bearing capacity (Q_p) and the friction bearing capacity (Q_s):

$$Q_{u,\text{Square}} = Q_p + Q_s$$

To calculate the point bearing capacity (Q_p) the following equation was used:

$$Q_p = 9 \times C_u \times A$$

Where

C_u - mean undrained shear strength

A - area

To calculate the friction bearing capacity (Q_s):

$$Q_s = P \times \sum_1^7 (f_n \times \Delta L)$$

Where

P - perimeter

f_n - unit friction resistance at any depth z. $f_n = \alpha C_u$

When the bearing capacity (Q_u) is derived the value equated is divided by the factor of safety to get the maximum pressure that can be applied to the soil from the foundation ($Q_{\text{Allowable}}$). The factor of safety generally used ranges from 2 to 3.

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}}$$

These equations had to be calculated to find the bearing capacity for both a square and a circle pile for each boring log. That calculation were derived as followed:

For boring log 1:

$$Q_{u,\text{Square}} = Q_p + Q_s = 56,862 \text{ lbs} + 358,490.6 \text{ lbs} = 415,352.6 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{415,352.6 \text{ lbs}}{3} = 138,450.87 \text{ lbs}$$

The Q allowable for boring log 1 was calculated to be 138,450.87 pounds. This means the allowable structural column load can not surpass 138,450.87 lbs or failure will occur.

For boring log 2:

$$Q_{u,\text{Square}} = Q_p + Q_s = 70,200 \text{ lbs} + 287,850 \text{ lbs} = 358,050 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{358,050 \text{ lbs}}{3} = 119,350 \text{ lbs}$$

The Q allowable for boring log 2 was calculated to be 119,350 pounds. This means the allowable structural column load can not surpass 119,350 lbs or failure will occur.



For boring log 3:

$$Q_{u,\text{Square}} = Q_p + Q_s = 84,240 \text{ lbs} + 382,200 \text{ lbs} = 466,440 \text{ lbs}$$

$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{466,440 \text{ lb}}{3} = 155,480 \text{ lbs}$$

The Q allowable for boring log 3 was calculated to be 155,480 pounds. This means the allowable structural column load can not surpass 155,480 lbs or failure will occur.

For boring log 4;

$$Q_{u,\text{Square}} = Q_p + Q_s = 81,432 \text{ lbs} + 354,387.5 \text{ lbs} = 435,819.5 \text{ lbs}$$

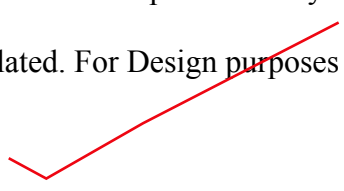
$$Q_{\text{Allowable}} = \frac{Q_u}{\text{F.S.}} = \frac{435,819.5 \text{ lbs}}{3} = \underline{145,273.17 \text{ lbs}}$$

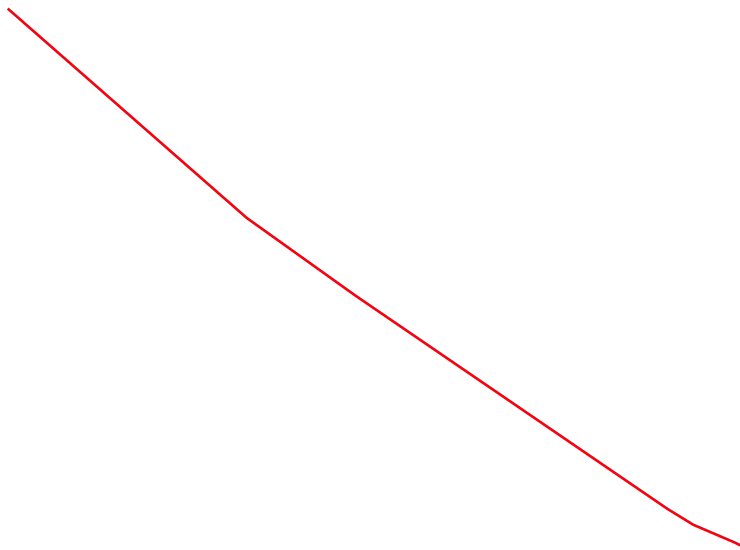
The Q allowable for boring log 4 was calculated to be 145,273.17 pounds. This means the allowable structural column load can not surpass 145,273.17 lbs or failure will occur.

CONCLUSION

Bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity (Q_u) is calculated by adding the point bearing capacity (Q_p) and the friction bearing capacity (Q_s). The ultimate bearing capacity is the maximum load the soil can support with no

failure. The allowable bearing capacity is just the ultimate bearing capacity divided by a factor of safety. The test that was conducted was the Standard Penetration Test (SPT). The Standard Penetration Test is a testing method that is used to determine the geotechnical properties of subsurface soils. The test compared to others is inexpensive and can estimate the density and shear strength parameters of soil accurately. Using this, the approximate shear strength properties of the soils can be estimated for the project. During the project the given boring logs and capacity curves for both square and circular dimensions were calculated. Also the recommended allowable structural column loads that the pile can carry for all the borings for different pile section dimensions were calculated. For Design purposes we will choose the minimum of all Q allowables at 119,350 lbs.





References

Introduction to Geotechnical Engineering, Book by Braja M Das, Originally published: 1985

Appendix

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f*ΔL
0	5	550	0.275	0.92	6088.5	0	6088.5	506	0
2.5	11	1500	0.75	0.62	16,605	9137.3	25,742.30	930	2325
5	11	1500	0.75	0.62	16,605	9137.3	25,742.30	930	4650
7.5	18	3000	1.5	0.39	33,210	11,495.30	44,705	1170	8775
10	16	2500	1.25	0.42	27,675	10,316.30	37,991.30	1050	10500
15	21	3400	1.7	0.37	37,638	24,719.70	62,357.70	1258	18870
18.75	31	4050	2.03	0.35	44,833.50	20,890.40	65,723.90	1417.5	26578.13
								Sum	71698.13

281773.6
358490.6

Boring 1 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f*ΔL
0	5	550	0.275	0.92	7722	0	7722	506	0
2.5	11	1500	0.75	0.62	21,060	11,625	32,685	930	2325
5	11	1500	0.75	0.62	21,060	11,625	32,685	930	4650
7.5	18	3000	1.5	0.39	42,120	14,625	56,745	1170	8775
10	16	2500	1.25	0.42	35,100	13,125	48,225	1050	10500
15	21	3400	1.7	0.37	47,736	31,450	79,186	1258	18870
18.75	31	4050	2.03	0.35	56,862	26,578.10	83,440.10	1417.5	26578.13
								Sum	71698.13

281773.6
358490.6

la: Boring 2 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f*ΔL
0	5	550	0.275	0.92	6088.5	0	6088.5	506	0
2.5	9	1200	0.6	0.62	13,284	7309.8	20,593.80	744	1860

5	12	1650	0.83	0.54	18,265.50	8754.1	27,019.60	891	4455
7.5	15	2000	1	0.48	22,140	9432	31,572	960	7200
15	10	1400	0.7	0.58	15,498	23,933.70	39,431.70	812	12180
18.75	47	5000	2.5	0.34	55,350	25,053.80	80,403.30	1700	31875
								Sum	57570

226250.1
287850

Boring 2 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	5	550	0.275	0.92	7722	0	7722	506	0
2.5	9	1200	0.6	0.62	16,848	9300	26,148	744	1860
5	12	1650	0.83	0.54	23,166	11,137.50	34,303.50	891	4455
7.5	15	2000	1	0.48	28,080	12,000	40,080	960	7200
15	10	1400	0.7	0.58	19,656	30,450	50,106	812	12180
18.75	47	5000	2.5	0.34	70,200	31,875	102,075	1700	31875
								Sum	57570

226250.1
287850

3a: Boring 3 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	6	700	0.35	0.78	7749	0	7749	546	0
2.5	13	1800	0.9	0.51	19,926	9019.4	28,945.40	918	2295
5	17	2550	1.28	0.42	28,228.50	10,522.60	38,751.10	1071	5355
7.5	14	1900	0.95	0.52	21,033	9707.1	30,740.10	988	7410
10	13	1800	0.9	0.51	19,926	9019.4	28,945.40	918	9180
15	11	1500	0.75	0.62	16,605	18,274.50	34,879.50	930	13950
18.75	58	6000	3	0.34	66,420	30,064.50	36,484.50	2040	38250
								Sum	76440

300409.2

382200

Boring 3 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	6	700	0.35	0.78	9828	0	9828	546	0
2.5	13	1800	0.9	0.51	25,272	11,475	36,747	918	2295
5	17	2550	1.28	0.42	35,802	13,387.50	49,189.50	1071	5355
7.5	14	1900	0.95	0.52	26,676	12,350	39,026	988	7410
10	13	1800	0.9	0.51	25,272	11,475	36,747	918	9180
15	11	1500	0.75	0.62	21,060	23,250	44,310	930	13950
18.75	58	6000	3	0.34	84,240	38,250	122,490	2040	38250
Sum									76440

300409.2

382200

la: Boring 4 Analysis for Circular Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	5	550	0.275	0.92	6088.5	0	6088.5	506	0
2.5	14	1900	0.95	0.52	21,033	9707.1	30,740.10	988	2470
5	15	2000	1	0.48	22,140	9432	31,572	960	4800
7.5	16	2500	1.25	0.42	27,675	10,316.30	37,991.30	1050	7875
15	18	3050	1.53	0.41	33,763.50	36,858.50	70,622	1250.5	18757.5
18.75	53	5800	2.9	0.34	64,206	29,062	93,268	1972	36975
Sum									70877.5

278548.6

354387.5

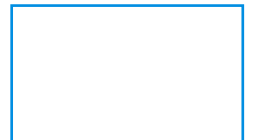
Boring 4 Analysis for Square Section Pile

Depth (ft)	SPT	Cu (psf)	Cu/Pa	α	Qp (lb)	Qs (lb)	Qu (lb)	f	f* ΔL
0	5	550	0.275	0.92	7722	0	7722	506	0
2.5	14	1900	0.95	0.52	26,676	12,350	39,026	988	2470
5	15	2000	1	0.48	28,080	12,000	40,080	960	4800

7.5	16	2500	1.25	0.42	35,100	13,125	48,225	1050	7875
15	18	3050	1.53	0.41	42,822	26,893.80	89,715	1250.5	18757.5
18.75	53	5800	2.9	0.34	81,432	36,975	118,407	1972	36975
Sum									70877.5

278548.6

354387.5



AVERAGE

Prairie View A&M University



CVEG 4021: Geotechnical Engineering Design Project **Design Project 2**

Autumn Carter

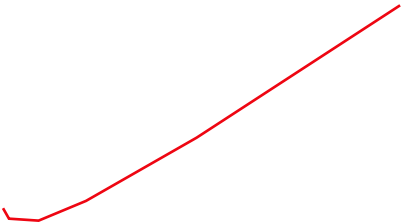
Shadaria Lynch

Perla Zaldivar

Submitted to:
Dr. J. B. Alam

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Letter of Transmittal

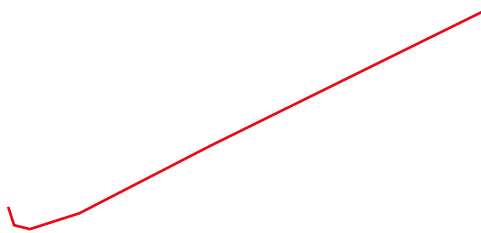
October 13, 2021

Dr. Jobair Bin Alam
Civil & Environmental Engineering
Prairie View A&M University

Dear Dr. Alam,

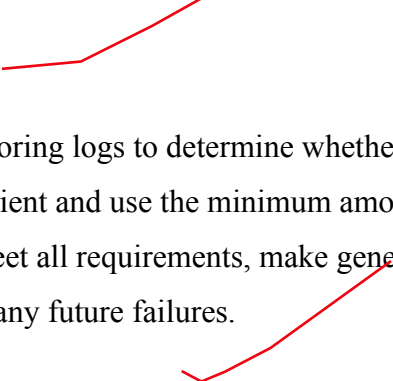
The attached technical report contains the detailed results of the bearing capacity of the soil. The report contains an analysis and recommendation for the allowable bearing capacity of the soil. This report consists of the introduction, soil analysis, the analysis and capacity curves of boring logs from B-1 to B-4 and conclusions and recommendations. If you have any questions or concerns, please do not hesitate to contact us.

Sincerely,
Autumn Carter
Shadaria Lynch
Perla Zaldivar

A red handwritten signature, likely belonging to one of the signatories listed above, is written in a cursive style across the lower right portion of the page.

Introduction

The engineers that created this document were given a task to recommend a foundation type by finding the allowable bearing capacity in the most economical way for both circular and square section pile; by following budget constraints. With a condensed budget, piles will be driven to a maximum of 20 feet depth for each boring log. The pile diameter for a circular pile cannot be more than 15 inches and for a square section pile, the maximum cross-sectional dimensions should not be more than 15" by 15".



The project's goal is to analyze the given boring logs to determine whether a circular or square pile section will be economically cost efficient and use the minimum amount of concrete to sustain long term foundation design. To meet all requirements, make general recommendations to ensure the foundation is defended from any future failures.

Chapter 1: Foundation Design

1.1 Foundation

The pile foundation can be a square or diameter per project guidelines. The selection depends on which foundation will be economically friendly and use less concrete. The analysis of the soil is an important factor in deciding the foundation. The boring log provides the description of the soil, depth, number of blows and the laboratory results. These elements work together to define the requirements for a long-term foundation design. The foundation design must also meet all regulations to ensure that the foundation is safe from any potential failures.

1.2 Soil Profile

Based on all the boring logs the bearing capacity was calculated based on boring log B-3. The boring log consists of fat clay, very dark gray from the zero depth to 5ft. From 5ft to 20ft the soil was found to be clay of high plasticity, light brown. The soil has a water table of at 18.75 feet depth, therefore consolidation of settlement can occur.

1.3 Ultimate Load Bearing Capacity

The Ultimate Load Bearing Capacity for a pile foundation can be found by,

$$Q_u = Q_p + Q_s \quad (1)$$

Where,

Q_p = Load carrying capacity of the pile point

Q_s = frictional resistance

The load carrying capacity can be found by,

$$Q_p = N^* c_u A_p \quad (2)$$

For saturated clays under undrained conditions ($\phi = 0$) the equation can be written as,

$$Q_p = 9c_u A_p \quad (3)$$

c_u = undrained cohesion of the soil

A_p = cross sectional area of pile tip

The frictional resistance can be found by,

$$Q_s = \sum fp\Delta L \quad (4)$$

f = unit friction resistance

p = perimeter of the pile section

ΔL = incremental pile length

For alpha method (α) the skin resistance is,

$$f = \alpha c_u \quad (5)$$

α = adhesion factor

1.4 Allowable Bearing Capacity

The allowable bearing capacity is the load per unit area the foundation applies on the underlying soil.

$$q_{all} = q_u / FS \quad (6)$$

The Factor of Safety for shallow foundation ranges from the values 3 to 4. The factor of safety taken into account was 3. The allowable bearing capacity for the square pile foundation was found to be 50045 lb. The allowable bearing capacity for the circular pile foundation was found to be 39380 lb.

1.5. Soil Analysis

The tables below display the analysis of the soil from each boring log using the alpha method. The depth and SPT values were taken from each boring log. The undrained cohesion of the soil (C_u) was found from the ranges displayed in Table 24 in the SPT handout on canvas. Alpha (α) was found using Table 12.11 in 'Principles of Foundation Engineering 9th ed.' The load carrying capacity of the pile point (Q_p), frictional resistance (Q_s), and ultimate load bearing capacity (Q_u), were also calculated in the tables. Sample calculations are displayed in Chapter 2 of the report.

Table 1a. Boring Log 1 Square

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	5	600	0.3	0.82	8424	0	8424
2.5	11	1600	0.8	0.54	22464	10800	33264
5	11	1600	0.8	0.54	22464	10800	33264
7.5	18	3200	1.6	0.38	44928	15200	60128
10	16	3200	1.6	0.38	44928	15200	60128
15	21	3200	1.6	0.38	44928	30400	75328
18.75	31	4000	2	0.35	56160	22800	78960

Table 1b. Boring Log 1 Circle

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	5	600	0.3	0.82	6642	0	6642
2.5	11	1600	0.8	0.54	17712	8488.8	26200.8
5	11	1600	0.8	0.54	17712	8488.8	26200.8
7.5	18	3200	1.6	0.38	35424	11947.2	47371.2
10	16	3200	1.6	0.38	35424	11947.2	47371.2
15	21	3200	1.6	0.38	35424	23894.4	59318.4
18.75	31	4000	2	0.35	44280	22401	66681

Table 2a. Boring Log 2 Square

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	5	750	0.375	0.82	10530	0	10530
2.5	9	1100	0.55	0.62	15444	6042	21486
5	12	1500	0.75	0.54	21060	7958	29018
7.5	15	2000	1	0.48	28080	9423	37503

15	10	1300	0.65	0.62	18252	23757	42009
18.75	47	4000	2	0.35	56160	20633	76793

Table 2b. Boring Log 2 Circle

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	5	750	0.375	0.82	8302	0	8302
2.5	9	1100	0.55	0.62	12177	6701	18878
5	12	1500	0.75	0.54	16605	7958	24563
7.5	15	2000	1	0.48	22140	9432	31572
15	10	1300	0.65	0.62	14391	23756	38147
18.75	47	4000	2	0.35	44280	20632	64912

Table 3a. Boring Log 3 Square

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	6	750	0.375	0.82	10530	0	10530
2.5	13	1700	0.85	0.54	23868	11475	35343
5	17	2500	1.25	0.42	35100	13125	48225
7.5	14	1900	1.0	0.48	26676	11400	38076
10	13	1700	0.85	0.54	23868	11475	35343
15	11	1500	0.8	0.54	21060	20250	41310
18.75	58	4000	2	0.35	56160	26250	82410

Table 3b. Boring Log 3 Circle

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	6	750	0.375	0.82	8302	0	8302
2.5	13	1700	0.85	0.54	18819	9019	27838
5	17	2500	1.25	0.42	27675	10316	37991
7.5	14	1900	0.95	0.48	21033	8960	29993
10	13	1700	0.85	0.54	18819	9019	27838
15	11	1500	0.75	0.54	16605	15916	32521
18.75	58	4000	2	0.35	44280	20632	64912

Table 4a. Boring Log 4 Square

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	6	750	0.375	0.82	10530	0	10530
2.5	14	1900	0.95	0.48	26676	8960	25636
5	15	2000	1	0.48	28080	9432	37512
7.5	16	3000	1.5	0.38	42120	11201	53321
15	18	3000	1.5	0.38	42120	33602	75722
18.5	53	4000	2	0.35	56160	20633	76793

Table 4b. Boring Log 4 Circle

Depth	SPT	Cu (psf)	Cu/Pa	a	Qp (lb)	Qs (lb)	Qu (lb)
0	6	750	0.375	0.82	8302	0	8302
2.5	14	1900	0.95	0.48	21033	8960	29993
5	15	2000	1	0.48	22140	9432	31572
7.5	16	3000	1.5	0.38	33210	11201	44411
15	18	3000	1.5	0.38	33210	33602	66812

18.5	53	4000	2	0.35	44280	20632	64912
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The figures below display the capacity curves for a circle and square foundation corresponding to each boring log.

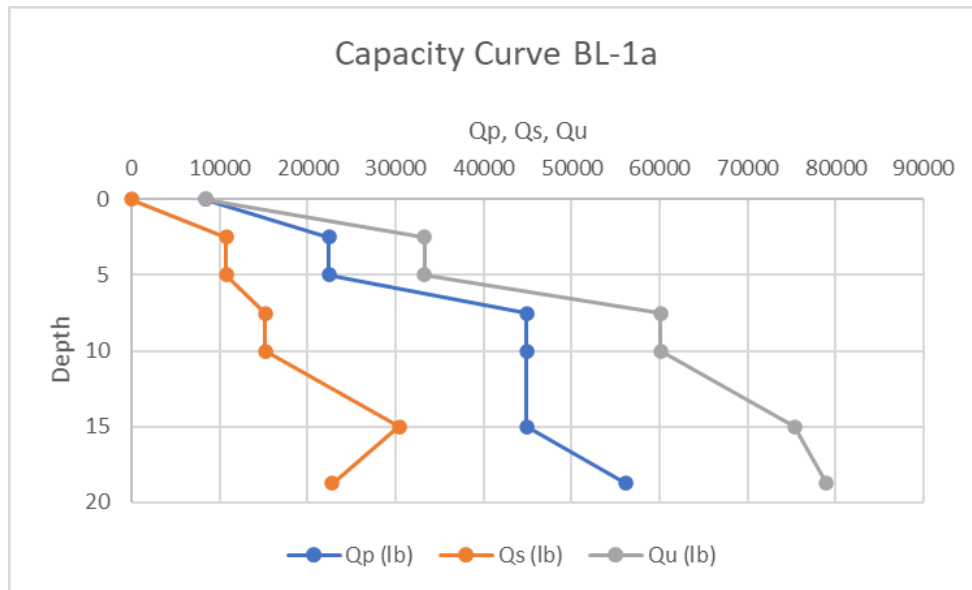


Figure 1a. Capacity Curve Boring Log 1 Square

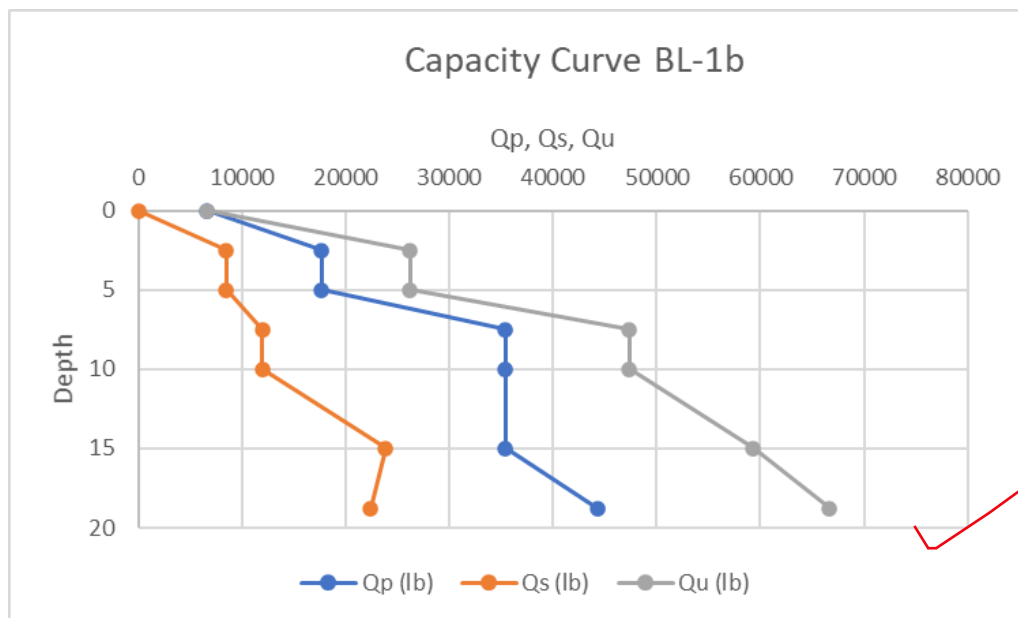


Figure 1b. Capacity Curve Boring Log 1 Circle

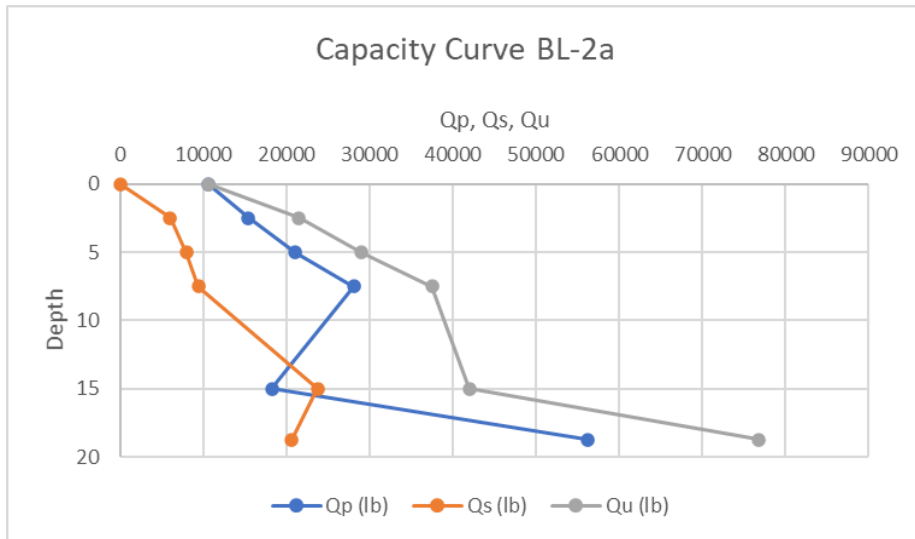


Figure 2a. Capacity Curve Boring Log 2 Square

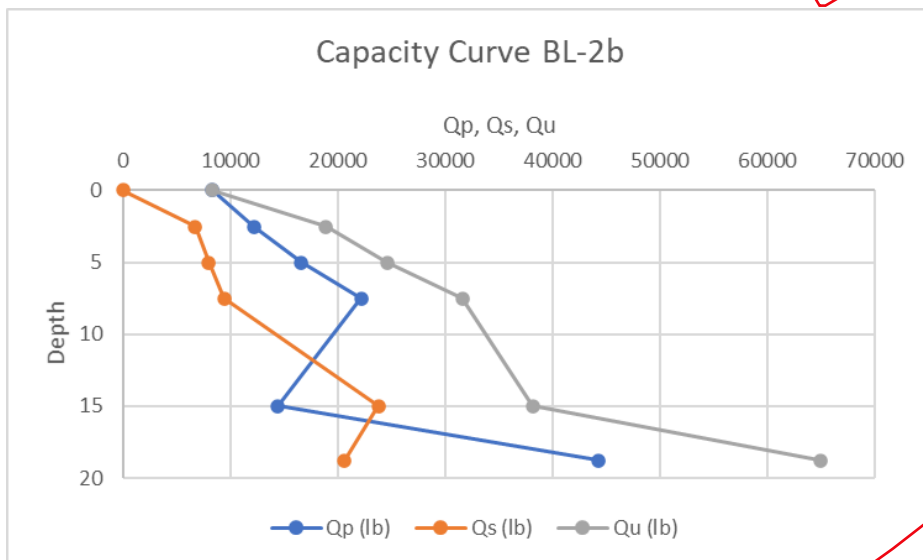


Figure 2b. Capacity Curve Boring Log 2 Circle

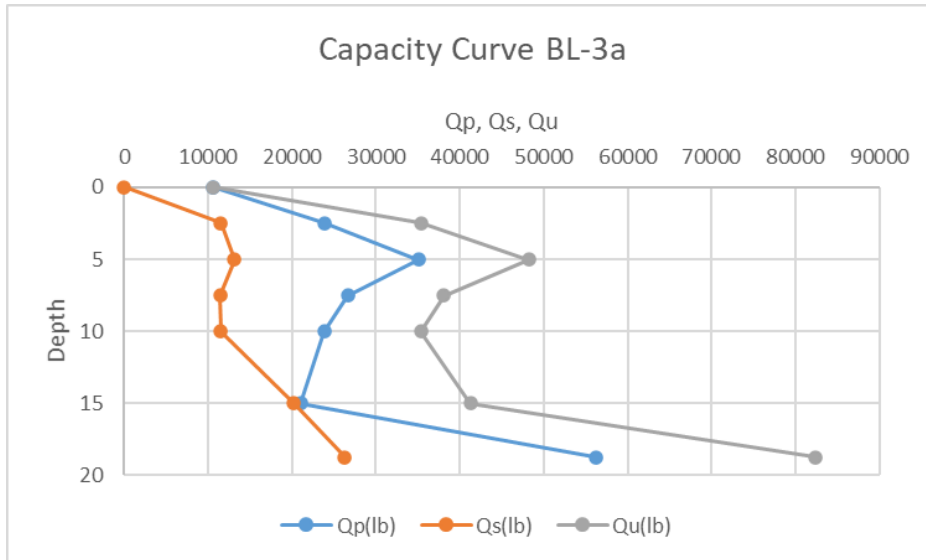


Figure 3a. Capacity Curve Boring Log 3 Square

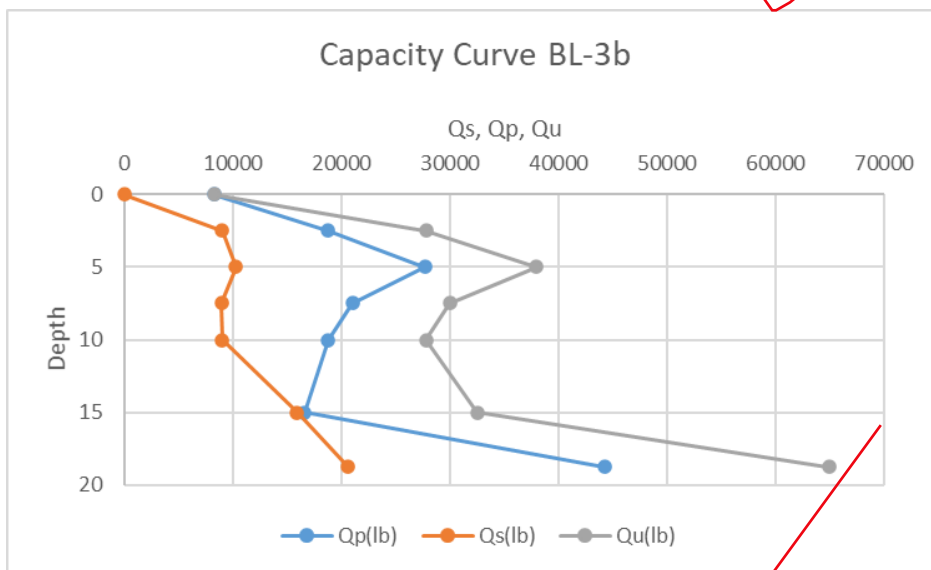


Figure 3b. Capacity Curve Boring Log 3 Circle

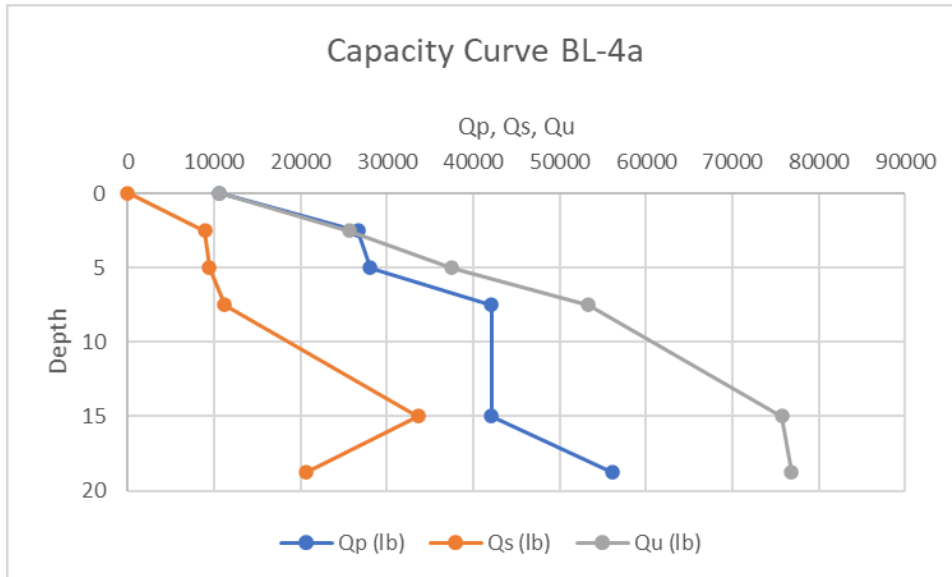


Figure 4a. Capacity Curve Boring Log 4 Square

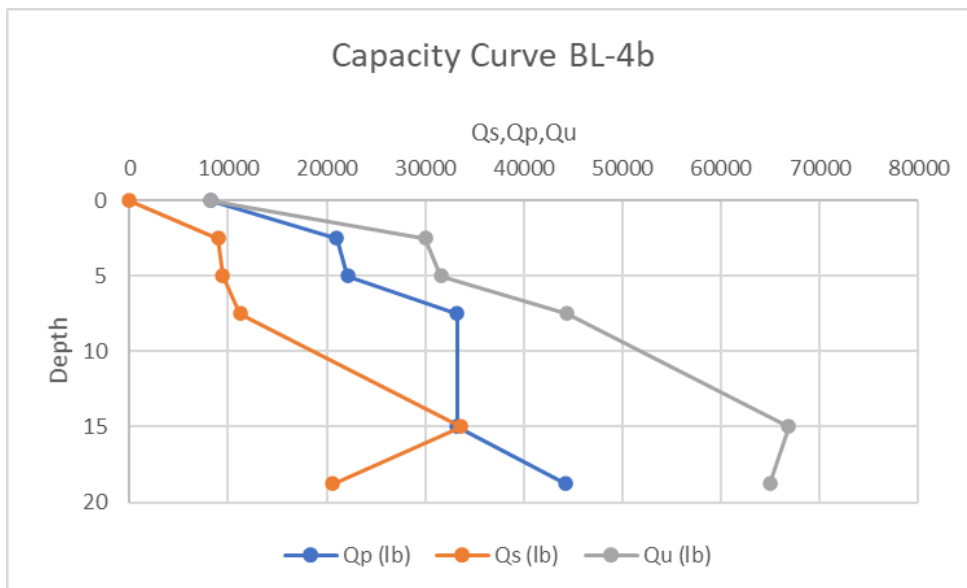


Figure 4b. Capacity Curve Boring Log 4 Circle

Chapter 2 Conclusion & Recommendations

2.1 Conclusion

Calculations were done using Meyerhof ultimate load carrying capacity equation for pile foundations, the alpha method was used. Based on our calculations, it is recommended that the circle pile foundation should be used since it is the most economically efficient foundation. Boring log 3, compared to others, was used to calculate the allowable bearing capacity based on its soil conditions. The allowable bearing capacity for the circle foundation was found to be 39380 lb, with a concrete volume of 24.54 cubic ft. ✓



Calculations

Square Pile

$$Q_u = Q_p + Q_s$$

$$Q_u = 9 * C_u * A_p + f * p * \Delta L$$

$$Q_u = 56160 + 93975$$

$$Q_u = 150135 \text{ lb}$$

$$Q_{all} = \frac{Q_u}{FS}$$

$$Q_{all} = \frac{150135 \text{ lb}}{3} = 50045 \text{ lb}$$

Find the volume

$$V = l * w * h$$

$$V = (1.56 \text{ ft})(1.56 \text{ ft})(20 \text{ ft})$$

$$V = 48.672 \text{ ft}^3$$

Circle Pile

$$Q_u = Q_p + Q_s$$

$$Q_u = 9 * C_u * A_p + f * p * \Delta L$$

$$Q_u = 44280 + 73862$$

$$Q_u = 118142 \text{ lb}$$

$$Q_{all} = \frac{Q_u}{FS}$$

$$Q_{all} = \frac{118142 \text{ lb}}{3} = 39380 \text{ lb}$$

Find the volume

$$V = \pi r^2 h$$

$$V = \pi * (0.625)^2 * 20 \text{ ft}$$

$$V = 24.54 \text{ ft}^3$$

Given

$$A_p = 1.56 \text{ ft}^2$$

Given

$$A_p = 1.23 \text{ ft}^2$$

$$r = \frac{15 \text{ in}}{2} = 7.5 \text{ in} \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) = 0.625 \text{ in.}$$

BELOW AVERAGE

Design Project 2
CVEG 4100: Geotechnical Engineering Design
Fall 2021



Submitted by:

Sydney Jones

Michael LeBlanc

Paige Hines

Submitted to:

Dr. Alam

Department of Civil and Environmental Engineering

Prairie View A&M University

Due: November 24, 2021

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Abstract

In the following report, we were told to proportion the pile dimension and calculate the permissible bearing capacity in the most cost-effective way for both circular and square section piles based on the given condition and soil parameters. We used a factor of safety of 3. We also created capacity curves and recommend the maximum structural column loads that a pile can support for all borings and pile section dimensions. For boring hole number 1 it was determined that the allowable capacity would be 53.1 kips for a square pile and 41.8 kips for a circle pile. For boring hole number 2 it was determined that the allowable capacity would be 46.3 kips for a square pile and 36.4 kips for a circle pile. For boring hole number 3 it was determined that the allowable capacity would be 43.28 kips for a square pile and 57.7 kips for a circle pile. For boring hole number 4 it was determined that the allowable bearing capacity would be 45.24 kip for a circle pile and 57.62 kip for a square pile. All of the relevant soil parameters are included in the soil boring logs for a project.



Introduction

For this project we were asked to estimate the bearing capacity of the soil in order to consider a foundation system. This report includes four test borings to depths of approximately 20 feet below and contains fat clay and lean clay of different moisture contents, liquid limits, plastic limits and plasticity limit. With every 5 foot increment, there are SPT number of blows. Our group utilized the provided information found in each boring log to calculate the strength of each soil sample and create the total capacity curve allowing us to determine whether the soil contained the proper strength to support the required structure. Due to financial constraints, piles will only be driven up to 20 feet. Additionally, the pile diameter (for circular piles) must not exceed 15 inches, and the maximum cross-sectional dimension for square section piles must not exceed 15 in. by 15 in.



Boring Logs

 BORING LOG														
PROJECT NO.: STR 2450L INVOICE NO.: 239386 PROJECT: New Building LOCATION: McKinney, Texas CLIENT: PVAMU CONTACT: DR. Alam					TEST HOLE: B-1 SHEET NUMBER: 1 of 1 DATE STARTED: 6/4/2019 DATE FINISHED: 6/4/2019 DRILLER: Leo K. LOGGER: Bradley W. REVIEWED BY: B. Caro									
DRILL RIG: CME-75 DRILLING METHOD: Hollow Stem Auger			TEST HOLE DIAMETER (in): 8 TOTAL DEPTH (ft): 20			GROUND WATER DATA:								
TYPE/		CASING	SPLIT SPOON	SHELBY TUBE	TOP	GRAB	ROCK CORE	DATE	TIME	WATER DEPTH (ft)	REMARKS			
SYMBOL		N/A	S ☒	U ☐	T ☒	G ☒	C ☐	6/4/2019	4:30:00 PM	17.5				
FIELD RESULTS							LABORATORY RESULTS							
DEPTH (FEET)	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	ROD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0	1	1	1	4				35.5	82	25	57	97.3		
3	3	4	7				Fat clay (CH), very dark gray	22.4						
5	3	5	6				(CH), light brown	19.0						
4	4	8	10					17.5	42	15	27	92.4		
10	4	7	9					19.9						
15	5	10	11				Lean clay (CL), light brown	19.8						
8	8	12	19					19.8						
20	Bottom of Borehole at 20 feet													

BORING LOG														
 Since 1977		PROJECT NO.: STR 2450L INVOICE NO.: 239386 PROJECT: New Building				TEST HOLE: B-2 SHEET NUMBER: 1 of 1 DATE STARTED: 6/4/2019 DATE FINISHED: 6/4/2019 DRILLER: Leo K. LOGGER: Bradley W. REVIEWED BY: B. Caro								
		LOCATION: McKinney, Texas CLIENT: PVAMU CONTACT: DR. Alam												
DRILL RIG: CME-75		TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:										
DRILLING METHOD: Hollow Stem Auger		TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS							
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/5/2019	9:30:00 AM	13					
SYMBOL	N/A	S ☒	U ☐	T ☒	G ☒	C ☐	6/4/2019	6:14:00 PM	18.5					
FIELD RESULTS							LABORATORY RESULTS							
DEPTH (FEET)	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	ROD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SIEVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		0	2	3					31.4					
2		2	4	5			Fat clay (CH), very dark gray	23.0	69	21	48	93.0		
5		3	4	8				19.4						
7		3	7	8				20.1						
10							(CH), brown	22.4	50	16	34	91.0		
15		4	4	6										
18		8	19	28			(CH), light brown	18.2						
20							Bottom of Borehole at 20 feet							

TERRA <i>Since 1977</i>		BORING LOG PROJECT NO.: STR 2450L INVOICE NO.: 239386 PROJECT: New Building LOCATION: McKinney, Texas CLIENT: PVAMU CONTACT: DR. Alam						TEST HOLE: B-3 SHEET NUMBER: 1 of 1 DATE STARTED: 6/4/2019 DATE FINISHED: 6/4/2019 DRILLER: Leo K. LOGGER: Bradley W. REVIEWED BY: B. Caro					
DRILL RIG: CME-75		TEST HOLE DIAMETER (in): 8		GROUND WATER DATA:									
DRILLING METHOD: Hollow Stem Auger		TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS						
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/4/2019	7:30:00 PM	17.5				
SYMBOL	N/A	S	U	T	G	C							
FIELD RESULTS				DESCRIPTION		LABORATORY RESULTS							
DEPTH (FEET)	SAMPLE	SPT, # of Blows				POCKET PEN. (TSF)	ROD (%)	GRAPHIC LOG	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SIEVE # 200 (%)
0	1	2	4										
2	2	5	8										
5	3	8	9										
4	4	6	8										
10	3	5	8										
15	4	5	6										
8	8	21	37										
				Bottom of Borehole at 20 feet									

		BORING LOG PROJECT NO.: STR 2450L INVOICE NO.: 239386 PROJECT: New Building LOCATION: McKinney, Texas CLIENT: PVAMU CONTACT: DR. Alam				TEST HOLE: B-4 SHEET NUMBER: 1 of 1 DATE STARTED: 6/5/2019 DATE FINISHED: 6/5/2019 DRILLER: Leo K. LOGGER: Bradley W. REVIEWED BY: B. Caro			
		DRILL RIG: CME-75 TEST HOLE DIAMETER (in): 8 DRILLING METHOD: Hollow Stem Auger TOTAL DEPTH (ft): 20				GROUND WATER DATA:			
						DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/	CASING	SPLIT SPOON	SHELBY TUBE	TOP	GRAB	ROCK CORE	6/5/2019	9:15:00 AM	14
SYMBOL	N/A	S ☒	U ☒	T ☒	G ☒	C ☒			

FIELD RESULTS						LABORATORY RESULTS								
DEPTH (FEET)	SAMPLE	SPT, # of Blows			POCKET PEN. (TSF)	RQD (%)	GRAPHIC LOG	DESCRIPTION	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SIEVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"										
0		0	2	3				34.6						
3		3	6	8			Fat clay (CH), very dark gray	20.0						
5		3	6	9			(CH), light brown	17.2						
4		4	7	9				17.3	35	13	22	86.2		
10							(CL), yellowish brown							
15		5	8	10				19.2						
9		9	23	30			Fat clay (CH), yellowish brown	18.3	54	20	34	86.5		
20							Bottom of Borehole at 20 feet							

Discussion

The imposed column load is normally carried by piles through skin friction along the pile shaft and bearing capacity at the pile point (or tip). The ultimate shaft resistance and ultimate point resistance are indicated by Q_s and Q_p , respectively, when the pile is carrying the ultimate load Q_u . From a standpoint of equilibrium,

$$Q_u = Q_p + Q_s$$

Point bearing piles (also known as end bearing piles) and friction piles, both of which are addressed, are two extreme instances. Because the full load is expected to be passed through the point in point bearing piles, $Q_s \approx 0$. With $Q_p \approx 0$, the full weight is expected to be passed via the pile shaft via friction or adhesion in friction piles.

For point bearing piles, pile foundations can be employed in circumstances when the soil near the ground surface is poor and cannot sustain shallow foundations. It is possible to drive piles through weak soil and transfer the weight to the underlying stiff stratum, especially when bedrock or a stiff stratum (e.g., stiff clay or dense sand) is present at relatively shallow depths. By expanding the pile a few meters, it can plug into the rigid stratum.

Alternatively, friction piles are used when there is no strong stratum within an acceptable depth. The shaft resistance, which originates from skin friction or adhesion, must be relied on in this case. At this stage, resistance is no longer a factor.

Due to the presence of various variables that cannot simply be defined, measuring the frictional (or skin) resistance of piles in clay is just as difficult as estimating it in sand. In the literature, there are several ways for calculating pile unit frictional resistance. We employed the Alpha technique in our report.

The unit skin resistance is written as,

$$f = \alpha C_u$$

where α is an empirical adhesion factor that ranges from 0-1, decreasing with the undrained shear strength, C_u . Overconsolidated clays have a higher C_u content and, as a result, a lower α . However, due to overburden stress, clay deposits at great depths can be cemented and have a high C_u content. Despite the greater C_u , α can still be closer to unity.

Table 12.11 in our Principles of Foundation Engineering, 9th Edition textbook shows the estimated fluctuation of the value of α . Because α is a function of vertical effective stress and undrained cohesion, the values of α in Table 12.11 may vary slightly. The ultimate side resistance can thus be given as,

$$Q_s = \Sigma f p \Delta L = \Sigma \alpha C_u p \Delta L$$

Where, p is perimeter and ΔL is the change in length.

The net ultimate load for piles in saturated clays under undrained conditions ($\phi = 0$) can be written as,

$$Q_p = 9 C_u A_p$$

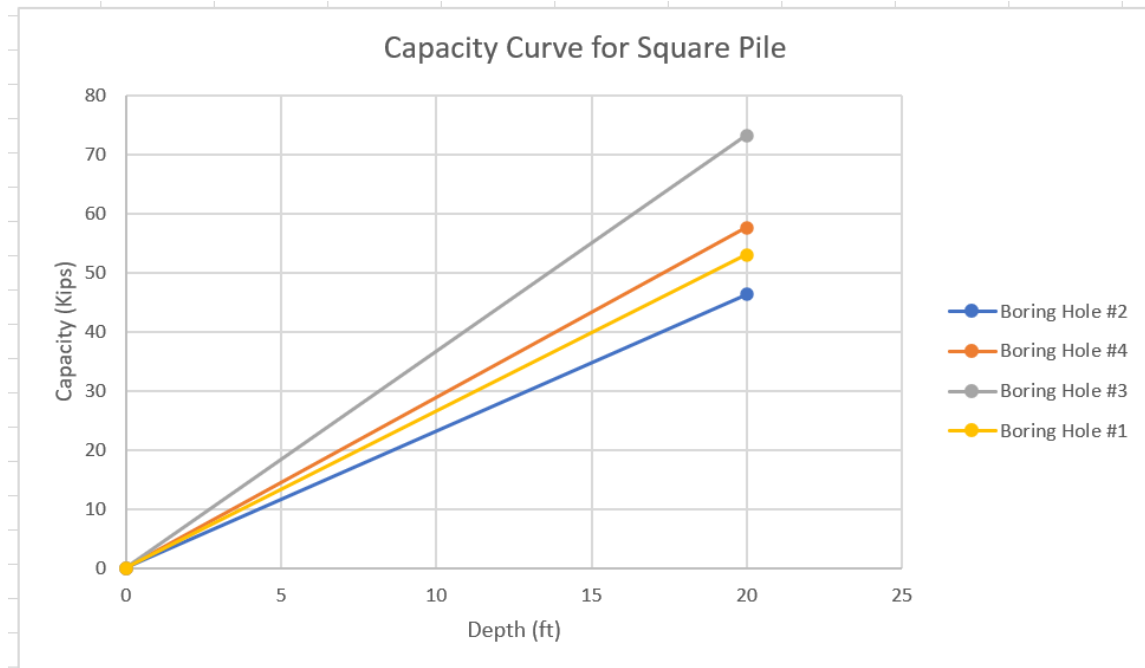
Where, C_u is the undrained cohesiveness of the soil beneath the pile's base.

Conclusion

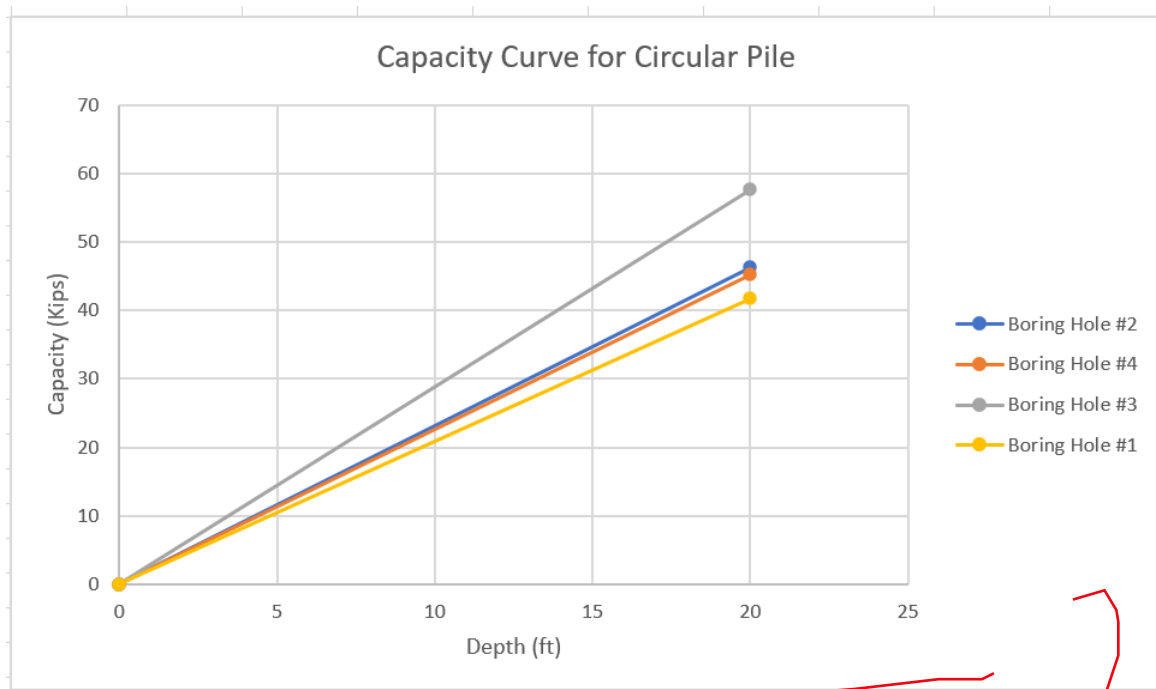
In conclusion, the third boring log had the highest capacity and as a result was the strongest soil out of the samples that were tested. The target of this project was to collect data and use the provided boring logs to determine the Q ultimate and Q allowable of each soil sample collected from the field and to decide whether a square or circular pile could carry the most capacity. We are a group who demonstrated our knowledge of SPT blow count testing, using the alpha method, calculating the Q_p and Q_s and creating a capacity curve to find the strength of soil as well as a result, ensure soil that will be built on will be strong enough to bear the load the soil is designed to carry.



Capacity Curve (s)



Capacity Curve (Square Pile)



Capacity Curve (Circular Pile)

Appendix

Boring Hole #4

Soil Type	Depth (ft)	Unit Weight (pcf)	Saturated Unit Weight (pcf)	SPT (N)	Cu=c (psf)	(Cu/Pa)
Fat Clay (CH)	5	129.96	-	14.00	1857.16	0.93
Fat Clay (CH)	2.5	126.93	-	15.00	2000.00	1.00
Lean Clay (CL)	6.5	108.39	-	16.00	2133.33	1.07
Saturated Lean Clay (CL)	4.5	-	128.80	18.00	2400.00	1.20
Saturated Fat Clay (CH)	1.5	-	131.70	53.00	5000.00	2.50
	20					

Table. 1: SPT and Cohesion Uniformity

				Circle	Square		
Depth (ft)	ΔL (ft)	α	Cu (psf)	$Q_s = \Delta L \alpha C_u P$ (lb)	$Q_s = \Delta L \alpha C_u P$ (kip)	$Q_s = \Delta L \alpha C_u P$ (lb)	$Q_s = \Delta L \alpha C_u P$ (kip)
0-5	5	0.5	1857.16	18223.38	18.22	23214.50	23.21
5-7.5	2.5	0.48	2000	9420.00	9.42	12000.00	12.00
7.5-14	6.5	0.46	2133.33	25036.23	25.04	31893.28	31.89
14-18.5	4.5	0.42	2400	17803.80	17.80	22680.00	22.68
18.5-20	1.5	0.34	5000	10008.75	10.01	12750.00	12.75

Table. 2: Ultimate Side Resistance

Circle		Square	
Qs=	80.49	Qs=	102.54
Qp=	55.22	Qp=	70.31
Qu=	135.71	Qu=	172.85
Qall=	45.24	Qall=	57.62

Table. 3: Results for Allowable Bearing Capacity

TABLE 12.11 Variation of α (Interpolated Values Based on Terzaghi et al., 1996)

$\frac{c_u}{p_a}$	α
≤ 0.1	1.00
0.2	0.92
0.3	0.82
0.4	0.74
0.6	0.62
0.8	0.54
1.0	0.48
1.2	0.42
1.4	0.40
1.6	0.38
1.8	0.36
2.0	0.35
2.4	0.34
2.8	0.34

Note: p_a = atmospheric pressure
 $\approx 100 \text{ kN/m}^2$

Table 3.2 Void Ratio, Moisture Content, and Dry Unit Weight for Some Typical Soils in a Natural State

Type of soil	Void ratio, e	Natural moisture content in a saturated state (%)	Dry unit weight, γ_d
			kN/m ³
Loose uniform sand	0.8	30	14.5
Dense uniform sand	0.45	16	18
Loose angular-grained silty sand	0.65	25	16
Dense angular-grained silty sand	0.4	15	19
Stiff clay	0.6	21	17
Soft clay	0.9–1.4	30–50	11.5–14.5
Loess	0.9	25	13.5
Soft organic clay	2.5–3.2	90–120	6–8
Glacial till	0.3	10	21

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Table 24. Approximate values of undrained shear strength for cohesive soils based on SPT blow count N-values (from Terzaghi and Peck, 1967)

Soil Consistency	SPT N (See Note)	S_u (psf)
Very Soft	< 2	< 250
Soft	2 - 4	250 - 500
Medium	4 - 8	500 - 1000
Stiff	8 - 15	1000 - 2000
Very Stiff	15 - 30	2000 - 4000
Hard	> 30	> 4000

Calculations for Boring Log #1

Test hole #1 $a = .76$ $p = 3.75$ ft

0-5 ft Fat clay $\gamma = 112.47 \text{ lb/ft}^3$ $C_u = 750 \text{ lb/ft}^2$

$Q_s = \sum c_u P \Delta L$

$Q_s = 5 \text{ ft} \cdot 750 \text{ lb/ft}^2 \cdot .76 = 5 \text{ ft} = 14250 \text{ lb} - \text{square}$

$Q_p = 9 (1.23 \text{ ft}^2) (750 \text{ lb/ft}^2) = 8302.5 \text{ lb} - \text{circle}$

$Q_p = 9 (1.56 \text{ ft}^2) (750 \text{ lb/ft}^2) = 10630 \text{ lb} - \text{square}$

$Q_p = 9 (A_{cm}) (C_u)$

$Q_s = 5 \text{ ft} \cdot 750 \text{ lb/ft}^2 \cdot .76 = .76 \cdot (3.93 \text{ ft}) = 11200.5 \text{ lb} - \text{circle}$

5-10 ft Fat clay $\gamma = 98.77 \text{ lb/ft}^3$ $C_u = 1200 \text{ lb/ft}^2$

$a = .68$

$Q_s = 5 \text{ ft} \cdot 1200 \text{ lb/ft}^2 \cdot .68 = 5 \text{ ft} = 17400 \text{ lb} - \text{square}$

$Q_p = 9 (1.23 \text{ ft}^2) (1200 \text{ lb/ft}^2) = 13284 - \text{circle}$

$Q_p = 9 (1.56 \text{ ft}^2) (1200 \text{ lb/ft}^2) = 16848 - \text{square}$

$Q_s = 5 \text{ ft} \cdot 1200 \text{ lb/ft}^2 \cdot .68 = .68 \cdot 3.93 \text{ ft} = 13676.4 - \text{circle}$

10-17.5 ft Lean clay $\gamma = 99.5 \text{ lb/ft}^3$ $C_u = 1700 \text{ lb/ft}^2$

$a = .54$

$Q_s = 7.5 \text{ ft} \cdot 1700 \text{ lb/ft}^2 \cdot .54 = 5 \text{ ft} = 34425 \text{ lb} - \text{square}$

$Q_p = 9 (1.23 \text{ ft}^2) (1700 \text{ lb/ft}^2) = 18819 \text{ lb} - \text{circle}$

$Q_p = 9 (1.56 \text{ ft}^2) (1700 \text{ lb/ft}^2) = 23868 \text{ lb} - \text{square}$

$Q_s = 7.5 \text{ ft} \cdot (1700 \text{ lb/ft}^2) \cdot (.54) = 3.93 \text{ ft} = 27058.05 \text{ lb} - \text{circle}$

17.5-20 ft Lean clay $\gamma_{sat} = 121.4 \text{ lb/ft}^3$ $C_u = 2100 \text{ lb/ft}^2$

$a = .48$

$Q_s = 2.5 \text{ ft} \cdot 2100 \text{ lb/ft}^2 \cdot .48 = 5 \text{ ft} = 12600 \text{ lb} - \text{square}$

$Q_p = 9 (1.23 \text{ ft}^2) (2100 \text{ lb/ft}^2) = 23247 \text{ lb} - \text{circle}$

$Q_p = 9 (1.56 \text{ ft}^2) (2100 \text{ lb/ft}^2) = 29484 \text{ lb} - \text{square}$

$Q_u = Q_s + Q_p$ $FS = 3$

$Q_u = 78,675 \text{ lb} + 80730 \text{ lb} = 159,405 \text{ lb}$

159.4 kips

$Q_{all} = \frac{159.4}{3} = 53.1 \text{ kips for square}$

$Q_u = 61838.65 \text{ lb} + 63652.5 \text{ lb} = 125,491.15 \text{ lb}$

125.4 kips

$Q_{all} = \frac{125.4 \text{ kips}}{3} = 41.8 \text{ kips for square}$

Calculation for Boring Log #2

Boring Test hole #2 $a = .82$ $P = 5\text{ft} - \text{square}$
 $O - 5\text{ft}$ Fat. Clay $C_u = 650\text{lb/ft}^2$ $P = 3.93\text{ft} - \text{circle}$

$$Q_s = 5\text{ft} \cdot 650\text{lb/ft}^2 \cdot .82 = 5\text{ft} = 13,325\text{lb} - \text{square}$$

$$Q_s = 5\text{ft} \cdot 650\text{lb/ft}^2 \cdot .82 \cdot 3.93\text{ft} = 16,473.45\text{lb} - \text{circle}$$

$$Q_p = 9(1.56\text{ft}^2)(650\text{lb/ft}^2) = 9126\text{lb} - \text{square}$$

$$Q_p = 9(1.23\text{ft}^2)(650\text{lb/ft}^2) = 7195.5\text{lb} - \text{circle}$$

5ft - 13ft Fat clay $C_u = 1850\text{lb/ft}^2$
 $a = .52$
 $Q_s = 8\text{ft} \cdot 1850\text{lb/ft}^2 \cdot .52 = 8\text{ft} = 38480\text{lb} - \text{square}$
 $Q_s = 8\text{ft} \cdot 1850\text{lb/ft}^2 \cdot .52 \cdot 3.93\text{ft} = 30,245.28\text{lb} - \text{circle}$
 $Q_p = 9(1.56\text{ft}^2)(1850\text{lb/ft}^2) = 25,974\text{lb} - \text{square}$
 $Q_p = 9(1.23\text{ft}^2)(1850\text{lb/ft}^2) = 20,119.5\text{lb} - \text{circle}$

13ft - 20ft Fat clay $C_u = 1375\text{lb/ft}^2$
 $a = .68$
 $Q_s = 7\text{ft} \cdot 1375\text{lb/ft}^2 \cdot .68 = 5\text{ft} = 32725\text{lb} - \text{square}$
 $Q_s = 7\text{ft} \cdot 1375\text{lb/ft}^2 \cdot .68 \cdot 3.93\text{ft} = 25721.85\text{lb} - \text{circle}$
 $Q_p = 9(1.56\text{ft}^2)(1375\text{lb/ft}^2) = 19306\text{lb} - \text{square}$
 $Q_p = 9(1.23\text{ft}^2)(1375\text{lb/ft}^2) = 15221.25\text{lb} - \text{circle}$

$$Q_u = Q_s + Q_p = 84530\text{lb} + 54405\text{lb} = 138935\text{lb} \approx 138.9\text{kips}$$

$$\frac{138.9\text{kips}}{3} = 46.3\text{kips square}$$

$$Q_u = 66440.58\text{lb} + 42896.25\text{lb} = 109,336.83\text{lb} \approx 109.3\text{kips}$$

$$\frac{109.3\text{kips}}{3} = 36.4\text{kips circle}$$

Calculations for Boring Log #3

Test hole #3

0-5ft Fat Clay

$\gamma =$

$C_u = 1600 \text{ psf}$
 $\alpha = .54$

$$Q_s = \sum C_u P \Delta L$$

$$= (.54)(1600 \text{ psf})(5 \text{ ft})(5 \text{ ft}) = 21600 \text{ lb} \leftarrow \text{Square}$$

$$Q_p = 9(1.23 \text{ ft}^2)(1600 \text{ psf}) = 17712 \text{ lb} \leftarrow \text{Circle}$$

$$Q_p = 9(1.56 \text{ ft}^2)(1600 \text{ psf}) = 22464 \text{ lb} \leftarrow \text{Square}$$

$$Q_s = (5 \text{ ft})(1600 \text{ psf})(.54)(3.93 \text{ ft}) = 16977.6 \text{ lb} \leftarrow \text{Circle}$$

5-10ft Fat Clay

$C_u = 1800 \text{ psf}$
 $\alpha = .52$

$$Q_s = \sum C_u P \Delta L$$

$$= (.52)(1800 \text{ psf})(5 \text{ ft})(5 \text{ ft}) = 23400 \text{ lb} \leftarrow \text{Square}$$

$$Q_p = 9(1.23 \text{ ft}^2)(1800 \text{ psf}) = 19926 \text{ lb} \leftarrow \text{Circle}$$

$$Q_p = 9(1.56 \text{ ft}^2)(1800 \text{ psf}) = 25272 \text{ lb} \leftarrow \text{Square}$$

$$Q_s = (5 \text{ ft})(1800 \text{ psf})(.52)(3.93 \text{ ft}) = 18392.4 \text{ lb} \leftarrow \text{Circle}$$

10-15ft Fat Clay

$C_u = 1200 \text{ psf}$
 $\alpha = .62$

$$Q_s = \sum C_u P \Delta L$$

$$= (.62)(1200 \text{ psf})(5 \text{ ft})(5 \text{ ft}) = 18600 \text{ lb} \leftarrow \text{Square}$$

$$Q_p = 9(1.23 \text{ ft}^2)(1200 \text{ psf}) = 13284 \text{ lb} \leftarrow \text{Circle}$$

$$Q_p = 9(1.56 \text{ ft}^2)(1200 \text{ psf}) = 16848 \text{ lb} \leftarrow \text{Square}$$

$$Q_s = (5 \text{ ft})(1200 \text{ psf})(.62)(3.93 \text{ ft}) = 14619.6 \text{ lb} \leftarrow \text{Circle}$$

15-20ft

$C_u = 4000 \text{ psf}$
 $\alpha = .355$

$$Q_s = \sum C_u P \Delta L$$

$$= (.355)(4000 \text{ psf})(5 \text{ ft})(5 \text{ ft}) = 35500 \text{ lb} \leftarrow \text{Square}$$

$$Q_p = 9(1.23 \text{ ft}^2)(4000 \text{ psf}) = 44280 \text{ lb} \leftarrow \text{Circle}$$

$$Q_p = 9(1.56 \text{ ft}^2)(4000 \text{ psf}) = 56160 \text{ lb} \leftarrow \text{Square}$$

$$Q_s = (5 \text{ ft})(4000 \text{ psf})(.355)(3.93 \text{ ft}) = 27903 \text{ lb} \leftarrow \text{Circle}$$

$$Q_u = Q_s + Q_p$$

Factor of Safety = 3

$$\text{Square } Q_u = (91660 \text{ lb}) + (44064 \text{ lb}) + (48672 \text{ lb}) + (35448 \text{ lb})$$

$$= 219844 \approx \frac{219.84 \text{ kip}}{3} = \boxed{73.28 \text{ kip for Square}}$$

$$\text{Circular } Q_u = (72183 \text{ lb}) + (27903.6 \text{ lb}) + (38318.4 \text{ lb}) + (34689.6 \text{ lb})$$

$$= 173094.6 \approx \frac{173.09 \text{ kip}}{3} = \boxed{57.7 \text{ kip for Circular}}$$

Calculations for Boring Log #4

Boring Hole #4 Circle $C = 2\pi r = 2\pi \left(\frac{7.5}{12}\right)$
 Factor of safety 3 $Q_s = \sum \alpha C_u P \Delta L = P \sum \alpha C_u \Delta L$ $C = 3.925 \text{ ft}$

$$Q_s = (3.925) \left[(0.5 \times 1857.16 \times 5) + (0.48 \times 2000 \times 2.5) + (0.46 \times 2133.33 \times 6.5) \right. \\ \left. + (0.42 \times 2400 \times 4.5) + (0.34 \times 5000 \times 1.5) \right] / 1000$$

$$Q_s = 80.49 \text{ kip}$$

$$Q_p = 9 \times C_u \times A_p = \left[9 \times 5000 \times \left(\frac{\pi}{4} \left(\frac{15}{12} \right)^2 \right) \right] / 1000 = 55.22 \text{ kip}$$

$$Q_{all} = \frac{Q_u}{F.S.} = \frac{Q_s + Q_p}{F.S.} = \frac{80.49 + 55.22}{3} = \boxed{45.24 \text{ kip}}$$

Square $P = 4a = 4 \left(\frac{15}{12} \right) = 5 \text{ ft}$

$$Q_s = (5) \left[(0.5 \times 1857.16 \times 5) + (0.48 \times 2000 \times 2.5) + (0.46 \times 2133.33 \times 6.5) \right. \\ \left. + (0.42 \times 2400 \times 4.5) + (0.34 \times 5000 \times 1.5) \right] / 1000$$

$$Q_s = 102.54 \text{ kip}$$

$$Q_p = \left(9 \times 5000 \times \left(\frac{15}{12} \times \frac{15}{12} \right) \right) / 1000 = 70.31 \text{ kip}$$

$$Q_{all} = \frac{102.54 + 70.31}{3} = \boxed{57.62 \text{ kip}}$$

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Exam 1

TOPICS COVERED IN Exam 1

- 1. Sub-soil Exploration**
- 2. Shallow Foundation Design**
- 3. Stress Increase**
- 4. Consolidation Settlement**

**NOTE: Pages E1 through E7 should be repeated for each Homework
and Similarly for all the other assignments in the course binder**

**Geotechnical Engineering Design Lab
FALL 2021**

Exam #1 QUESTIONS

CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
(Time: 1.50 hours)

NAME: Student ID:

POLICY TO ERADICATE CHEATING (PROTECT INTEGRITY OF EXAMS)

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Problem 1 (15 pts)

Two isolated square footings (size: 3m x 3m) at the end of a building are subjected to the loading as indicated in Figure 1. The soil profile consists of 4m thick sand layer, which is underlain by a 3m thick firm clay deposit. A rigid permeable rock layer is present below the clay deposit. The ground water table is located 0.5 m below the footing.

Determine:

- 1) Determine the stress at the footing level (For both footing) for this loading condition. **(10 pts)**
- 2) Justify which of the foundations is likely to settle most under this existing condition. **(5 pts)**

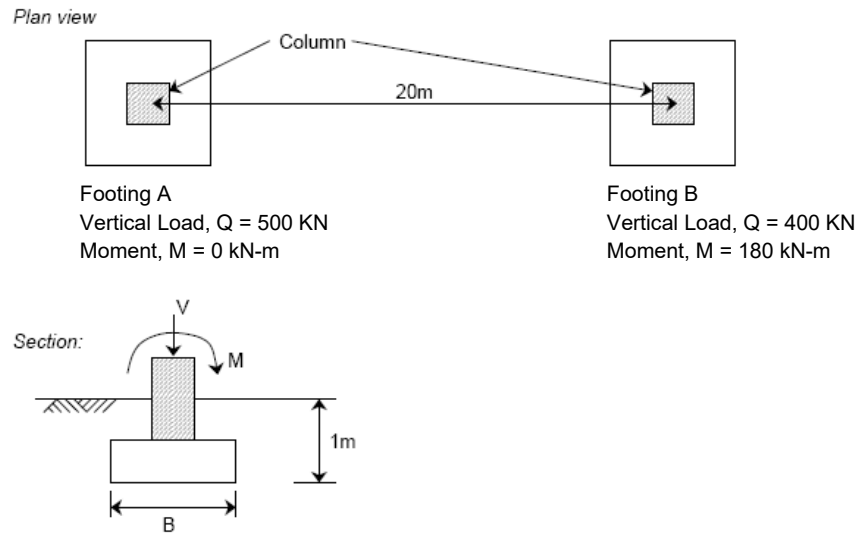


Figure 1

Problem 2 (15 pts)

There is a tunnel 12 m below ground surface. A water tank foundation is planned to be constructed on the ground surface at the location as shown in Figure 2 (Plan view). The 18 m diameter water tank will impose 70 kPa stress (Including tank self-weight plus water pressure) on the ground surface. What will be the stress increase due to the tank construction at point C, at the tunnel level that is 12 m below ground surface?

Use graphical method to find stress increase

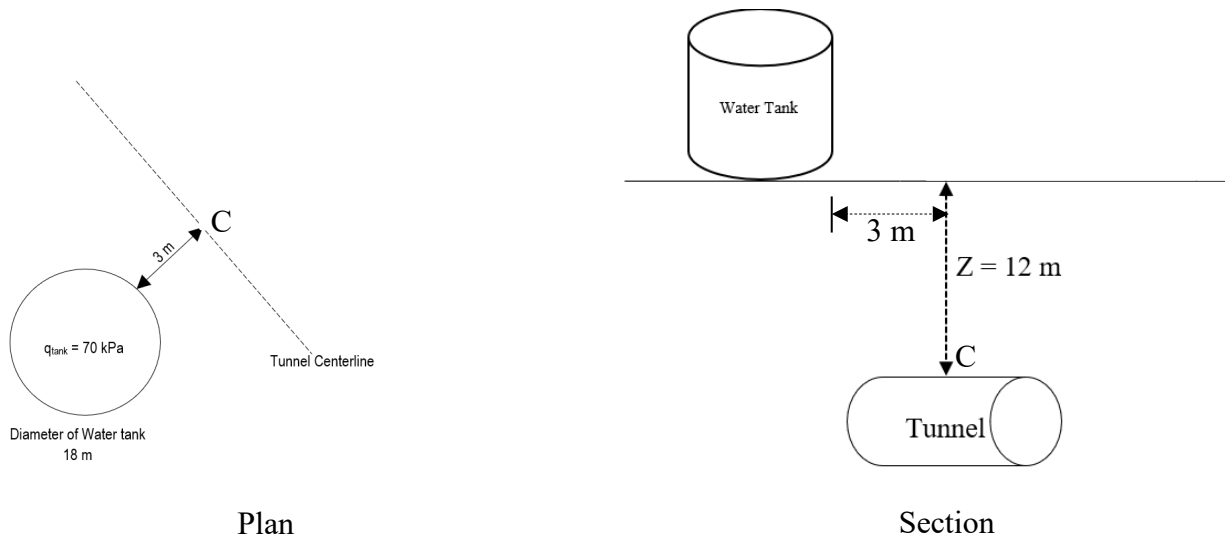
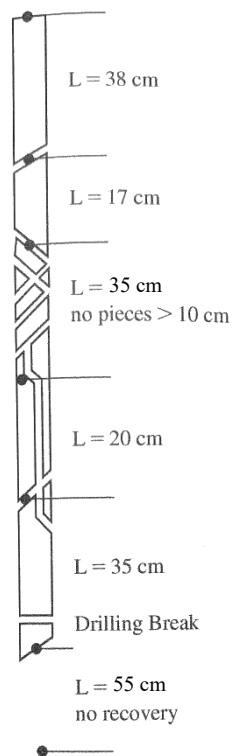


Figure 2

Problem 3 (10 pts)

What is the Rock Quality Designation (RQD) for the following core sample as shown in Figure 3, and qualify the rock?

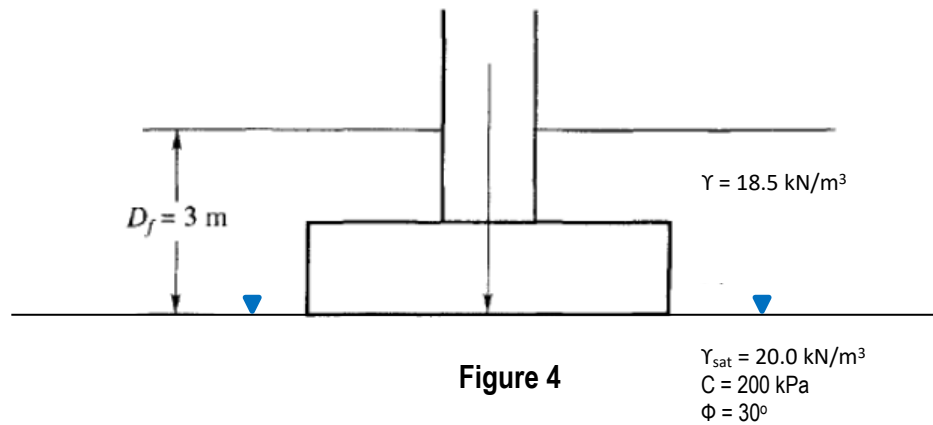


Note: 1 inch = 2.54 cm

Figure 3

Problem 4 (20 pts)

A square footing in Figure 4 of size 6 m × 6 m is founded at a depth of 3m in a clayey sand stratum of uniform consistency. The soil parameters of the soil layer are shown in the figure. Assuming a factor safety of 3, determine the allowable bearing capacity of the soil.



Problem 5 (30 pts)

Figure 5 shows a section of a foundation supporting a square footing of an industrial building. The column of the footing supports 375-kip load as shown in Figure 5. The dimension of the square footing is 5 ft. $\times$ 5 ft. The soil profile is also shown in the figure. The water table is at the base of the foundation. Consolidation test results of the soil from the clay layer are given below.

Preconsolidation Pressure, $\sigma_c = 1368.6$ psf

Compression Index, $C_c = 0.396$

Swelling Index, $C_s = 0.04$

Initial Void Ratio, $e_0 = 0.8$

Calculate the primary consolidation settlement of the square footing (@center) due to the given loading condition of the 5 ft. $\times$ 5 ft. square footing. **Determine stress increase using m&n method (Boussinesq Case)**

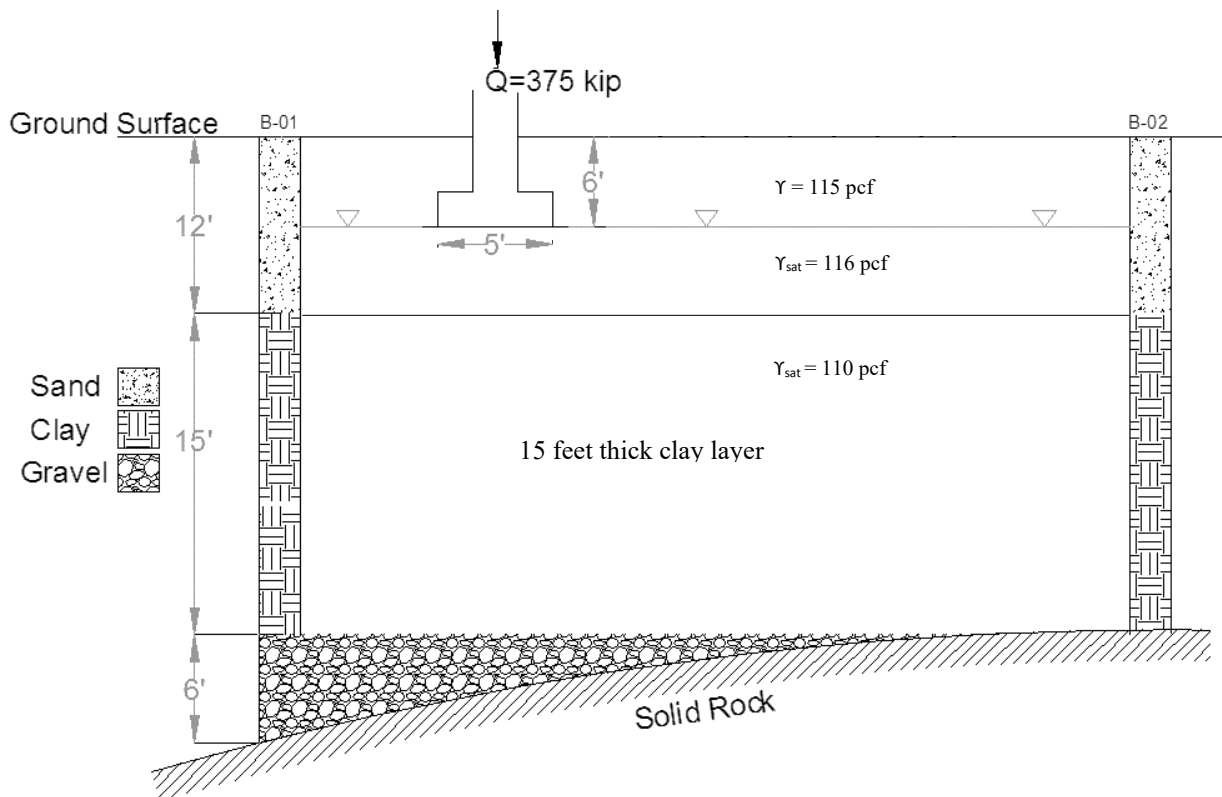


Figure 5

CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
(Time: 1.50 hours)

Problem 6 (10 pts)

Determine the SPT blow count number (N value) for the following boring log. Write your answer in the log as shown.

DRILL RIG: CME-75 TEST HOLE DIAMETER (in): 8							GROUND WATER DATA:						
DRILLING METHOD: Hollow Stem Auger TOTAL DEPTH (ft): 20							DATE	TIME	WATER DEPTH (ft)	REMARKS			
TYPE/ SYMBOL	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/4/2019	4:30:00 PM	17.5				
	N/A	S ☒	U ☒	T ☒	G ☒	C ☒							
DEPTH (FEET)	SAMPLE	FIELD RESULTS			SPT (N) ↓	GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
		SPT, # of Blows						MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEIVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"									
0	1	1	4					35.5	82	25	57	97.3	
3	3	4	7				Fat clay (CH), very dark gray	22.4					
5	3	5	6				(CH), light brown	19.0					
4	4	8	10					17.5	42	15	27	92.4	
10	4	7	9					19.9					
15	5	10	11				Lean clay (CL), light brown	19.8					
8	8	12	19					19.8					
20							Bottom of Borehole at 20 feet						

ABOVE AVERAGE

NAME: Nathaniel Smith

Student ID: P21676811

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CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
(Time: 1.50 hours)

Problem 1 (15 pts)

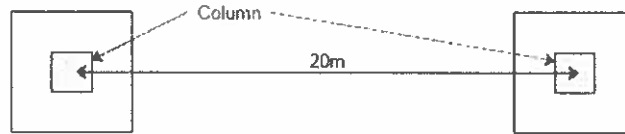
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Determine:

- 1) Determine the stress at the footing level (For both footing) for this loading condition. (10 pts)
- 2) Justify which of the foundations is likely to settle most under this existing condition. (5 pts)

Footing B is likely to settle the most

Plan view



Footing A
 Vertical Load, $Q = 500 \text{ kN}$
 Moment, $M = 0 \text{ kN-m}$

Footing B
 Vertical Load, $Q = 400 \text{ kN}$
 Moment, $M = 180 \text{ kN-m}$

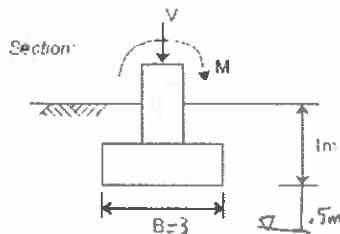


Figure 1

A) Total $M = 0 \text{ kN-m}$

$$e = \frac{M}{Q} = \frac{0}{500 \text{ kN}} = 0$$

$$\frac{L}{6} = \frac{3}{6} = \frac{1}{2}$$

$$e < \frac{L}{6}$$

$$\sigma_A = \frac{Q}{A} = \frac{500 \text{ kN}}{9 \text{ m}^2}$$

$$\sigma_A = 55.56 \text{ kPa}$$

B) Total $M = 180 \text{ kN-m}$

$$e = \frac{M}{Q} = \frac{180}{400} = \frac{9}{20} = 0.45$$

$$\frac{L}{6} = \frac{3}{6} = \frac{1}{2} = 0.5$$

$$e < \frac{L}{6}$$

$$\sigma_B = \frac{Q}{A} = \frac{400 \text{ kN}}{9 \text{ m}^2}$$

$$\sigma_B = 44.44 \text{ kPa}$$

***CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
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Problem 2 (15 pts)

There is a tunnel 12 m below ground surface. A water tank foundation is planned to be constructed on the ground surface at the location as shown in Figure 2 (Plan view). The 18 m diameter water tank will impose 70 kPa stress (Including tank self-weight plus water pressure) on the ground surface. What will be the stress increase due to the tank construction at point C, at the tunnel level that is 12 m below ground surface?

Use graphical method to find stress increase

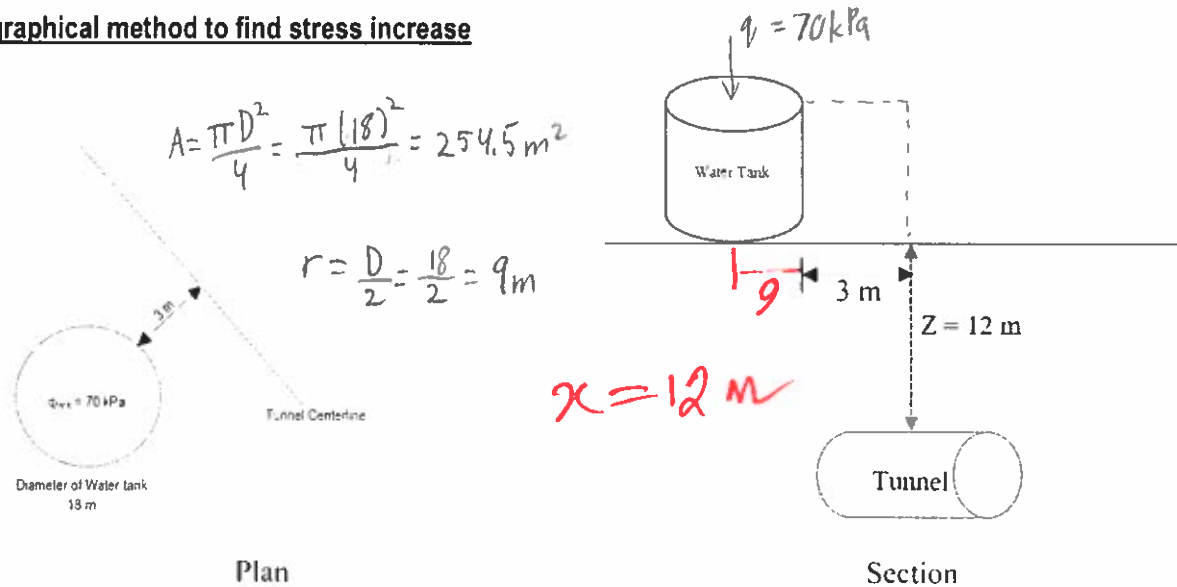


Figure 2

$$\frac{Z}{r} = \frac{12}{9} = 1.33 \quad \checkmark$$

$$\frac{x}{r} = \frac{3}{9} = .33 \quad \times$$

$$I = .52$$

$$\Delta \sigma_z = I q = .52(70 \text{ kPa}) = \boxed{36.4 \text{ kPa}}$$

(-5)

CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
(Time: 1.50 hours)

CVEG 4100 – Geotechnical Engineering Design
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Problem 3 (10 pts)

What is the Rock Quality Designation (RQD) for the following core sample as shown in Figure 3, and qualify the rock?

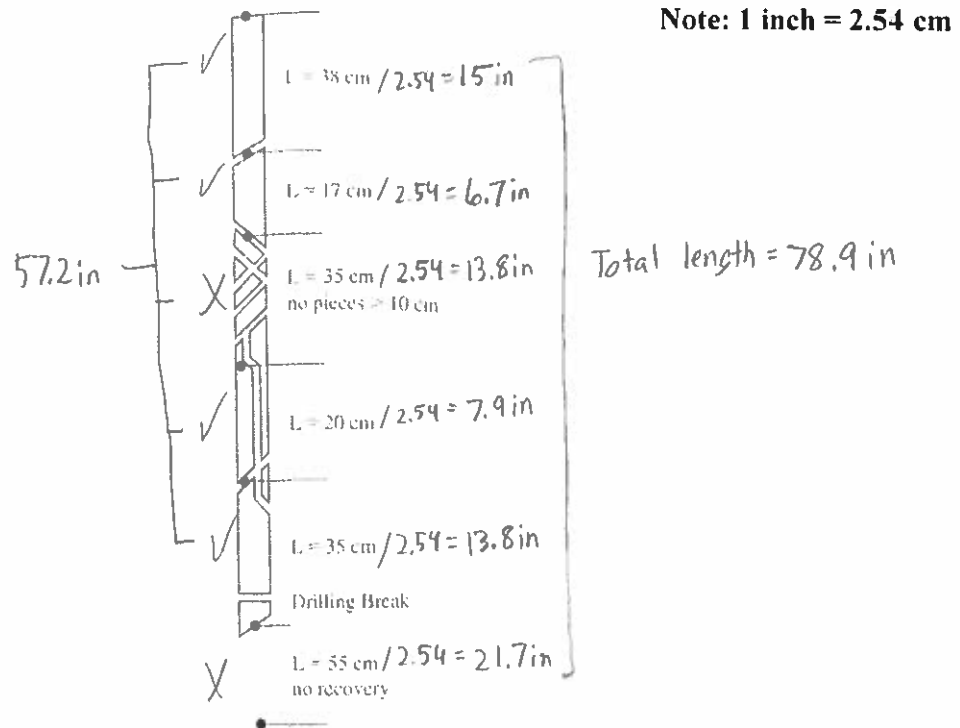


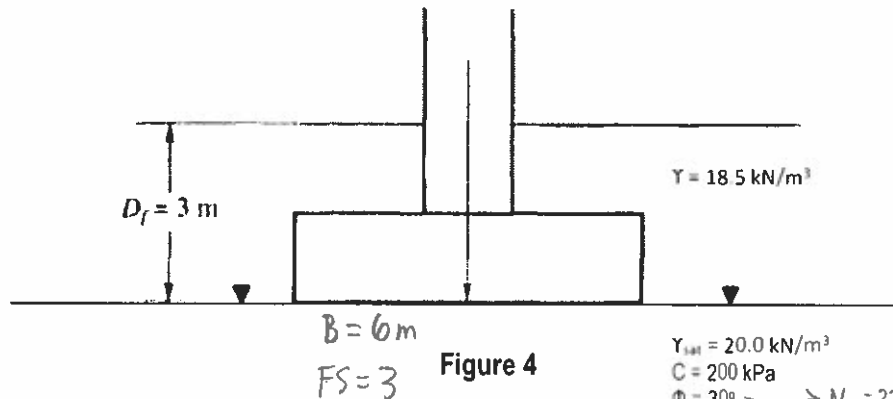
Figure 3

$$RQD = \frac{57.2}{78.9} \times 100 = \underline{72.5\%} \rightarrow \text{Rock rating is fair because the RQD is between 50\% and 75\%}$$

(-2)

Problem 4 (20 pts)

A square footing in Figure 4 of size 6 m × 6 m is founded at a depth of 3m in a clayey sand stratum of uniform consistency. The soil parameters of the soil layer are shown in the figure. Assuming a factor safety of 3, determine the allowable bearing capacity of the soil.



$\gamma = 18.5 \text{ kN/m}^3$
 $\gamma_{\text{sat}} = 20.0 \text{ kN/m}^3$
 $C = 200 \text{ kPa}$
 $\Phi = 30^\circ$

$N_c = 37.16$
 $N_q = 22.46$
 $N_\gamma = 19.13$

$q = \gamma D_f$

$q_u = 1.3 C N_c + q N_q + 0.4 \gamma B N_\gamma$

$= 1.3(200 \text{ kN/m}^2)(37.16) + (18.5 \text{ kN/m}^3)(3 \text{ m})(22.46) + 0.4(18.5 \text{ kN/m}^3)(6 \text{ m})(19.13)$
 $= 9661.6 \text{ kPa} + 1246.53 \text{ kPa} + 849.37 \text{ kPa}$

$q_u = 11757.5 \text{ kPa}$

$\bar{\gamma} = \gamma' + \frac{d}{B}(\gamma - \gamma')$

$q_{\text{all}} = \frac{q_u}{FS} = \frac{11757.5 \text{ kPa}}{3} = 3919.17 \text{ kPa}$

(-5)

***CVEG 4100 – Geotechnical Engineering Design
Mid Term Exam, Fall 2021
(Time: 1.50 hours)***

Problem 5 (30 pts)

Figure 5 shows a section of a foundation supporting a square footing of an industrial building. The column of the footing supports 375-kip load as shown in Figure 5. The dimension of the square footing is 5 ft. × 5 ft. The soil profile is also shown in the figure. The water table is at the base of the foundation. Consolidation test results of the soil from the clay layer are given below.

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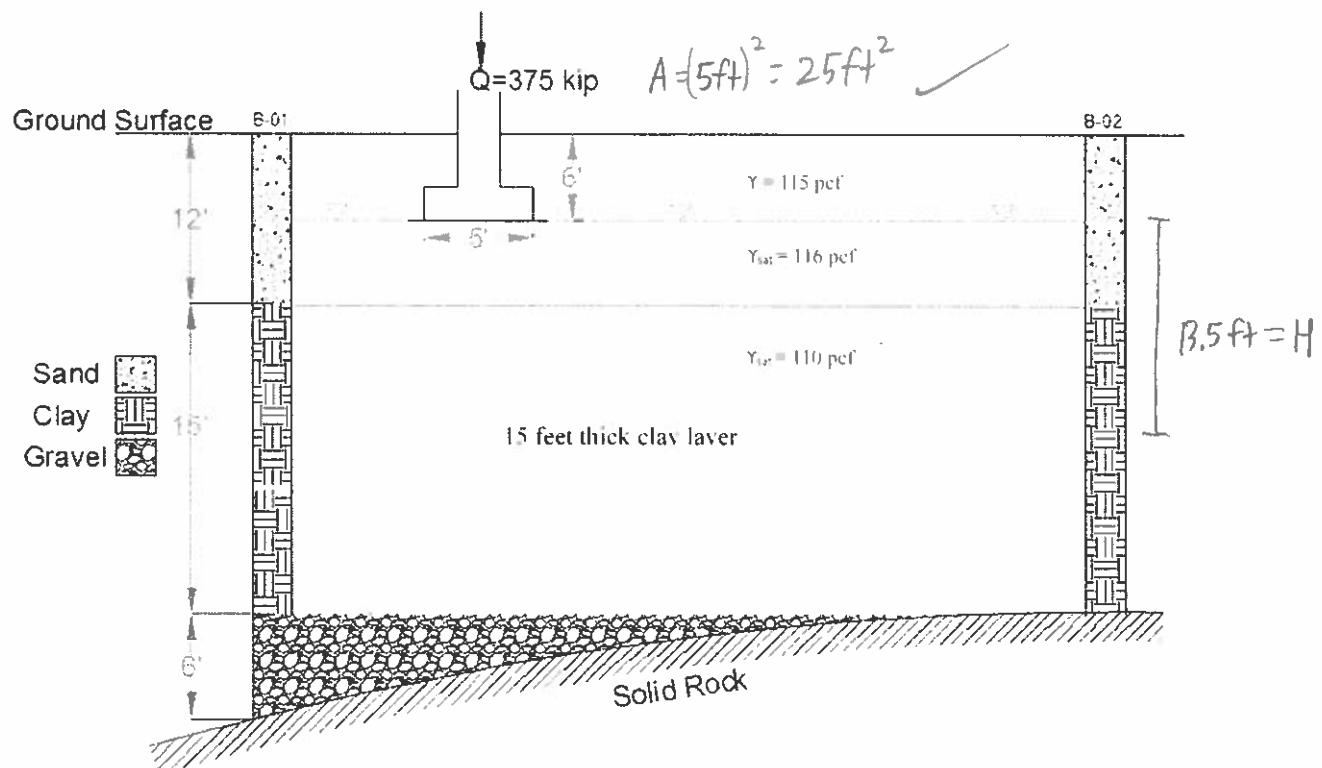


Figure 5

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

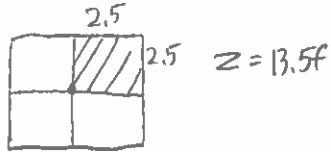
$$\begin{aligned}\sigma_o' &= 6ft(115 pcf) + 6ft(116 pcf - 62.4 pcf) + 7.5 ft(110 pcf - 62.4 pcf) \\ &= 690 psf + 321.6 psf + 357 psf = 1368.6 psf\end{aligned}$$

$$OCR = \frac{1368.6}{1368.6} = 1 \rightarrow NC$$

CONTINUES ON
NEXT PAGE

CVEG 4100 – Geotechnical Engineering Design
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$$S_c = \frac{C_c \cdot H}{1 + e_0} \log \left(\frac{\sigma_0 + \Delta \sigma}{\sigma_0} \right)$$



$$m = \frac{x}{z} = \frac{2.5}{13.5} = .19$$

$$n = \frac{y}{z} = \frac{2.5}{13.5} = .19$$

$$\rightarrow I = .016$$

$$\Delta \sigma = 4 \times I \times q_v$$

$$= 4 \times I \times \frac{Q}{A}$$

$$= 4 \times .016 \times \frac{375 \text{ kip} \left(\frac{1000 \text{ lb}}{1 \text{ kip}} \right)}{25 \text{ ft}^2}$$

$$= 960 \text{ psf}$$

$$S_c = \frac{(.396)(13.5 \text{ ft})}{1 + .8} \log \left(\frac{1368.6 + 960}{1368.6} \right)$$

$$S_c = 2.97 \log(1.70)$$

$$S_c = .68 \text{ ft}$$

***CVEG 4100 – Geotechnical Engineering Design
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CVEG 4100 – Geotechnical Engineering Design
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DRILLING METHOD: Hollow Stem Auger		TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/ SYMBOL	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	
N/A	S	U	T	G	C		
6/4/2019	4:30:00 PM	17.5					

FIELD RESULTS					GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS						
DEPTH (FEET)	SAMPLE	SPT, # of Blows					SPT (N)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEVE # 200 (%)	ADDITIONAL TESTS
		0-6"	6-12"	12-18"									
0	1	1	4	5	✓		35.5	82	25	57	97.3		
3	3	4	7	11	✓	Fat clay (CH), very dark gray	22.4						
5	3	5	6	11	✓	(CH), light brown	19.0						
8	4	8	10	18	✓		17.5	42	15	27	92.4		
10	4	7	9	16	✓		19.9						
15	5	10	11	21	✓	Lean clay (CL), light brown	19.8						
18	8	12	19	31	✓		19.8						
20						Bottom of Borehole at 20 feet							

AVERAGE

CVEG 4100 – Geotechnical Engineering Design
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NAME: Alex Martinez

80
Student ID: P21632543

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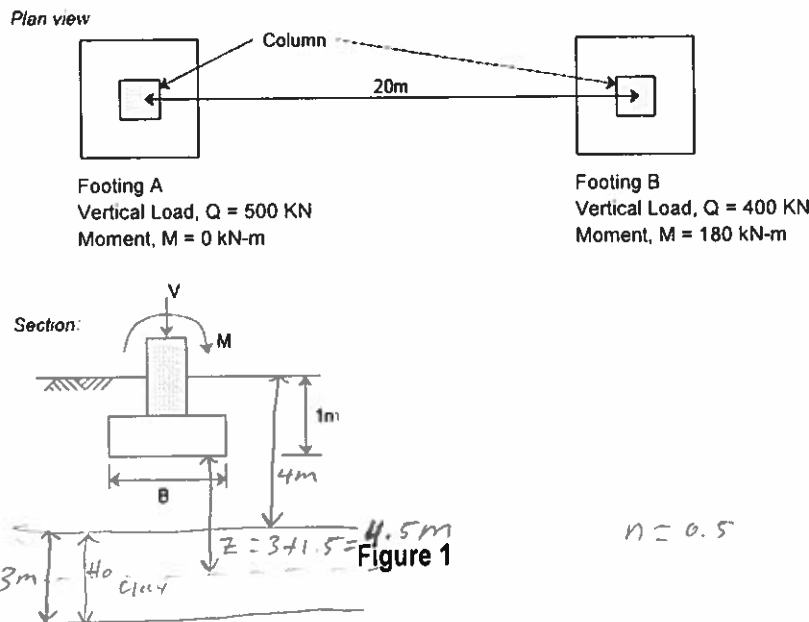
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Determine:

- 1) Determine the stress at the footing level (For both footing) for this loading condition. (10 pts)
- 2) Justify which of the foundations is likely to settle most under this existing condition. (5 pts)



$$H_0 = 3 \text{ m}$$

$$C_c = 0.4$$

$$e_0 = 1.34$$

$$\sigma_0 = 130 \text{ kPa}$$

$$n = 0.5$$

$$\Delta H = \frac{H_0 C_c}{1 + e_0} \log \left[\frac{\sigma_0 + \Delta \sigma}{\sigma_0} \right]$$

$$\Delta \sigma = \frac{q B^2}{(B + 2nz)^2}$$

Footing A

$$Q = 500 \text{ kN} \quad \Delta \sigma = \frac{q}{(B + 2nz)^2} = \frac{500 \text{ kN}}{(3 + 2(0.5)(4.5))^2} = 8.88 \text{ kN/m}^2$$

$$M = 0 \text{ kN-m}$$

$$\Delta H = \frac{3 \times 0.4}{1 + 1.34} \log \left[\frac{130 + 8.88}{130} \right] = 0.014 \text{ m}$$

Footing B

$$Q = 400 \text{ kN}$$

$$M = 180 \text{ kN-m}$$

$$C_c = 0.33$$

$$F = \frac{M}{\text{crit dist}} = \frac{180}{1.5} = 120 \text{ kN}$$

$$\Delta \sigma = \frac{400 + 120}{(3 + 2(0.5)(4.5))^2} = 9.24 \text{ kN/m}^2$$

$$\Delta H = \frac{3 \times 0.33}{1 + 1.34} \log \left[\frac{130 + 9.24}{130} \right] = 0.0126 \text{ m}$$

Footing A > Footing B
So footing A will settle more

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There is a tunnel 12 m below ground surface. A water tank foundation is planned to be constructed on the ground surface at the location as shown in Figure 2 (Plan view). The 18 m diameter water tank will impose 70 kPa stress (Including tank self-weight plus water pressure) on the ground surface. What will be the stress increase due to the tank construction at point C, at the tunnel level that is 12 m below ground surface?

Use graphical method to find stress increase

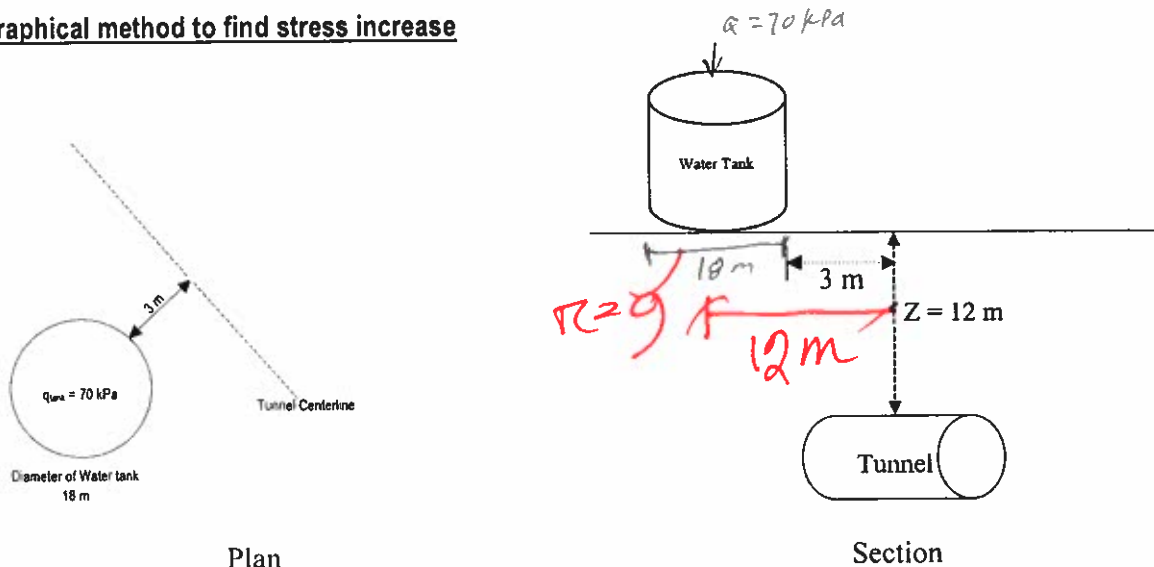


Figure 2

$$\sigma_z = p \left\{ 1 - \frac{1}{(1 + (r/z)^2)^{3/2}} \right\}$$

@ 12 m

$$\sigma_z = 70 \text{ kPa} \left\{ 1 - \frac{1}{(1 + (9/12)^2)^{3/2}} \right\} = 34.16 \text{ kPa}$$

(-5)

CVEG 4100 – Geotechnical Engineering Design
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CVEG 4100 – Geotechnical Engineering Design
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(Time: 1.50 hours)

Problem 3 (10 pts)

What is the Rock Quality Designation (RQD) for the following core sample as shown in Figure 3, and qualify the rock?

$$RQD = \frac{\text{Cumulative length of core} \times 100}{\text{total length of core}}$$

length of pieces > 10 cm
 $38 + 17 + 20 + 35 = 110 \text{ cm}$

$$RQD = \frac{110 \text{ cm}}{200 \text{ cm}} \times 100$$

RQD = 55% ✓
Rock Quality is Fair

Note: 1 inch = 2.54 cm

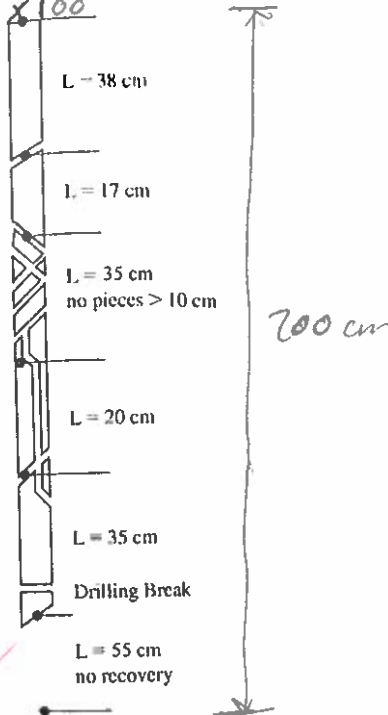
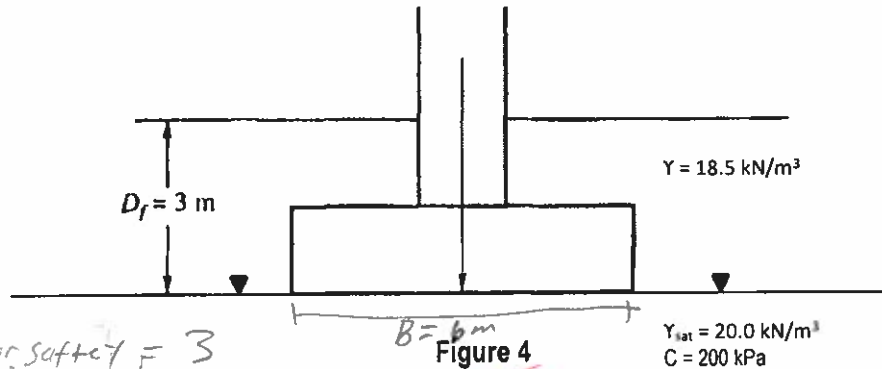


Figure 3

Problem 4 (20 pts)

A square footing in Figure 4 of size 6 m × 6 m is founded at a depth of 3 m in a clayey sand stratum of uniform consistency. The soil parameters of the soil layer are shown in the figure. Assuming a factor safety of 3, determine the allowable bearing capacity of the soil.



$$q = \gamma D_f$$

$$= 18.5 \times 3 = 55.5 \text{ kN/m}^2$$

Factor safety = 3

$$q_u = 1.3 C N_c + q N_q + 0.4 \gamma B N_\gamma$$

$$(1.3 [200 \text{ kPa}] (30.14)) + (55.5 \text{ kN/m}^2) (18.4)$$

$$+ ((.4) (20 \text{ kN/m}^3) (6 \text{ m}) (22.40))$$

$$q_u = 7836.4 + 1021.2 + 1075.2$$

$$q_u = 9932.8 \text{ kN/m}^2$$

$$Y_{\text{sat}} = 20.0 \text{ kN/m}^3$$

$$C = 200 \text{ kPa}$$

$$\Phi = 30^\circ$$

Use table 6.2

$$N_c = 30.14$$

$$N_q = 18.40$$

$$N_\gamma = 22.40$$

Net ultimate bearing

$$q_{nu} = q_u - \gamma D_f = 9932.8 \text{ kN/m}^2 - (18.5 \times 3) \text{ kN/m}^2$$

$$= 9877.3 \text{ kN/m}^2$$

Net safe

$$q_{ns} = \frac{q_{nu}}{\text{FOS}} = \frac{9877.3 \text{ kN/m}^2}{3} = 3292.43 \text{ kN/m}^2$$

Safe bearing capacity = $q_{ns} + \gamma D_f$

$$3292.43 \text{ kN/m}^2 + (18.5 \text{ kN/m}^3 \times 3 \text{ m})$$

$$\text{Allowable bearing capacity} = 3347.93 \text{ kN/m}^2$$

CVEG 4100 – Geotechnical Engineering Design
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Problem 5 (30 pts)

Figure 5 shows a section of a foundation supporting a square footing of an industrial building. The column of the footing supports 375-kip load as shown in Figure 5. The dimension of the square footing is 5 ft. × 5 ft. The soil profile is also shown in the figure. The water table is at the base of the foundation. Consolidation test results of the soil from the clay layer are given below.

Preconsolidation Pressure, $\sigma_c = 1368.6$ psf

Compression Index, $C_c = 0.396$

Swelling Index, $C_s = 0.04$

Initial Void Ratio, $e_0 = 0.8$

Calculate the primary consolidation settlement of the square footing (@center) due to the given loading condition of the 5 ft. × 5 ft. square footing. Determine stress increase using m&n method (Boussinesq Case)

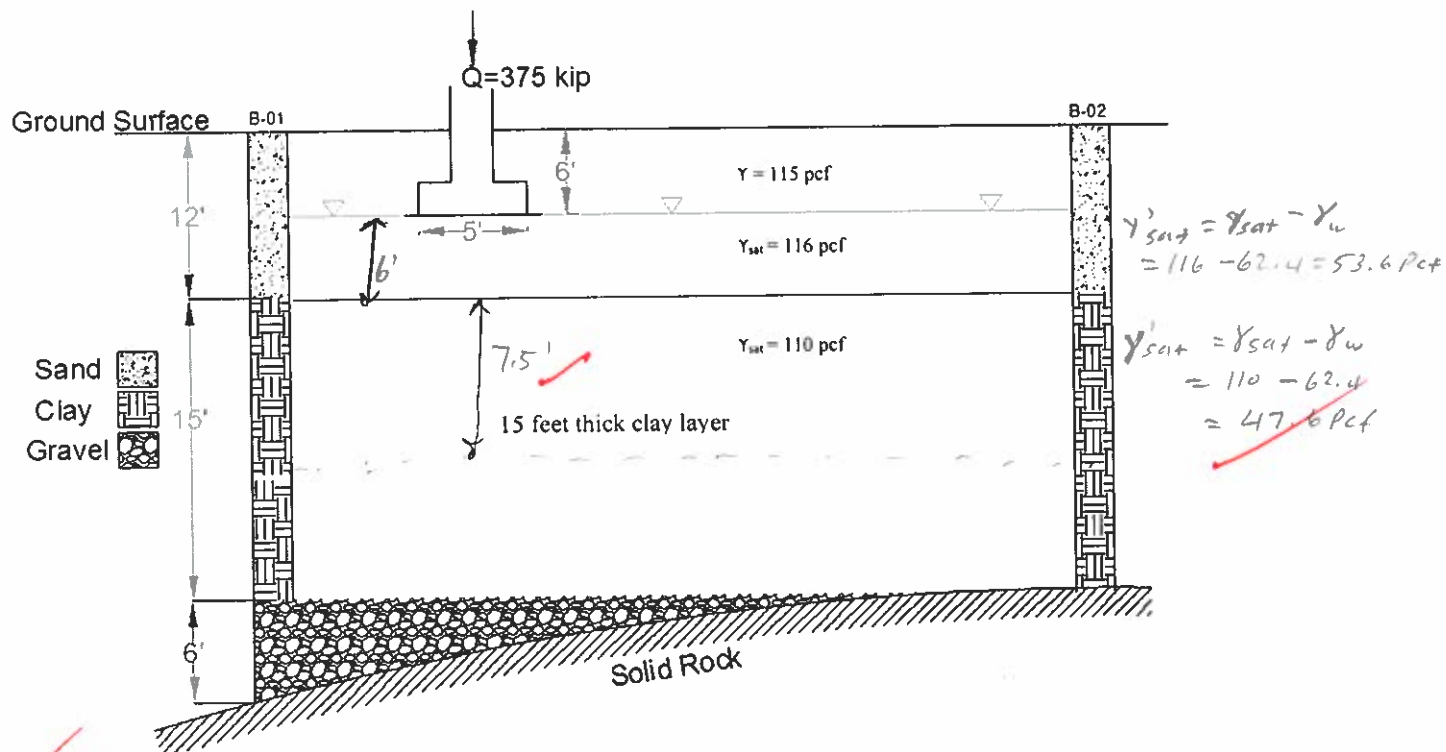


Figure 5

Given: $\sigma_c = 1368.6$ psf, $C_c = 0.396$, $C_s = 0.04$, $e_0 = 0.8$, $Q = 375$ kip

$$\sigma'_0 = (115 \times 6) + (53.6 \times 6) + (47.6 \times 7.5) = 1368.6 \text{ psf (Pre-consolidated Pressure)}$$

$$s_c = \left(\frac{C_s}{1+e_0} \times H \times \log_{10} \frac{\sigma'_0}{\log_{10} \sigma'_0} \right) + \left[\frac{C_c}{1+e_0} \times H \times \log_{10} \frac{(\sigma'_0 + \Delta \sigma')}{\sigma'_0} \right]$$

$$s_c = \frac{C_c}{1+e_0} \times H \times \log_{10} \left(\frac{\sigma'_0 + \Delta \sigma'}{\sigma'_0} \right)$$

$$= \frac{0.396}{1+0.8} \times 15 \times \log_{10} \left(\frac{1368.6 + 982.4}{1368.6} \right)$$

$$= 0.775 \text{ ft}$$

$$R = 6 + 7.5 = 13.5 \text{ ft}$$

By Boussinesq

$$\Delta \sigma' = \frac{3Q}{\pi R^2} \left[\frac{1}{1 + \left(\frac{R}{z} \right)^2} \right]^{5/2}$$

$$= \frac{1.5 \times 375 \times 10^3}{\pi \times 13.5^2} \left(\frac{1}{1 + \left(\frac{13.5}{7.5} \right)^2} \right)^{5/2}$$

$$= 0.4824 \times 10^3 = 482.4 \text{ psf}$$

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Mid Term Exam, Fall 2021
(Time: 1.50 hours)

Problem 6 (10 pts)

Determine the SPT blow count number (N value) for the following boring log. Write your answer in the log as shown.

DRILL RIG: CME-75 DRILLING METHOD: Hollow Stem Auger								TEST HOLE DIAMETER (in): 8 TOTAL DEPTH (ft): 20		GROUND WATER DATA:			
TYPE/ SYMBOL	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	DATE	TIME	WATER DEPTH (ft)	REMARKS			
N/A		S ☒	U ☐	T ☒	G ☒	C ☐	6/4/2019	4:30:00 PM	17.5				
DEPTH (FEET)	SAMPLE	FIELD RESULTS			SPT (N)	GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS					
		SPT, # of Blows						MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SEVE # 200 (%)	ADDITIONAL TESTS
0-6"	6-12"	12-18"											
0	1	1	4	5		Fat clay (CH), very dark gray	35.5	82	25	57	97.3		
3	4	7	11	22.4									
5	3	5	6	11		(CH), light brown	19.0						
8	4	8	10	18		17.5	42	15	27	92.4			
10	4	7	9	16		19.9							
15	5	10	11	21		19.8							
18	8	12	19	31		19.8							
20	Bottom of Borehole at 20 feet												

BELOW AVERAGE

76

NAME Altumn Carter Student ID: 21391881

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Problem 1 (15 pts)

Two isolated square footings (size: 3m x 3m) at the end of a building are subjected to the loading as indicated in Figure 1. The soil profile consists of 4m thick sand layer, which is underlain by a 3m thick firm clay deposit. A rigid permeable rock layer is present below the clay deposit. The ground water table is located 0.5 m below the footing.

Determine:

- 1) Determine the stress at the footing level (For both footing) for this loading condition. (10 pts)
- 2) Justify which of the foundations is likely to settle most under this existing condition. (5 pts)

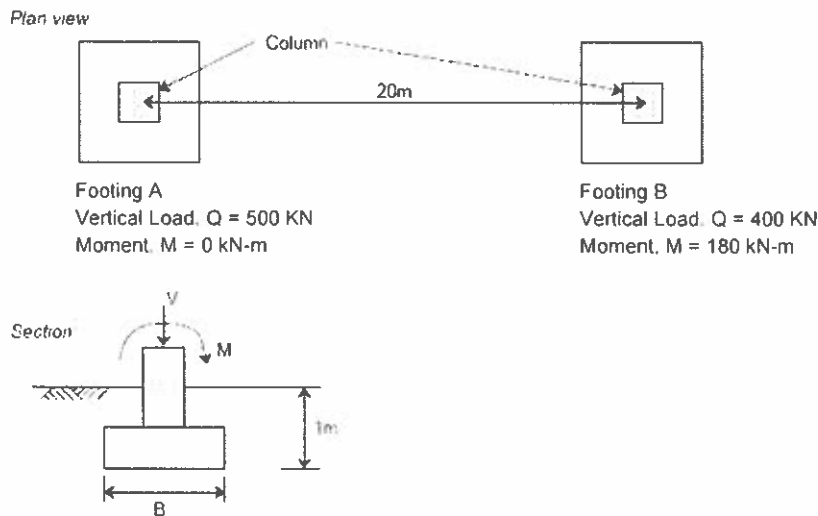


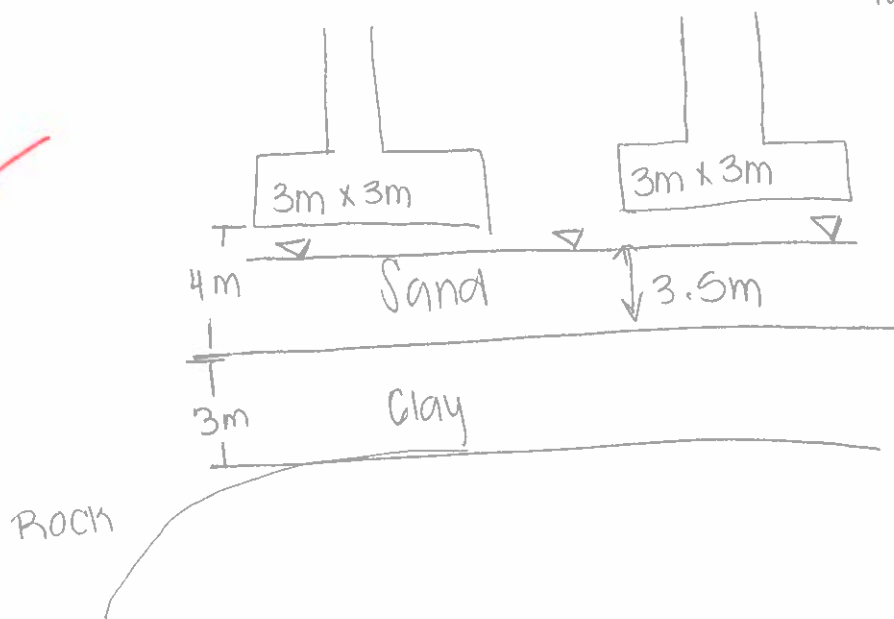
Figure 1

Footing A

$$e = \frac{M}{Q} = \frac{0 \text{ kN-m}}{500 \text{ kN}} = 0 \text{ m}$$

Footing B

$$e = \frac{M}{Q} = \frac{180 \text{ kN-m}}{400 \text{ kN}} = 0.45 \text{ m}$$



$q = ?$

$$q = \frac{Q}{A} + \frac{M}{B L^2}$$

2. Footing A will settle the most due to no moment against its foundation

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Final Stress

$$L=20m$$

$$e = \frac{M}{Q} = \frac{0kN \cdot m}{500kN} = 0$$

$$\bar{e} = \frac{14}{4} = \frac{140}{400} = 0.45$$

$$L/6 = 20/6 = \underline{3.33'}$$

Problem 2 (15 pts)

There is a tunnel 12 m below ground surface. A water tank foundation is planned to be constructed on the ground surface at the location as shown in Figure 2 (Plan view). The 18 m diameter water tank will impose 70 kPa stress (Including tank self-weight plus water pressure) on the ground surface. What will be the stress increase due to the tank construction at point C, at the tunnel level that is 12 m below ground surface?

Use graphical method to find stress increase

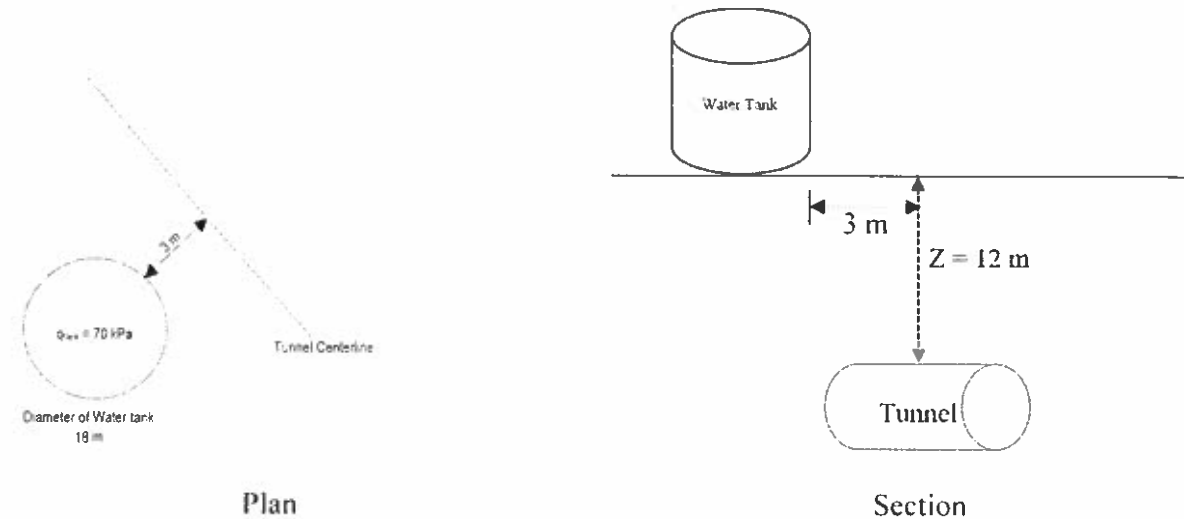


Figure 2

Find stress increase due to tank construction at Point C
 12m below ground surface
 $z = 12\text{m}$ ✓ $d = 18\text{m}$ ✓

$$\frac{z}{r} = \frac{12\text{m}}{9\text{m}} \quad \frac{x}{r} = \frac{0\text{m}}{9\text{m}} = 0$$

$$\frac{12}{9} = 1.33$$

m and n method

$$I = 0.70$$

Stress Increase

$$(0.70)(70\text{ kPa}) = 49\text{ kPa}$$

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(Time: 1.50 hours)***

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Problem 3 (10 pts)

What is the Rock Quality Designation (RQD) for the following core sample as shown in Figure 3, and qualify the rock?

$$\frac{\text{lin}}{2.54} = \frac{x}{38}$$

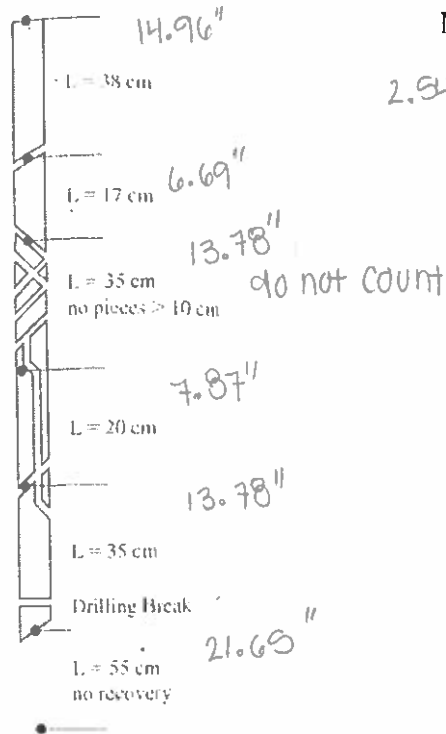


Figure 3

not broken

So 14.96", 6.69", 13.78", 21.65"

$$\frac{(14.96 + 6.69 + 13.78 + 21.65)}{57} \cdot 100 = 100\%$$

quality the rock (90-100%) very good

(-2)

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(Time: 1.50 hours)

Problem 4 (20 pts)

A square footing in Figure 4 of size 6 m × 6 m is founded at a depth of 3m in a clayey sand stratum of uniform consistency. The soil parameters of the soil layer are shown in the figure. Assuming a factor safety of 3, determine the allowable bearing capacity of the soil.

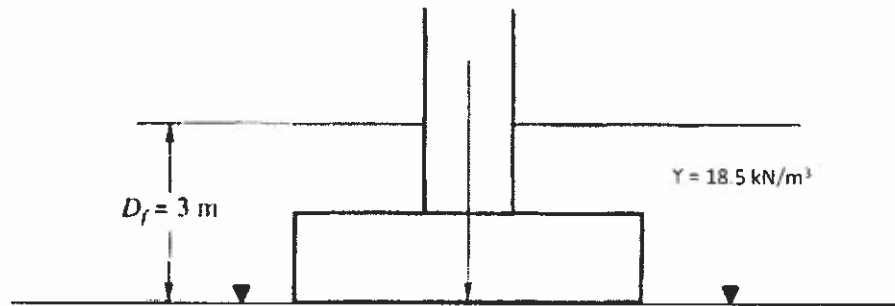


Figure 4

$Y_{sat} = 20.0 \text{ kN/m}^3$
 $C = 200 \text{ kPa}$
 $\Phi = 30^\circ$

Square footing formula

$$q_u = 1.3 C N_c + q N_q + 0.4 \gamma B N_\gamma$$

$$q = (\gamma)(D_f) = (18.5 \text{ kN/m}^3)(3 \text{ m}) = 55.5 \text{ kN/m}^2$$

$$\phi = 30^\circ$$

$$N_c = 37.16 \checkmark$$

$$N_q = 22.46 \checkmark$$

$$N_\gamma = 19.13 \checkmark$$

$$q_u = (1.3)(200 \text{ kPa})(37.16) + (55.5)(22.46) + (0.4)(18.5)(6 \text{ m})(19.13)$$

$$q_u = 11757.50 \text{ kN/m}^2$$

$$q_{all} = \frac{q_u}{FS} = \frac{11757.50}{3}$$

$$q_{all} = \underline{3919.16 \text{ kPa}}$$

? $\gamma = ?$

(-5)

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Problem 5 (30 pts)

Figure 5 shows a section of a foundation supporting a square footing of an industrial building. The column of the footing supports 375-kip load as shown in Figure 5. The dimension of the square footing is 5 ft. $\times$ 5 ft. The soil profile is also shown in the figure. The water table is at the base of the foundation. Consolidation test results of the soil from the clay layer are given below.

Preconsolidation Pressure, $\sigma_c = 1368.6$ psf

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Swelling Index, $C_s = 0.04$

Initial Void Ratio, $e_0 = 0.8$

Calculate the primary consolidation settlement of the square footing (@center) due to the given loading condition of the 5 ft. $\times$ 5 ft. square footing. **Determine stress increase using m&n method (Boussinesq Case)**

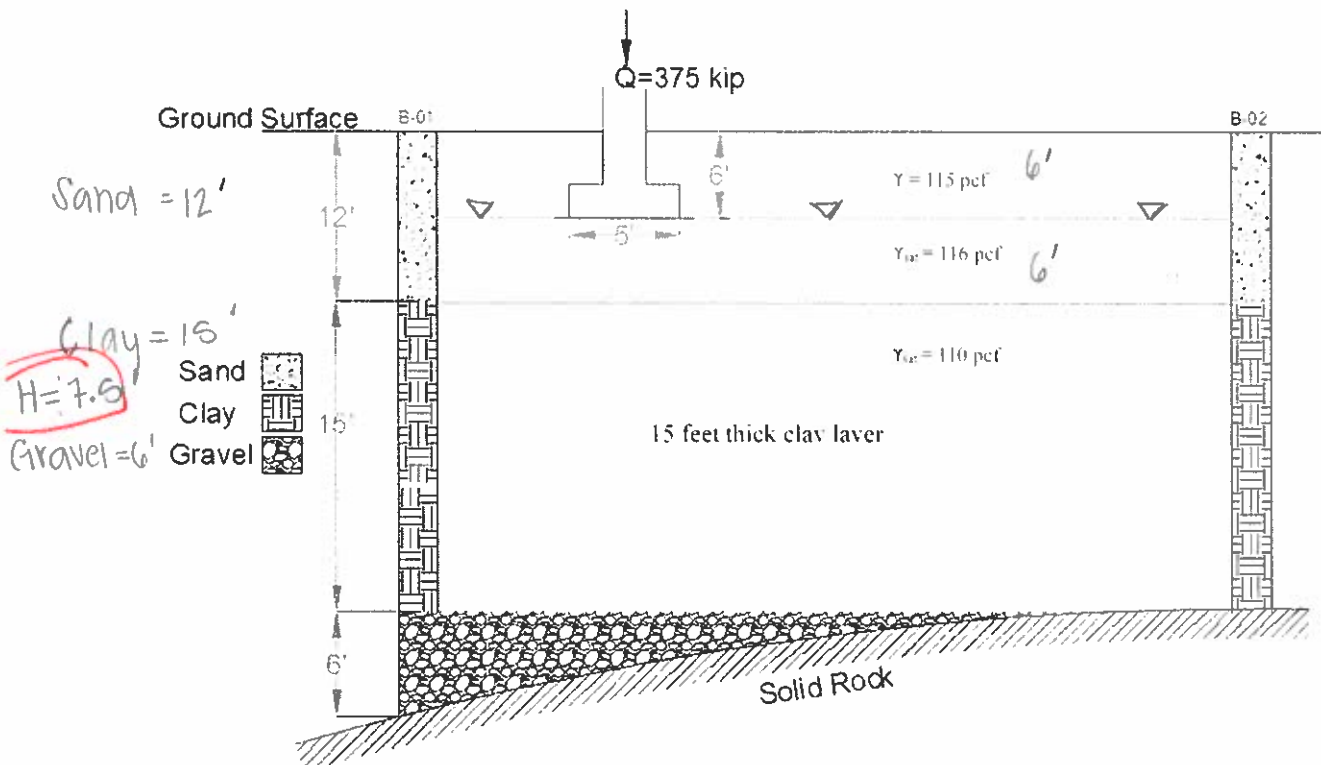


Figure 5

Back side!

5' x 5'

Given

$$Q = 375 \text{ kip}$$

$$\sigma_c = 1368.6 \text{ PSF}$$

$$C_c = 0.396$$

$$C_s = 0.04$$

$$e_0 = 0.8$$

$$\gamma_{\text{above water table}} = 115 \text{ PCF}$$

$$\gamma_{\text{sat}}(\text{sand}) = 116 \text{ PCF}$$

$$\gamma_{\text{sat}}(\text{clay}) = 110 \text{ PCF}$$

$$\text{Sand} = 12'$$

$$\text{Clay} = 15'$$

$$\text{Gravel} = 6'$$

$$\Delta \sigma' = (6)(115) + (6)(116 - 62.4) + (7.5)(110 - 62.4) = 1368.6 \text{ lb/ft}^2$$

$$1368.6 \text{ lb/ft}^2 \cdot \frac{1}{12} = 114.05 \text{ kip/ft}^2$$

$$\text{ORC} = \frac{\Delta \sigma'}{\Delta \sigma} = \frac{1368.6 \text{ PSF}}{1368.6 \text{ PSF}} = 1 \quad \text{NC Clay}$$

$$\text{Find } S_c ? \quad \frac{C_c \cdot H}{1 + e_0} \log \left(\frac{\Delta \sigma' + \Delta \sigma}{\Delta \sigma'} \right)$$

Find M and N

$$x \text{ and } y = 2.5 \text{ ft}$$

$$z = 6 + 7.5 = 13.5$$

$$q = \frac{Q}{A} = \frac{375 \text{ k}}{25 \text{ ft}^2} = 15 \text{ k/ft}^2 \cdot 1200$$

$$m = \frac{x}{z} = \frac{2.5}{13.5} = 0.185$$

$$I = 0.015$$

$$\Delta \sigma = (4)(I)(q)$$

$$n = \frac{y}{z} = \frac{2.5}{13.5} = 0.185$$

$$(4)(0.015)(18000) = 1080 \text{ PSF}$$

$$\Delta \sigma' + \Delta \sigma$$

$$1368.6 + 1080 = 2448.6 \text{ PSF}$$

$$S_c = \frac{(0.396)(15)}{1 + 0.8} \log \left(\frac{1368.6 + 1080}{1368.6} \right) = 0.833 \text{ PSF}$$

$$(0.833)(12) = 10 \text{ kip/ft}^2$$

(-2)

unit ????

***CVEG 4100 – Geotechnical Engineering Design
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(Time: 1.50 hours)***

CVEG 4100 – Geotechnical Engineering Design
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DRILLING METHOD: Hollow Stem Auger								TOTAL DEPTH (ft): 20		DATE	TIME	WATER DEPTH (ft)	REMARKS
TYPE/ SYMBOL	CASING	SPLIT SPOON	SHELBY TUBE	TCP	GRAB	ROCK CORE	6/4/2019	4:30:00 PM	17.5				
	N/A	S ☒	U ☒	T ☒	G ☒	C ☒							
DEPTH (FEET)	SAMPLE	FIELD RESULTS			GRAPHIC LOG	DESCRIPTION	LABORATORY RESULTS						
		SPT, # of Blows					SPT (N)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PASSING SENE* 200 (%)	ADDITIONAL TESTS
0		1	4	5			35.5	82	25	57	97.3		
3		3	7	11		Fat clay (CH), very dark gray	22.4						
5		3	6	11		(CH), light brown	19.0						
8		4	10	18			17.5	42	15	27	92.4		
10		4	9	16		Lean clay (CL), light brown	19.9						
15		5	11	21			19.8						
18		8	19	31			19.8						
20						Bottom of Borehole at 20 feet							

**GEOTECHNICAL ENGINEERING DESIGN LAB
FALL 2021**

Exam 2

TOPICS COVERED IN Exam 2 (Final Exam)

- 1. Deep Foundation System**
- 2. Lateral Earth Pressure**
- 3. Slope Stability Analysis**

**NOTE: Pages E1 through E7 should be repeated for each Homework
and Similarly for all the other assignments in the course binder**

**Geotechnical Engineering Design Lab
FALL 2021**

Exam #2 QUESTIONS

NAME: Student ID:

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Problem 1 (20 pts)

A precast concrete pile of size 20 inch diameter is to be driven into stiff clay which extends more than 150 ft. The unconfined compressive strength of the soil is 6 ksf as shown in Figure 1. Assume factor of safety 2.5.

(a) Determine the length of the pile required to carry the working load of 200 kips **(10 pts). Use α Method**

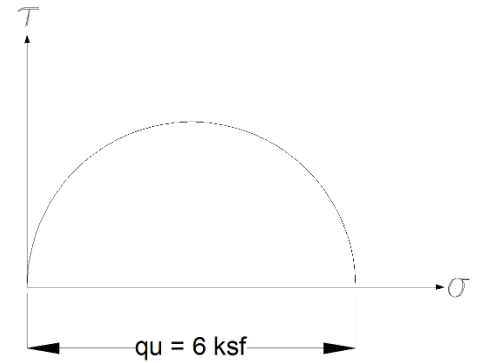
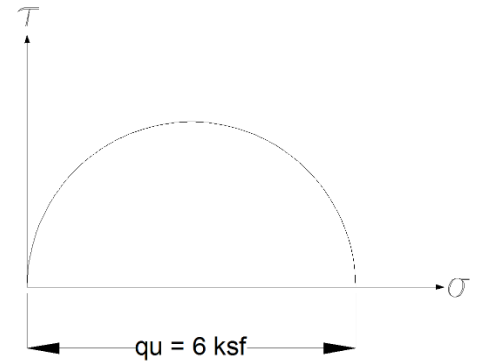


Figure 1

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Final Exam, Fall 2021
(December 08, 2021_9.30 am – 11.30 am)

(b) If the maximum length of the pile is allowed to be 100 ft, what would be the required diameter of the pile to carry 200 kips load **(10 pts)**.



Problem 2 (20 pts)

The section of a landfill slope is shown in Figure 2. The average strength values of the waste is $c = 85.6$ psf and $\phi = 17^\circ$. The average unit weight of the waste is 75 pcf. Using the ordinary method of slices, fill up Table 1 (Next page) and compute the factor of safety along the slip surface shown in the figure. **Show detail calculation in finding W.**

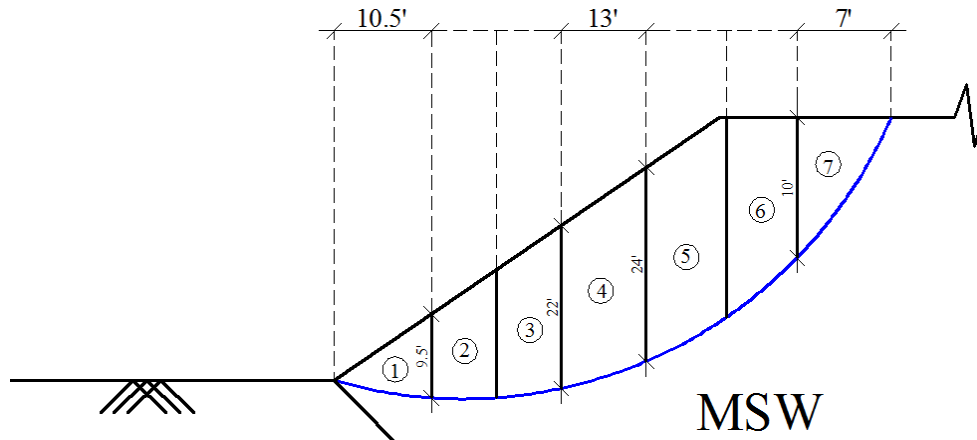


Figure 2

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Table 1: Design Table

Slice Number	W (lb)	α	$W \sin \alpha$ (lb)	$W \cos \alpha$ (lb)	l (ft)
1		-18			11
2	10106.25	-7			10
3	15262.5	8			12
4		24			14
5	14850	38			12
6	9000	53			13
7		67			10

Problem 3 (20 pts)

Determine the active pressure on the retaining wall as shown in Figure 3. The soil properties are shown in the figure. Draw the pressure diagram showing pressure values **(10 pts)**. Also, determine the location of the resultant force from the bottom of the wall **(10 pts)**. **Show detail calculation.**

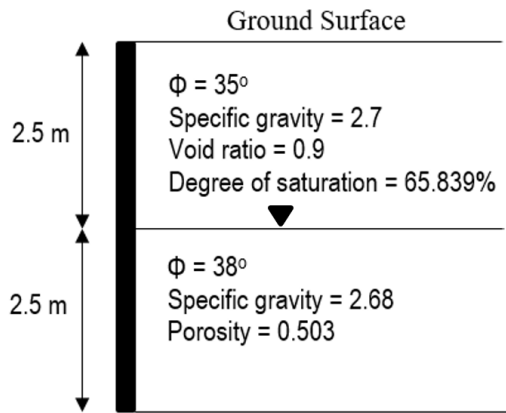


Figure 3

Problem 4 (10 pts)

A 6 m high retaining wall is to support a purely cohesive soil with unit weight 18 kN/m^3 , soil cohesion is 15 kN/m^2 . Determine the depth of tensile crack that will potentially form for this case. Also, determine the maximum depth of vertical cut without any earth retaining structure. **Show schematic diagram showing the wall, the soil pressure diagram showing depth of tensile crack, and max depth of vertical cut for this case as shown in the class.**

Problem 5 (10 pts)

A natural infinite slope consists of purely sandy soil with height 20 m. The slope is fully submerged under water with saturated unit weight of 19 kN/m^3 and friction angle 30° . How will the height of the slope affect the design of this slope? In critical condition, what would be the inclination angle of the slope?

Problem 6 (20 pts)

A flow net under a concrete dam is shown in Figure 4. From the given flow net, find out the following.

- (a) total number of flow lines (**2 pts**)
- (b) total number of equipotential lines (**2 pts**)
- (c) number of flow channels (**2 pts**)
- (d) total number of equipotential drop (**2 pts**)
- (e) pressure head (h_p) at point A (**12 pts**)

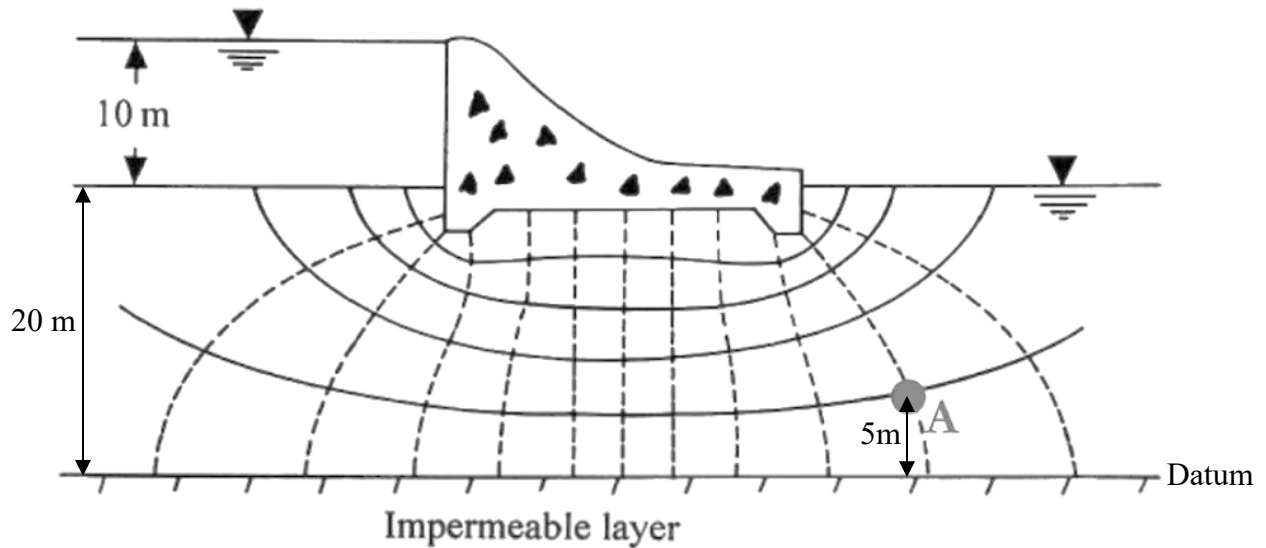


Figure 4

ABOVE AVERAGE

NAME: Perla Zaldivar

90
Student ID: P21814445

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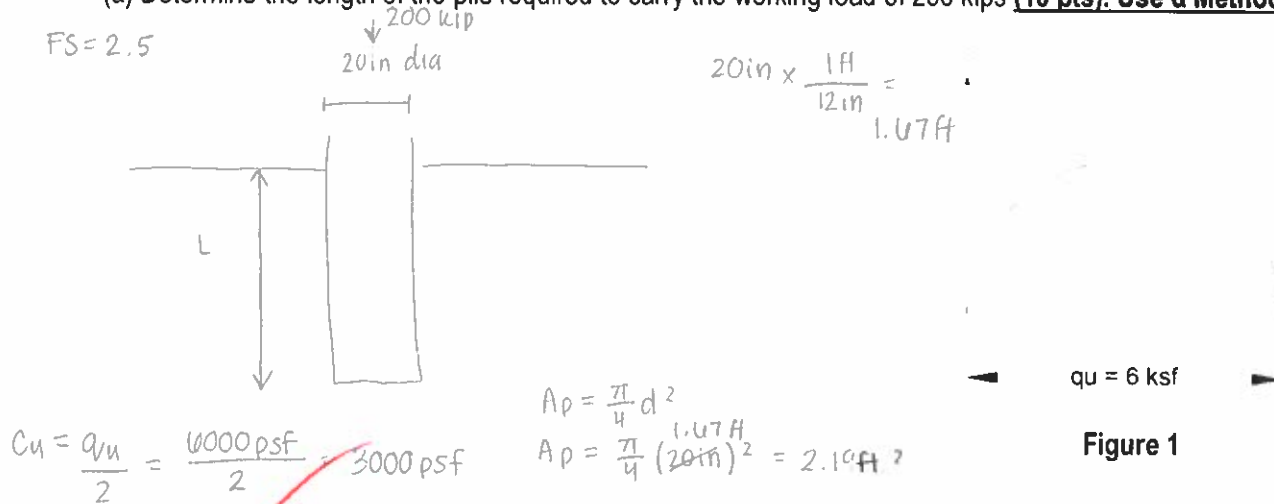
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Problem 1 (20 pts)

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(a) Determine the length of the pile required to carry the working load of 200 kips **(10 pts). Use a Method**



$$Q_u = Q_p + Q_s$$

$$Q_p = q_u A_p$$

$$Q_p = 9(3000 \text{ psf})(2.19 \text{ ft}^2)$$

$$Q_p = 59140.7 \text{ lb}$$

$$Q_s = f_p \Delta L$$

↓

$$f = \alpha C_u \quad \text{Table 12.11}$$

$$f = (0.39)(3000 \text{ psf}) \quad \frac{C_u}{2000} = \frac{3000}{2000} = 1.5 \quad \alpha = 0.39$$

$$f = 1170 \text{ psf}$$

$$p = \pi d = \pi (1.67 \text{ ft}) = 5.25 \text{ ft}$$

$$Q_s = (1170 \text{ psf})(5.25 \text{ ft})L$$

$$Q_s = 6142.5 L$$

$$Q_u = 59140.7 + 6142.5 L$$

$$Q_{all} = \frac{Q_u}{FS} = \frac{59140.7 + 6142.5 L}{2.5}$$

$$Q_{all} = 23656.28 + 2457 L$$

$$200 \text{ kip} \rightarrow 200,000 \text{ lb}$$

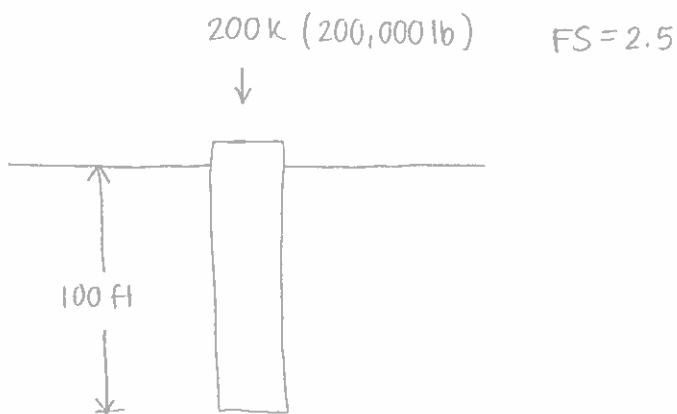
$$Q_{design} = Q_{all}$$

$$200,000 = 23656.28 + 2457 L$$

$$176,343.72 = 2457 L$$

$$L = 71.77 \text{ ft}$$

(b) If the maximum length of the pile is allowed to be 100 ft, what would be the required diameter of the pile to carry 200 kips load **(10 pts)**.



qu = 6 ksf

$$Q_u = Q_p + Q_s$$

$$Q_p = q_{cu} A_p$$

$$Q_p = q(3000 \text{ psf}) (\pi/4) d^2$$

$$Q_p = 21205.75 d^2$$

$$Q_s = f_p \Delta L$$

↓

$$f = \alpha c_u \quad \text{Table 12.11}$$

$$f = 0.39(3000) \frac{c_u}{p_a} = 1.5 \quad \alpha = 0.39$$

$$f = 1170 \text{ psf}$$

$$p = \pi d$$

$$Q_s = 1170 (\pi) (d) (100 \text{ ft})$$

$$Q_s = 367566.34 d$$

$$Q_u = 21205.75 d^2 + 367566.34 d \quad \checkmark$$

$$Q_{all} = \frac{Q_u}{FS}$$

$$200,000 = \frac{21205.75 d^2 + 367566.34 d}{2.5}$$

$$500,000 = 21205.75 d^2 + 367566.34 d$$

$$0 = 21205.75 d^2 + 367566.34 d - 500,000 \quad \checkmark$$

solver

$$d = 1.27 \text{ ft}$$

Problem 2 (20 pts)

The section of a landfill slope is shown in Figure 2. The average strength values of the waste is $c = 85.6$ psf and $\phi = 17^\circ$. The average unit weight of the waste is 75 pcf. Using the ordinary method of slices, fill up Table 1 (Next page) and compute the factor of safety along the slip surface shown in the figure. **Show detail calculation in finding W.**

$$C = 85.6 \text{ psf}$$

$$\phi = 17^\circ$$

$$\gamma = 75 \text{ pcf}$$

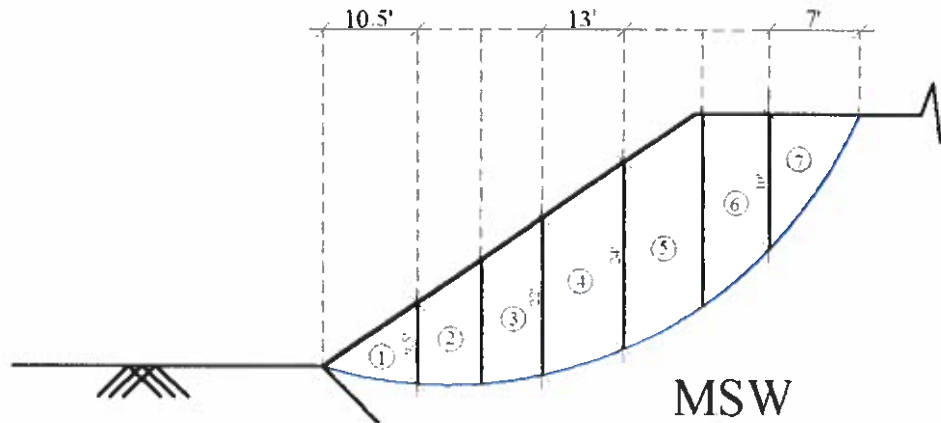


Figure 2

$$\begin{aligned} \textcircled{1} \quad W &= \gamma A \\ W &= (75 \text{ pcf}) \left[\frac{1}{2} (10.5 \text{ ft}) (9.5 \text{ ft}) \right] \\ W &= 3740.625 \text{ lb} \end{aligned}$$

$$\begin{aligned} \textcircled{4} \quad W &= \gamma A \\ W &= (75 \text{ pcf}) \left[\frac{1}{2} (22 \text{ ft} + 24 \text{ ft}) (13 \text{ ft}) \right] \\ W &= 22425 \text{ lb} \end{aligned}$$

$$\begin{aligned} \textcircled{7} \quad W &= \gamma A \\ W &= (75 \text{ pcf}) \left[\frac{1}{2} (10 \text{ ft}) (7 \text{ ft}) \right] \\ W &= 2625 \text{ lb} \end{aligned}$$

Table 1: Design Table

Slice Number	W (lb)	α	$W \sin \alpha$ (lb)	$W \cos \alpha$ (lb)	l (ft)
1	3740.63	-18	-1159	3556.95	11
2	10106.25	-7	-1231.64	10030.92	10
3	15262.5	8	2124.13	15113.97	12
4	22425	24	9121.07	20486.24	14
5	14850	38	9142.57	11701.96	12
6	9000	53	7187.72	5416.34	13
7	2025	67	2416.33	1025.67	10

where is F.S. = ?

(-2)

Problem 3 (20 pts)

Determine the active pressure on the retaining wall as shown in Figure 3. The soil properties are shown in the figure. Draw the pressure diagram showing pressure values (10 pts). Also, determine the location of the resultant force from the bottom of the wall (10 pts). Show detail calculation.

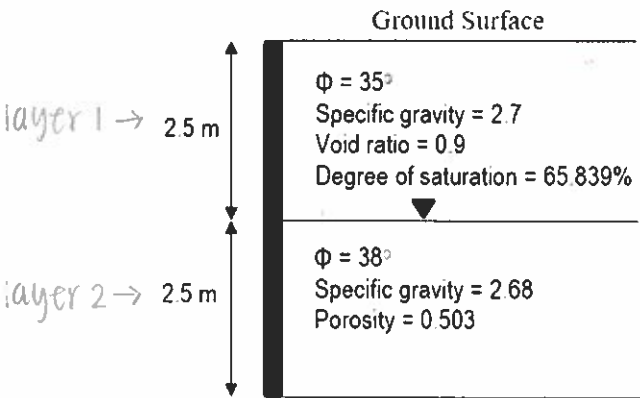
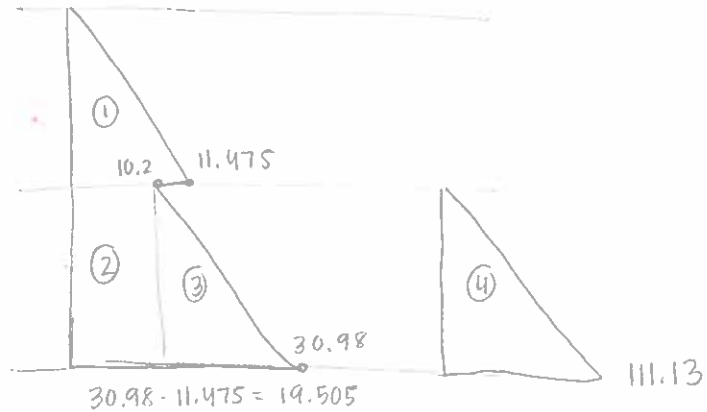


Figure 3



layer 1
 $G_s = 2.7$
 $e = 0.9$
 $S = 65.839\%$

layer 2
 $G_s = 2.68$
 $n = 0.503$

$K_{a1} = \frac{1 - \sin 35}{1 + \sin 35}$
 $K_{a1} = 0.27$

$K_{a2} = \frac{1 - \sin 38}{1 + \sin 38}$
 $K_{a2} = 0.24$

$\gamma = \frac{G_s \gamma_w (1+w)}{1+e}$
 $S = \frac{w G_s}{e}$
 $S_e = w G_s$
 $\frac{S_e}{G_s} = w$
 $w = \frac{(0.65839)(0.9)}{2.7}$
 $w = 0.219$

$\gamma_{sat} = [(1-n)G_s + n]\gamma_w$
 $\gamma_{sat} = [(1+0.503)(2.68 + 0.503)](9.81)$
 $\gamma_{sat} = 44.45 \text{ kN/m}^3$

$\gamma = \frac{2.7(9.81)(1+0.219)}{1+0.9}$
 $\gamma = 17 \text{ kN/m}^3$

$\sigma_h = \gamma h K_a - 2c\sqrt{K_a}$
 @ $h=0$ $\sigma_h = 0$
 @ $h=2.5\text{m}$ $\sigma_h = (17 \text{ kN/m}^3)(2.5\text{m})(0.27) - 0$
 $\sigma_h = 11.475$
 @ $h=2.5\text{m}$ $\sigma_h = (17 \text{ kN/m}^3)(2.5\text{m})(0.24) - 0$
 $\sigma_h = 10.2$
 @ $h=5\text{m}$ $\sigma_h = 10.2 + (44.45 - 9.81)(2.5)(0.24) - 0$
 $\sigma_h = 30.98$

water pressure = $44.45 \text{ kN/m}^3 (2.5\text{m}) = 111.13$

$F_1 - A_1 = (1/2)(2.5)(11.475) = 14.34 \text{ kN}$
 $F_2 - A_2 = (2.5)(10.2) = 25.5$
 $F_3 - A_3 = (1/2)(2.5)(19.505) = 24.38$
 $F_4 - A_4 = (1/2)(2.5)(111.13) = 138.91$

$F = A_1 + A_2 + A_3 + A_4 = 203.13 \text{ kN}$

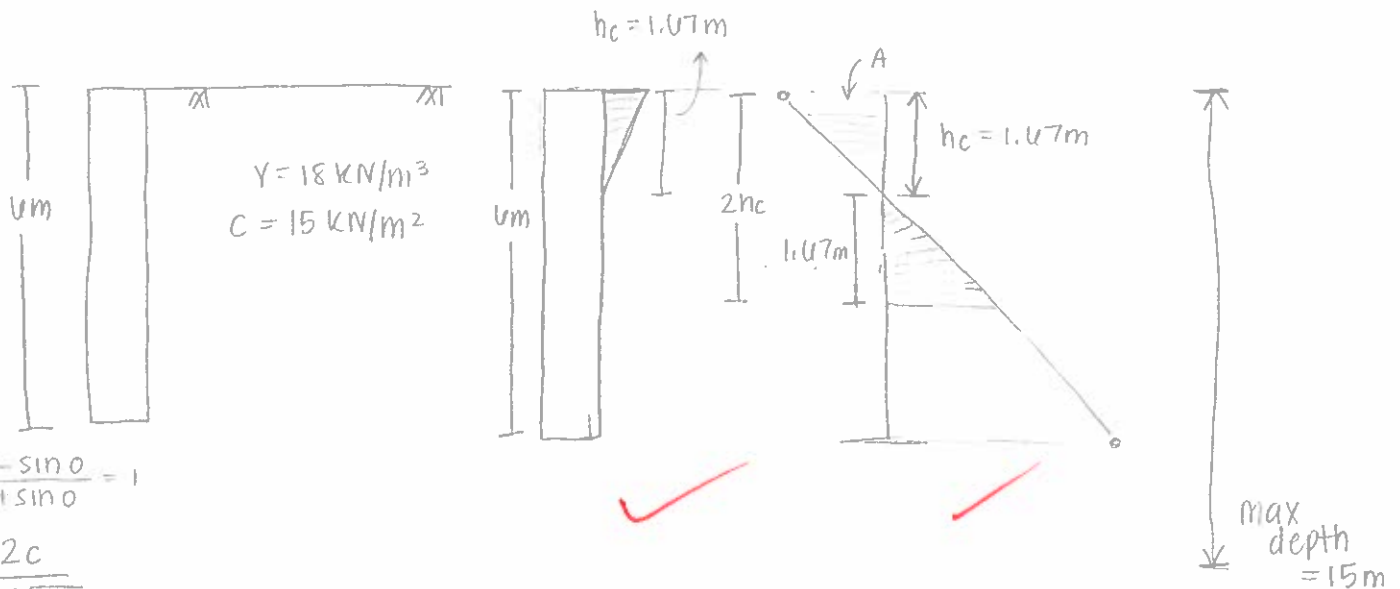
$F_a = \sum A \bar{y}$
 $a = \frac{1}{F} [\sum A \bar{y}]$
 $a = \frac{1}{203.13} [(14.34(1/3)(2.5) + 2.5) + 25.5(2.5/2) + 24.38(1/3)(2.5) + 138.91(1/3)(2.5)]$
 $a = \frac{1}{203.13} [14.45 + 31.875 + 20.31 + 115.75]$

Problem 4 (10 pts)

$$\phi = 0$$

A 6 m high retaining wall is to support a purely cohesive soil with unit weight 18 kN/m^3 , soil cohesion is 15 kN/m^2 .

- ✓ Determine the depth of tensile crack that will potentially form for this case. Also, determine the maximum depth of vertical cut without any earth retaining structure. **Show schematic diagram showing the wall, the soil pressure diagram showing depth of tensile crack, and max depth of vertical cut for this case as shown in the class.**



$$K_a = \frac{1 - \sin 0}{1 + \sin 0} = 1$$

$$h_c = \frac{2c}{\gamma \sqrt{K_a}}$$

$$h_c = \frac{2(15 \text{ kN/m}^2)}{(18 \text{ kN/m}^3) \sqrt{1}}$$

$$h_c = 1.07 \text{ m}$$

max depth

$$2h_c = \frac{4c}{2\sqrt{K_a}}$$

$$2h_c = \frac{4(15 \text{ kN/m}^2)}{2\sqrt{1}}$$

$$2h_c = 30 \text{ m}$$

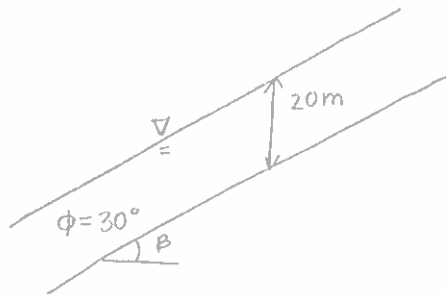
$$h_c = 15 \text{ m}$$

Problem 5 (10 pts)

A natural infinite slope consists of purely sandy soil with height 20 m. The slope is fully submerged under water with saturated unit weight of 19 kN/m^3 and friction angle 30° . How will the height of the slope affect the design of this slope? In critical condition, what would be the inclination angle of the slope?

$$\gamma_{\text{sat}} = 19 \text{ kN/m}^3$$

$$\phi = 30^\circ$$



The height of the slope doesn't play a big factor compare to the inclination angle or presence of water table in the soil.

FS = 1 in critical condition

$$F_s = \frac{\gamma'}{\gamma_{\text{sat}}} \left(\frac{\tan \phi}{\tan \beta} \right)$$

$$1 = \frac{(19 - 9.81)}{19} \left(\frac{\tan 30}{\tan \beta} \right)$$

$$1 = 0.483 \left(\frac{\tan 30}{\tan \beta} \right)$$

$$2.06 = \frac{\tan 30}{\tan \beta}$$

$$2.06 (\tan \beta) = \tan 30$$

$$\beta = 15.66^\circ$$

Problem 6 (20 pts)

A flow net under a concrete dam is shown in Figure 4. From the given flow net, find out the following.

- (a) total number of flow lines (2 pts)
- (b) total number of equipotential lines (2 pts)
- (c) number of flow channels (2 pts)
- (d) total number of equipotential drop (2 pts)
- (e) pressure head (h_p) at point A (12 pts)

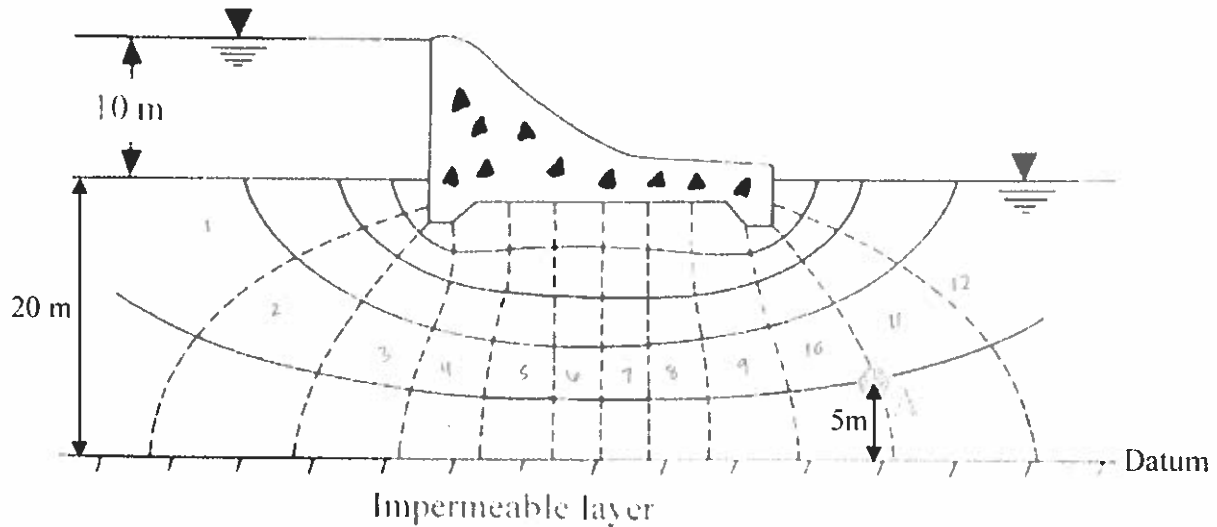


Figure 4

- a. 5 flow lines ~~X~~ → 6
- b. 13 equipotential lines ✓
- c. 12 ~~X~~ → 5
- d. 2 ~~X~~ → 12 ✓
- e.

H_p	H_e	H_T
10	20	30

$$H_e(A) = 20 - 5 = 15m \quad \checkmark$$

$$\text{Total head } H_T(A) = 30 \quad \times$$

@ A

$$H_p(A) = H_T(A) - H_e(A) = 30m - 15m = 15m \quad \times$$

(-8)

AVERAGE

NAME: Alex Martinez

Student ID: P21632543

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Problem 1 (20 pts)

A precast concrete pile of size 20 inch diameter is to be driven into stiff clay which extends more than 150 ft. The unconfined compressive strength of the soil is 6 ksf as shown in Figure 1. Assume factor of safety 2.5.

(a) Determine the length of the pile required to carry the working load of 200 kips **(10 pts). Use α Method**

Given: dia. = 20 in = 1.67 ft extends to more than 150 ft

$u = \frac{q_u}{2} = 3 \text{ ksf}$ Unconfined compressive strength = 6 ksf

Working load = 200 kips

F.S. = 2.5

$\alpha = 0.6$

$$Q_u = Q_s + Q_p = (q \times C_u \times A_p) + (\alpha C_u \times P \times L)$$

$$\Rightarrow (9 \times 3 \times \frac{\pi}{4} \times (1.67)^2) + (0.6 \times 3 \times \pi \times 1.67 \times L)$$

$$Q_u = 59.141 + 9.44L$$

$$Q_{all} = Q_u / F.S. = (59.141 + 9.44L) / 2.5$$

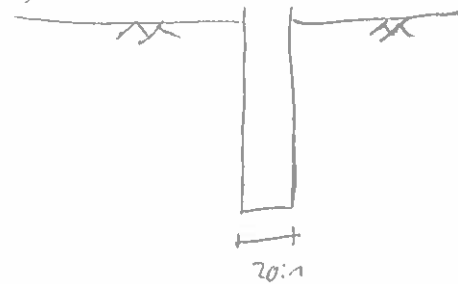
$$200 \text{ kips} = \frac{(59.141 + 9.44L)}{2.5}$$

$$500 = 59.141 + 9.44L$$

$$L = 46.68 \text{ ft}$$

$q_u = 6 \text{ ksf}$

Figure 1



(-5)

CVEG 4100 – Geotechnical Engineering Design
Final Exam, Fall 2021
(December 08, 2021_9.30 am – 11.30 am)

(b) If the maximum length of the pile is allowed to be 100 ft, what would be the required diameter of the pile to carry 200 kips load **(10 pts)**.

Given: $\text{max } L = 100 \text{ ft}$ $\alpha = .6$

$$Q_u = 200 \text{ kips}$$

$$Q_u = Q_s + Q_p = (q \times C_u \times A_p) + (\alpha C_u \times P \times L)$$

$$\Rightarrow \left(9 \times 3 \times \frac{\pi}{4} \times d^2 \right) + (.6 \times 3 \times \pi \times d \times 100 \text{ ft})$$

$$Q_u = 21.205 d^2 + 565.486 d$$

$$q_u = 6 \text{ ksf}$$

$$Q_{all} = Q_u / FS = (21.205 d^2 + 565.486 d) / 2.5$$

$$200 = (21.205 d^2 + 565.486 d) / 2.5$$

$$500 = 21.205 d^2 + 565.486 d$$

$$21.205 d^2 + 565.486 d - 500 = 0$$

Using Solver
on calc.

$$d = 0.857 \text{ ft}$$

$$d = 10.28 \text{ in}$$

(-5)

Problem 2 (20 pts)

The section of a landfill slope is shown in Figure 2. The average strength values of the waste is $c = 85.6$ psf and $\phi = 17^\circ$. The average unit weight of the waste is 75 pcf. Using the ordinary method of slices, fill up Table 1 (Next page) and compute the factor of safety along the slip surface shown in the figure. **Show detail calculation in finding W.**

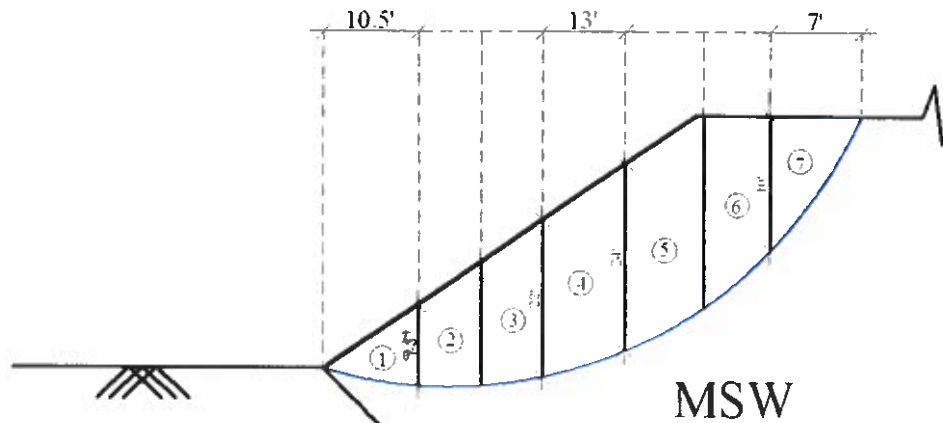


Figure 2

Given: $c = 85.6$

$\phi = 17^\circ$

Avy. unit weight = 75 pcf $W = Area \times l \times \gamma$

Next Page
→

Table 1: Design Table

Slice Number	W (lb)	α	$W \sin \alpha$ (lb)	$W \cos \alpha$ (lb)	l (ft)
1	3740.63	-18	-1155.92	3557.55	11
2	10106.25	-7	-1231.64	10030.42	10
3	15262.5	8	2124.13	15113.97	12
4	22425	24	9121.07	20486.26	14
5	14850	38	9142.57	11761.96	12
6	9000	53	7187.72	5416.34	13
7	2625	67	2416.33	1025.67	10

3x Calc.)

Slice 1: $\frac{1}{2} \times 9.5 \times 10.5 \times 1 \times 75 = W$
 $W = 3740.625 \text{ lb}$

$W \sin \alpha = 3740.63 \times \sin(-18)$
 $= -1155.92 \text{ lb}$

$W \cos \alpha = 3740.63 \times \cos(-18)$
 $= 3557.55 \text{ lb}$

Slice 4: $\frac{1}{2} \times (22+24) \times 13 \times 1 \times 75$
 $W = 22425 \text{ lb}$

Slice 7: $\frac{1}{2} \times 7 \times 16 \times 1 \times 75$
 $W = 2625 \text{ lb}$

Factor of safety = $\frac{CL + \tan \phi \sum N}{\sum T}$

$\sum N = \sum W \cos \alpha$

$\sum T = \sum W \sin \alpha$

$11 + 12 + 13 + 14 + 15 + 16 + 17$
 $11 + 16 + 12 + 14 + 12 + 13 + 10$
 $= 82 \text{ ft}$

$\sum N = \sum W \cos \alpha = 67332.65$

$\sum T = \sum W \sin \alpha = 27604.25$

$FOS = \frac{85.6 \times 82 \times (\tan 17^\circ) \times 67332.65}{27604.25}$

$= 1.00021741 \approx 1$

Problem 3 (20 pts)

Determine the active pressure on the retaining wall as shown in Figure 3. The soil properties are shown in the figure. Draw the pressure diagram showing pressure values (10 pts). Also, determine the location of the resultant force from the bottom of the wall (10 pts). Show detail calculation.

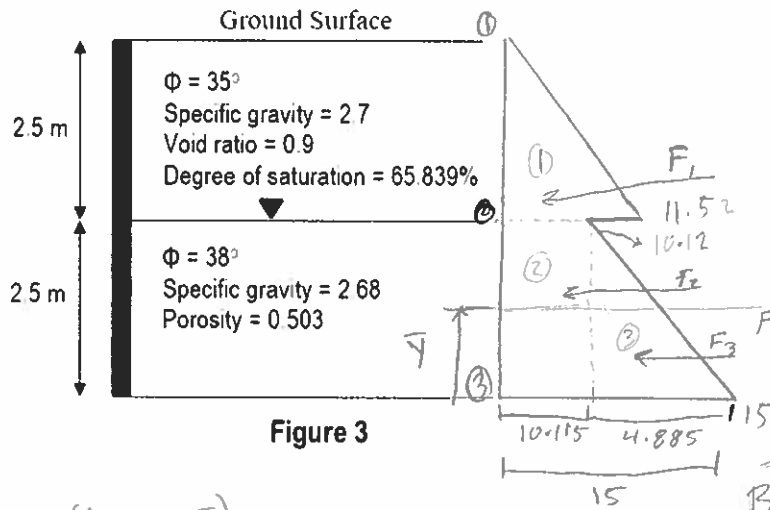


Figure 3

$$F = F_1 + F_2 + F_3$$

$$F = \left(\frac{1}{2} \times 11.5175 \times 2.5 \right) + (10.115 \times 2.5) + \left(\frac{1}{2} \times 4.885 \times 2.5 \right)$$

$$\bar{Y} = \frac{F_1 \times \left(2.5 + \frac{2.5}{3} \right) + F_2 \times \left(\frac{2.5}{2} \right) + F_3 \times \left(\frac{2.5}{3} \right)}{F}$$

$$\Rightarrow \frac{(14.4 \times 3.33) + (25.29 \times 1.25) + (6.11 \times 0.8)}{45.8 \text{ kN}}$$

$$\bar{Y} = 1.85 \text{ m}$$

Bottom 2.5 m (Below WT)

$$e = \frac{n}{1-n} = \frac{0.503}{1-0.503} = 1.012$$

$$\gamma_{\text{sat}} = \frac{\gamma_w (G + e)}{1 + e} = \frac{9.81 (2.68 + 1.012)}{1 + 1.012}$$

$$\gamma_{\text{sat}} = 18.001 \text{ kN/m}^3$$

Layer 3

$$K_a = 0.238$$

$$\sigma_v' = (17 \times 2.5 + 18 \times 2.5) - (9.81 \times 2.5) = 62.975$$

$$p_a = K_a \sigma_v' = 0.238 \times 62.975$$

$$p_a = 15 \text{ kN/m}^2$$

Layer 1:

$$p_{a1} = 0$$

Layer 2 Just above WT

$$K_a = \frac{1 - \sin \phi}{1 + \sin \phi} = \frac{1 - \sin 35}{1 + \sin 35} = 0.271$$

$$\sigma_v' = 17 \times 2.5 = 42.5$$

$$p_a = K_a \sigma_v' = 0.271 \times 42.5$$

$$p_a = 11.5175 \text{ kN/m}^2$$

Layer 2 Just below WT

$$K_a = \frac{1 - \sin 38}{1 + \sin 38} = 0.238$$

$$\sigma_v' = 42.5$$

$$p_a = K_a \sigma_v' = 0.238 \times 42.5$$

$$p_a = 10.115 \text{ kN/m}^2$$

Problem 4 (10 pts)

A 6 m high retaining wall is to support a purely cohesive soil with unit weight 18 kN/m^3 , soil cohesion is 15 kN/m^2 . Determine the depth of tensile crack that will potentially form for this case. Also, determine the maximum depth of vertical cut without any earth retaining structure. Show schematic diagram showing the wall, the soil pressure diagram showing depth of tensile crack, and max depth of vertical cut for this case as shown in the class.

$h_c = \text{depth of tensile crack}$
 $k_a \cdot k_p = 1$

$$h_c = \frac{2c}{\gamma \sqrt{k_a}}$$

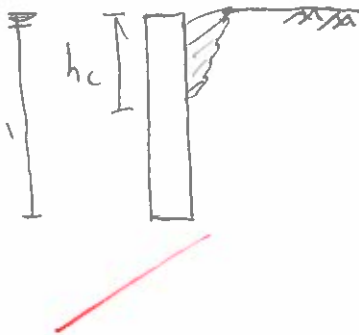
$$k_a = \frac{1}{k_p}$$

$$k_p = \frac{1 + \sin \phi}{1 - \sin \phi}$$

2



(5)

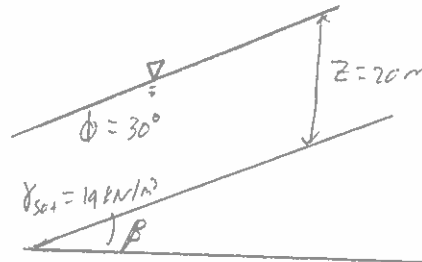


Problem 5 (10 pts)

A natural infinite slope consists of purely sandy soil with height 20 m. The slope is fully submerged under water with saturated unit weight of 19 kN/m^3 and friction angle 30° . How will the height of the slope affect the design of this slope? In critical condition, what would be the inclination angle of the slope?

FOS

$$F = \left(\frac{\gamma'}{\gamma_{\text{sat}}} \times \frac{\tan \phi}{\tan \beta} \right)$$



height of sandy layer for
Submerged condition does not affect design
for critical condition

$$F = 1$$

$$\Rightarrow \frac{\gamma'}{\gamma_{\text{sat}}} \frac{\tan \phi}{\tan \beta} = 1$$

$$\left(\frac{19 - 10}{19} \right) \frac{\tan 30^\circ}{\tan \beta} = 1$$

$$\tan \beta = 0.273$$

$$\boxed{\beta = 15.29^\circ}$$

Problem 6 (20 pts)

A flow net under a concrete dam is shown in Figure 4. From the given flow net, find out the following.

- (a) total number of flow lines (2 pts)
- (b) total number of equipotential lines (2 pts)
- (c) number of flow channels (2 pts)
- (d) total number of equipotential drop (2 pts)
- (e) pressure head (h_p) at point A (12 pts)

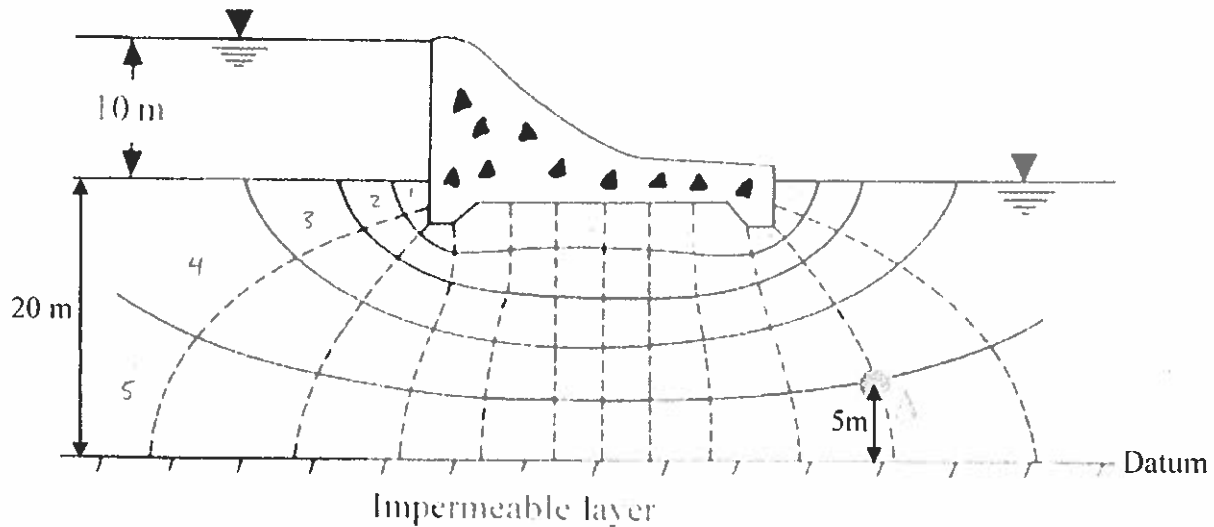


Figure 4

- a) Number flow line = 4 X
- b) number equipotential lines = 12 X
- c) number flow channels = 5 ✓
- d) total number equipotential drop = 60 X

(-10)

BELOW AVERAGE

66

NAME: Abram August Student ID: P2202 8029

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CVEG 4100 – Geotechnical Engineering Design
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(December 08, 2021_9.30 am – 11.30 am)

Problem 1 (20 pts)

A precast concrete pile of size 20 inch diameter is to be driven into stiff clay which extends more than 150 ft. The unconfined compressive strength of the soil is 6 ksf as shown in Figure 1. Assume factor of safety 2.5.

(a) Determine the length of the pile required to carry the working load of 200 kips **(10 pts). Use a Method**

$\Delta L = 150 \text{ ft}$

given: F.S. = 2.5

diameter = 20 in = 1.667 ft

$s = C_u = \frac{q_u}{2} = \frac{6}{2} = 3$ (15.56)

$\phi = 0$

$Q_u = Q_s + Q_p$ where $Q_p = q \times A_p \times C_u$

$A_p = \frac{\pi}{4} d^2 = \frac{\pi}{4} (20 \text{ in})^2 = \frac{314.16 \text{ in}^2}{144 \text{ in}^2} = 2.181 \text{ ft}^2$

$\Rightarrow Q_p = q \times 2.181 \text{ ft}^2 \times 3,000 \frac{\text{lb}}{\text{ft}^2} = 59,860 \text{ lbs}$

$Q_s = f \times P \times \Delta L \rightarrow f = \alpha \times C_u$ where $\alpha = 1.66 \times 12.11$
 $= (0.39 \times 3,000 \frac{\text{lb}}{\text{ft}^2}) \times (\pi \times 1.667 \text{ ft}) \times L = 6126.12 L$

$\frac{C_u}{P_a} = \frac{3,000 \text{ lb/ft}^2}{2,000 \text{ lb/ft}^2} = 1.5$
 $\Rightarrow \alpha = 0.39$

$\Rightarrow Q_{all} = \frac{Q_u}{F.S.} = \frac{59,860 \text{ lbs} + 6126.12 L}{2.5} = 23,544 \text{ lbs} + 2450.45 L = 200,000 \text{ lbs} \Rightarrow L = 72$



OK

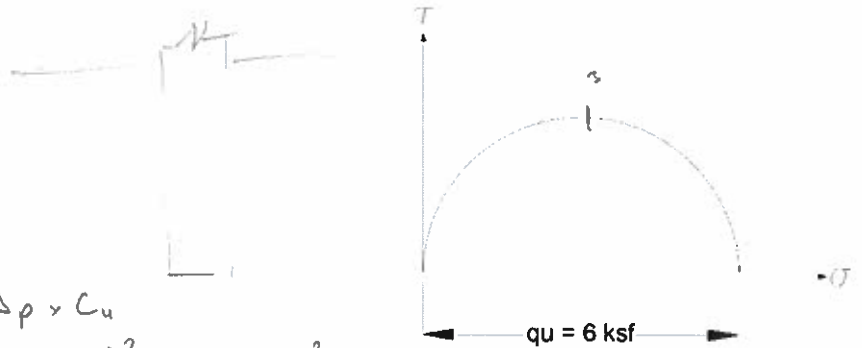


Figure 1

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(b) If the maximum length of the pile is allowed to be 100 ft, what would be the required diameter of the pile to carry 200 kips load **(10 pts)**.

$$Q_u = Q_p + Q_s$$

$$\rightarrow 200,000 \text{ lbs} = 9 \times A_p \times C_u + f \times p \times 100 \text{ ft}$$

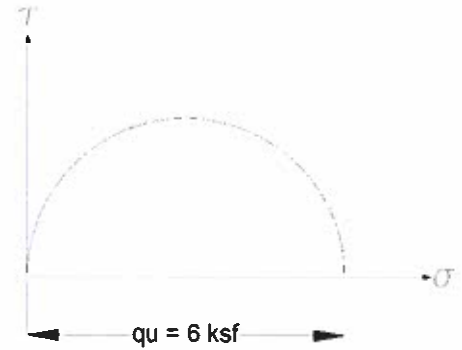
$$200,000 \text{ lbs} = 9 \times \left(\frac{\pi}{4} d^2 \right) \times \frac{3000 \text{ lbs}}{\text{ft}^2} + 1170 \times (\pi \times d) \times 100 \text{ ft}$$

$$200,000 \text{ lbs} = 21205.75 d^2 + 367,566.34 d$$

$$\rightarrow 21,205.75 d^2 + 367,566.34 d - 200,000 = 0$$

$$\rightarrow d = 4.89 \text{ ft}$$

(-2)



or solver

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Problem 2 (20 pts)

The section of a landfill slope is shown in Figure 2. The average strength values of the waste is $c = 85.6$ psf and $\phi = 17^\circ$. The average unit weight of the waste is 75 pcf. Using the ordinary method of slices, fill up Table 1 (Next page) and compute the factor of safety along the slip surface shown in the figure. **Show detail calculation in finding W.**

$$c = 85.6 \frac{\text{lb}}{\text{ft}^2}$$

$$\phi = 17^\circ$$

$$\gamma = 75 \frac{\text{lb}}{\text{ft}^3}$$

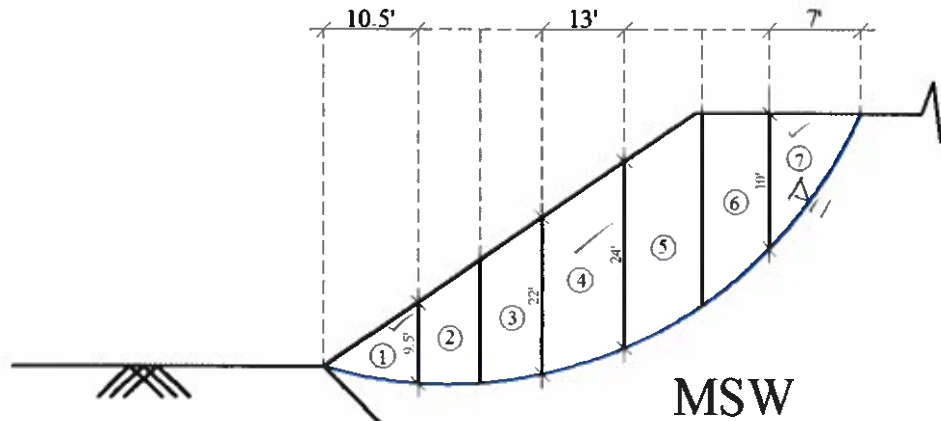


Figure 2

$W = \text{Area} \times \gamma$ (Triangle or Trapezoid) $\rightarrow$

① $W = \frac{1}{2} \times (10.5 \text{ ft} \times 9.5 \text{ ft}) \times 75 \frac{\text{lb}}{\text{ft}^3} = 3740.63$

④ $W = \left[\frac{1}{2} \times (22 \text{ ft} \times 24 \text{ ft}) \times 13 \text{ ft} \times 75 \frac{\text{lb}}{\text{ft}^3} \right] = 22,425$

⑦ $W = \left[\frac{1}{2} \times 10 \text{ ft} \times 7 \text{ ft} \right] \times 75 \frac{\text{lb}}{\text{ft}^3} = 2,625$

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$\phi = 17^\circ$
 $c = 85.6$

Table 1: Design Table

Slice Number	W (lb)	α	$W \sin \alpha$ (lb)	$W \cos \alpha$ (lb)	l (ft)
1	3740.63	-18	1093.65	3577.18	11
2	10106.25	-7	2954.78	9664.65	10
3	15262.5	8	4462.32	14595.60	12
4	22425	24	6556.44	21445.13	14
5	14850	38	4341.72	14201.13	12
6	9000	53	2631.35	8606.74	13
7	21625	67	767.48	2510.30	10

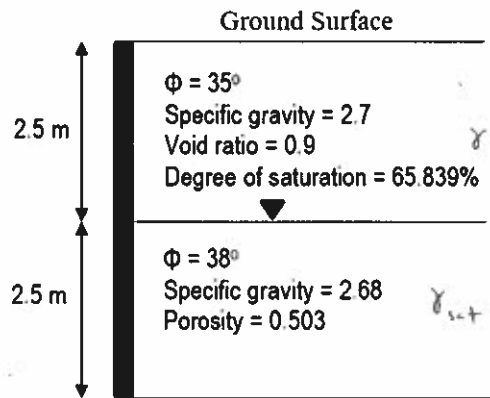
$c \times l$
 941.6
 856
 1027.2
 1198.1
 1027.2
 1112.8
 856

$$F = \frac{\sum c \times l + W \cos \alpha \times \tan \phi}{\sum W \sin \alpha} = \frac{29826.932}{22,807.74} = 1.31$$

(-2)

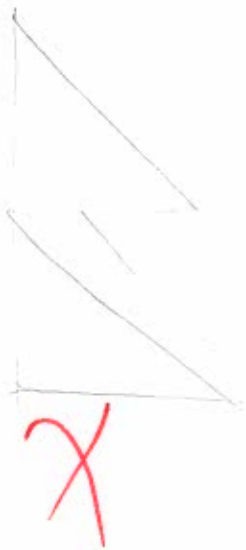
Problem 3 (20 pts)

Determine the active pressure on the retaining wall as shown in Figure 3. The soil properties are shown in the figure. Draw the pressure diagram showing pressure values (10 pts). Also, determine the location of the resultant force from the bottom of the wall (10 pts). Show detail calculation.



$$k_{a1} = \frac{1 - \sin 35^\circ}{1 + \sin 35^\circ} = 0.27$$

$$k_{a2} = \frac{1 - \sin 38^\circ}{1 + \sin 38^\circ} = 0.24$$



$$h = 0, \sigma_h = \gamma \times 0 \times k_a = 17.33 \times 0 \times 0.27 - 2 \times 0 \times \sqrt{0.27} = 0$$

$$h = 2.5, \sigma_h = 17.33 \times 2.5 \times 0.24 - 2 \times 0 \times \sqrt{0.24} = 10.398$$

$$h = 2.5, \sigma_h = 10.398 + (18 - 6.24) \times 2.5 \times 0.24 =$$

$$h = 5, \sigma_h =$$

(-10)

Problem 4 (10 pts)

A 6 m high retaining wall is to support a purely cohesive soil with unit weight 18 kN/m^3 , soil cohesion is 15 kN/m^2 . Determine the depth of tensile crack that will potentially form for this case. Also, determine the maximum depth of vertical cut without any earth retaining structure. **Show schematic diagram showing the wall, the soil pressure diagram showing depth of tensile crack, and max depth of vertical cut for this case as shown in the class.**

$$z_c = \frac{2 \times c'}{\gamma \times \sqrt{k_a}} \quad \text{where } k_a = \tan^2 \left(45 - \frac{\phi}{2} \right) = 1$$

$$= \frac{2 \times 15 \frac{\text{kN}}{\text{m}^2}}{(18)(1)} = \frac{30}{18} \text{ m} = 1.67 \text{ m}$$

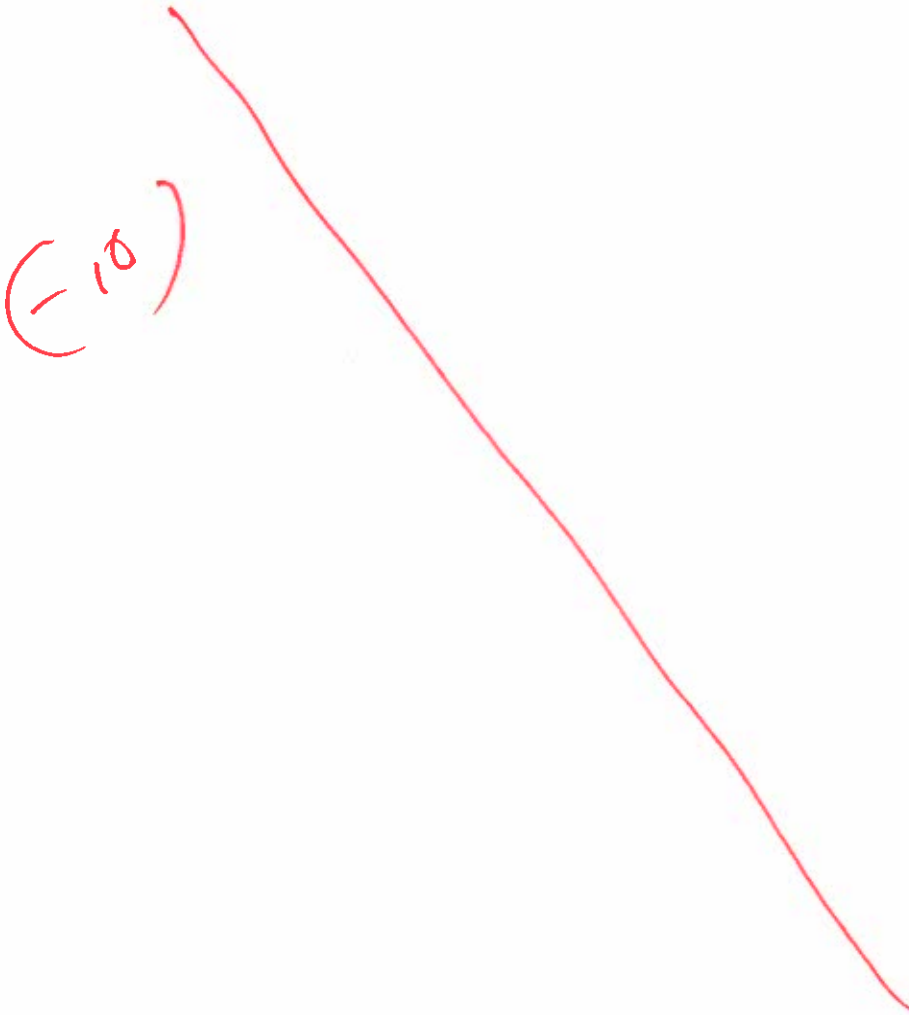
$$\bar{z} = \frac{6 - \left(\frac{30}{18} \right)}{3} = 1.44 \text{ m} \quad \checkmark$$

depth of vertical cut?

(-2)

Problem 5 (10 pts)

A natural infinite slope consists of purely sandy soil with height 20 m. The slope is fully submerged under water with saturated unit weight of 19 kN/m^3 and friction angle 30° . How will the height of the slope affect the design of this slope? In critical condition, what would be the inclination angle of the slope?



Problem 6 (20 pts)

A flow net under a concrete dam is shown in Figure 4. From the given flow net, find out the following.

- (a) total number of flow lines (2 pts) 8 flow lines ~~X~~
 (b) total number of equipotential lines (2 pts) 13 lines ~~X~~
 (c) number of flow channels (2 pts) 5 channel ~~X~~
 (d) total number of equipotential drop (2 pts) 12 drops ~~X~~
 (e) pressure head (h_p) at point A (12 pts) 10 m ~~X~~

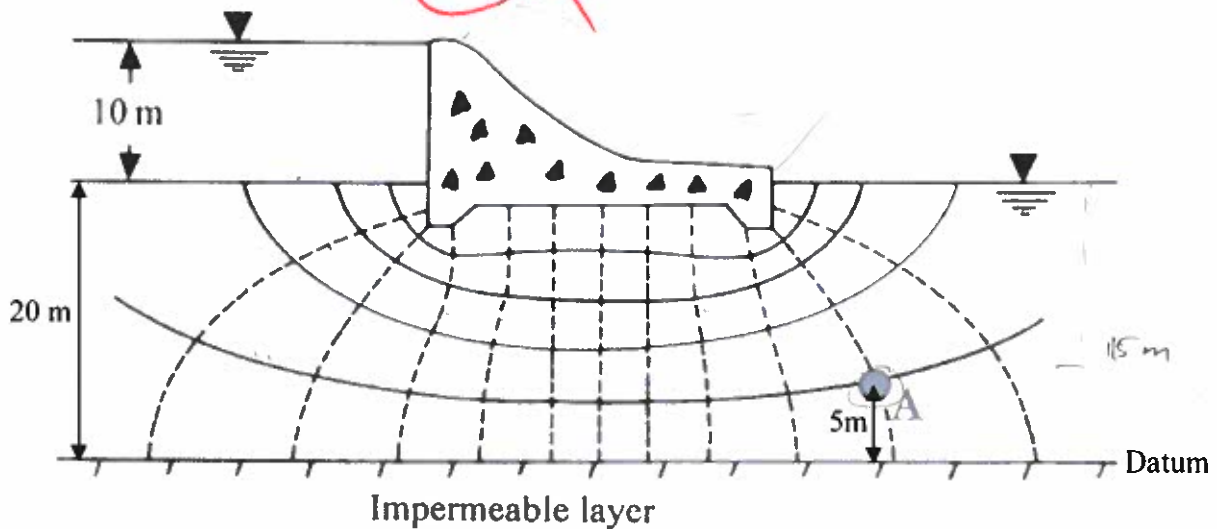


Figure 4

	H_p	H_e	H_T
A	10	20	30

$$H_{p(A)} = H_{T(A)} - H_{e(A)} = 30 - 20 = 10$$

(-8)