Names _____

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Iowa State University CCEE Dept.
CE 460 Spring 2014

CE 460 Foundation Engineering
Exam 1 – Part 2
Due on or before March 12, 2014 – 2:10 p.m. (start of class)

Perform all work on the provided sheets. Use the pages provided and back of the sheets, if necessary. The problems can have more than one correct solution, so it is important to **show your work, units and equations** so I can follow your reasoning in solving a problem if any potential partial credit can be given.

Scores: **Problem 1:** _____ / 30 **Problem 2:** _____ / 30

Problem 1: (30 points):

Refer to the log and diagram on the following page.

A square footing with a width of 10 feet will bear at a depth of 4 feet below final ground level in the soil profile. The groundwater level is 9 feet below ground.

Perform the following computations and determinations:

a) Prepare the effective stress distribution for the given soil profile to a depth of 30 feet (display on the graph provided adjacent to the soil profile/foundation diagram).

Provide the value for the effective stress at the following depths:

Depth of Interest (below ground level)	**Initial Effective Vertical Stress σ_i (psf)**
4 feet	
6½ feet	
12 feet	
19 feet	
26½ feet	

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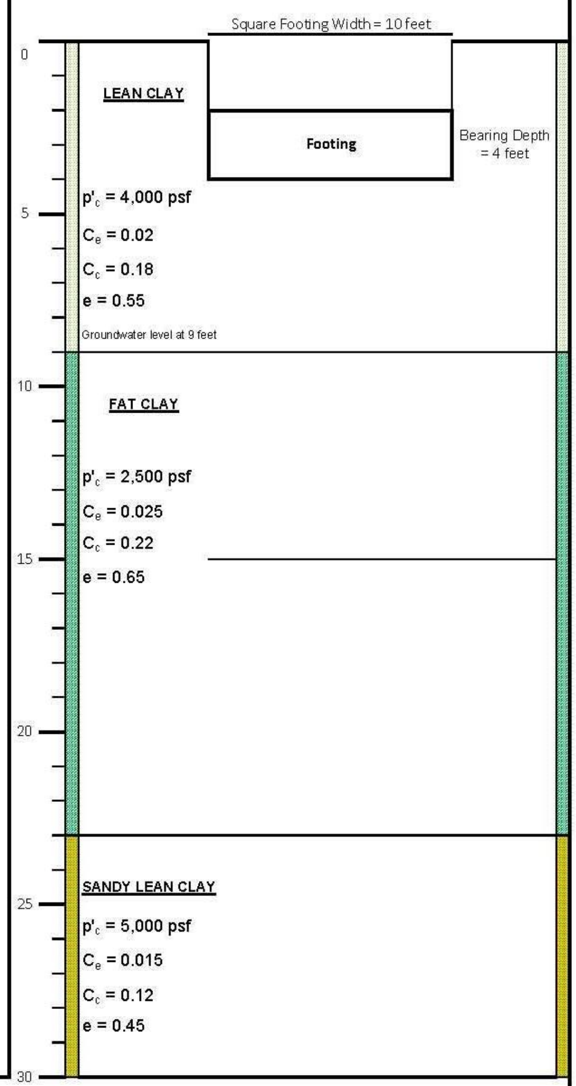
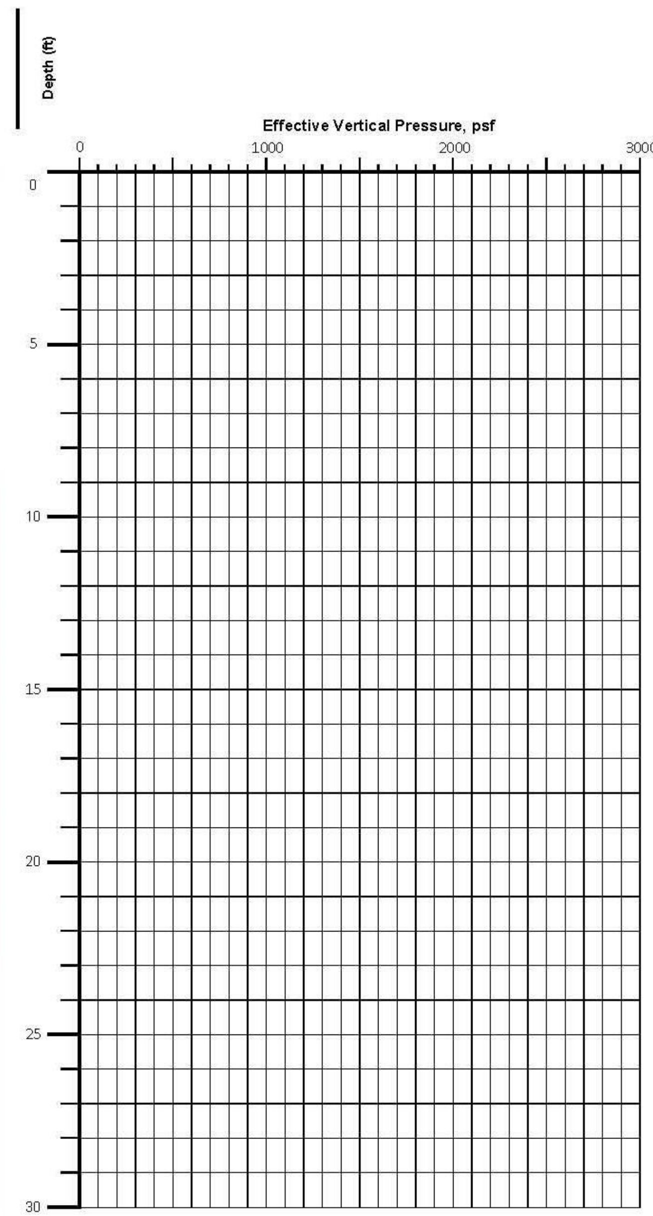
Boring Log with laboratory and field tests for CE 460 Exam No. 1 - Part 1 and 2 and planned foundation size and depth for bearing capacity and settlement determination
Note the level of groundwater.

Soil Description: LEAN CLAY (0 to 9 ft); Groundwater level at 9 feet; FAT CLAY (9 to 23 ft); SANDY LEAN CLAY (23 to 30 ft)

Sample No.	Water Content (%)	Dry Unit Weight (pcf)	Unconfined Compressive Strength (psf)	Vane Shear Strength (psf)
1	13.2	106	5600	
2	15.7	108	3050	
3	11.6	112	3350	
4	21.1	101	1880	
5	24.9	98		1060
6	27.5	96		640
7	26.2	97	1180	
8	14.1	116	4800	
9	16.1	114	6200	





b) For the given soil profile, laboratory and field test data on the boring log, what soil strength parameters would you select for the soil layers for the determination of bearing capacity for a planned 10 foot wide square foundation bearing at a depth of 4 feet below the ground surface? (same general question as Part 1)

Soil Layer	Depth below ground level	Friction Angle, Φ (deg)	Cohesion, c (psf)
Lean Clay	to depth of 9 feet		
Fat Clay	below a depth of 9 feet		
Sandy Lean Clay	below a depth of 23 feet		

c) What is the ultimate bearing capacity of the square footing?
[Use appropriate bearing capacity equations and Terzaghi bearing capacity factors from Das textbook, or from NAVFAC figures]

d) What is the net allowable bearing pressure (round to nearest 100 psf), and corresponding column load that can be placed on the footing using a Factor of Safety of 3.0 against bearing capacity failure?
(use the soil unit weight instead of concrete unit weight for net pressure computation)

e) Using the net allowable bearing pressure determined previously, what is the increase in vertical stress and final vertical stresses at the following depths below the base of the 10 foot wide square footing?
(use Boussinesq charts and include the interpreted factors)

Depth below footing	Depth below ground level	z / B	Boussinesq Influence Factor	Effective Vertical Stress $\Delta\sigma$ (psf)	Final Effective Vertical Stress σ_f (psf)
2½ feet	**6½ feet**				
8 feet	**12 feet**				
15 feet	**19 feet**				
22½ feet	**26½ feet**				

f) Determine the expected settlement due to the net allowable foundation pressure in the following soil layers and intervals: (A dashed line is shown on the soil profile figure for reference in the split of the upper and lower portion of the Fat Clay layer. The initial and final pressures computed in a) and e) would be valid for the middle of these layers)

Soil Layer	Depth below footing	Computations	Soil Layer Settlement (inches)
Lean Clay	0 to 5 feet		
Fat Clay (upper portion)	5 to 11feet		
Fat Clay (lower portion)	11 to 19 feet		
Sandy Lean Clay	19 to 26 feet		

g) What is the total estimated settlement for the foundation under the allowable load determined?

h) **(BONUS 2 points)** What could be done if the estimated settlement exceeds the tolerable settlement for the structure?

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Problem 2: (30 points):

A continuous footing with a width of 6 feet will support vertically oriented wall loads only.

The foundation will bear at a depth of 4 feet below final ground level in the soil profile indicated on the attached Figure 2.

The final groundwater level is 4 feet below ground (as indicated in figure).

Use: γ_t =120 lb/ft^3 for the soil unit weight above the water table, and
γ_t =122.4 lb/ft^3 for the soil unit weight below the water table

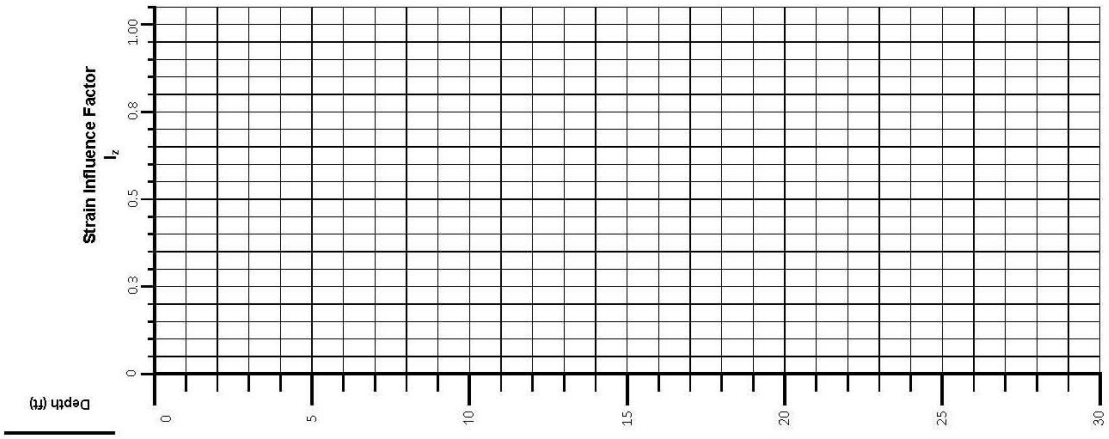
Perform the following computations and determinations:

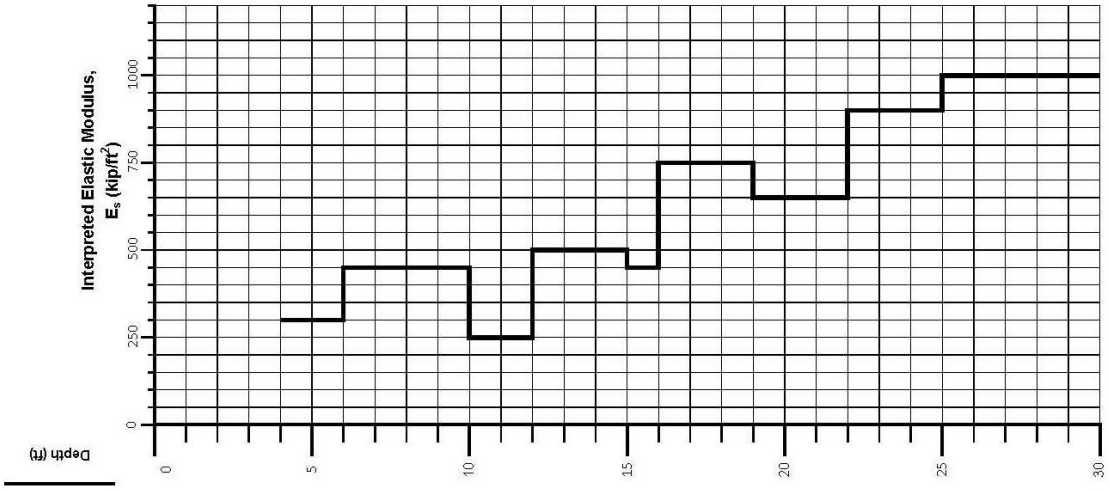
a) What strength parameters would you select for the soil layers from the provided standard penetration test (SPT) - N_{60} data for determination of bearing capacity for the footing bearing at a depth of 4 feet? Indicate the reference used for the interpretation.

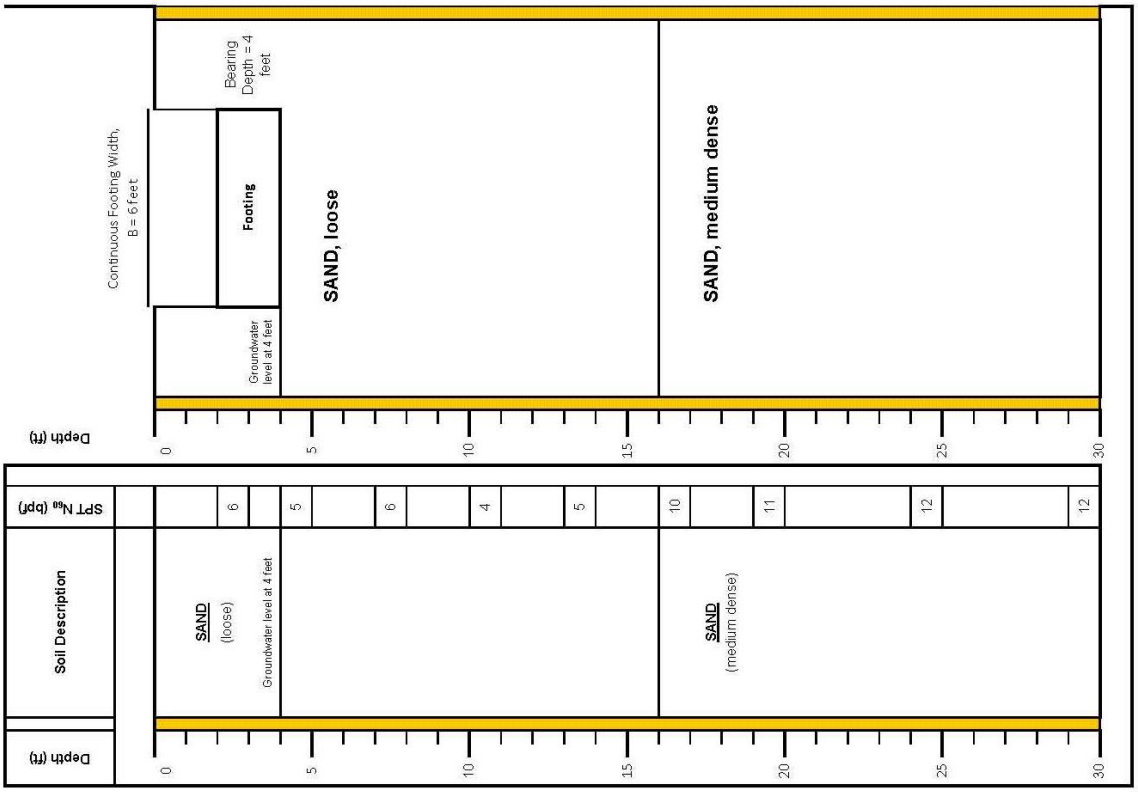
Soil Layer	Depth below ground level	Friction Angle, Φ' (deg)	Cohesion, c' (psf)	Reference
Loose Sand, fine	to depth of 16 feet			
Medium Dense Sand, coarse	16 to 30 feet			

b) Provide the applicable bearing capacity factors for use in the general bearing capacity equation for the referenced footing geometry and soil profile:

	Bearing Capacity Factors		Shape Factors		Depth Factors		Inclination Factors	
Cohesion Component Terms	N_c		F_{cs}		F_{cd}		F_{ci}	
Surcharge Component Terms	N_q		F_{qs}		F_{qd}		F_{qi}	
γ Component Terms	N_γ		$F_{\gamma s}$		$F_{\gamma d}$		$F_{\gamma i}$	


Strain Influence Factor
I_z
0
0.3
0.5
0.8
1.00
Depth (ft)
0
5
10
15
20
25
30


Interpreted Elastic Modulus,
E_s (kip/ft^2)
0
250
500
750
1000
Depth (ft)
0
5
10
15
20
25
30


Continuous Footing Width,
B = 6 feet
Bearing
Depth = 4
feet
Footing
Groundwater
level at 4 feet
SAND, loose
SAND, medium dense
Depth (ft)
0
5
10
15
20
25
30
SPT N_{60} (bpf)
6
5
6
4
5
10
11
12
12
Soil Description
SAND
(loose)
Groundwater level at 4 feet
SAND
(medium dense)
Depth (ft)
0
5
10
15
20
25
30

c) What is the ultimate bearing capacity of the continuous wall footing?

d) What is the net allowable bearing pressure (round to nearest 100 psf) for the wall footing using a Factor of Safety of 3.0 against bearing capacity failure?
(use the soil unit weight instead of concrete unit weight for net pressure computation)

e) Calculate the maximum strain influence factor, $I_{z(m)}$, and plot the strain influence factor with depth for Schmertmann's method.
(display on the graph provided adjacent to the soil profile/foundation diagram).

f) The modulus of elasticity interpreted from in-situ field tests is also shown.

Divide the soil profile data within the zone of strain influence into a practical number of incremental layers for settlement computations.

Provide the corresponding layer information in the table on the following page.
(use as many or as few of the cells/rows in the table as you need)

Include the units being used in your tabulated values

Layer No.	**Depths** (below footing or below ground - optional)	Δz_i	I_{zi}	E_{si}	$\Delta z_i \times I_z/E_s$
				$\Sigma\{\Delta z_i \times I_z/E_s\}$	

g) Compute the following correction factors:

Depth correction factor: C_1

Creep correction factors: C_2 (1 year)
(for a time period
of 1 to 25 years) C_2 (25 years)

h) Compute the estimated foundation settlement from 1 to 25 years.

S_e @ 1 year: S_e@ 20 years:

i) **(BONUS 2 points)** For a tall load bearing masonry gymnasium wall (about 30' high and 180' long), what magnitude of differential settlement is tolerable over a length of 40 feet along the wall without the risk of cracking?