Menoufia University		**Year: 4th Civil**
Faculty of Engineering		**Subject: Foundation Engineering**
Shebin El-Kom		**Code: CVE412**
Department: Civil Eng.		**Time allowed: 3 hours**
Academic Year: 2014-2015	Menoufia University	**Date: 12/1/2015**
First Semester Examination		**Max. Degree: 100**

Attempt all questions. Any missing data may be reasonably assumed.

Marks

Question (1): **[20]**

a) Define the following, and for what cases may be used: (6)
i) Shallow foundation.
ii) Deep foundation.

b) Differentiate between Terzaghi and Hansen bearing capacity equations for calculating bearing capacity of soil. (6)

c) A square footing is required to carry a column load of 56 ton with factor of safety against bearing capacity failure of 3.0. The foundation is to be placed at depth of 1.50 m below the surface of a loose granular soil where the water table will be at foundation level. The angle of friction equals to 28° and the bulk unit weights of the soil above and below the water table are 1.65 and 1.83 t/m^3, respectively. Determine a suitable size of the foundation. (8)

Question (2): **[20]**

a) State using clear sketches the different types of shallow foundations showing when each type may be used. (6)

b) Design a square footing to support a brick column 60×60 cm, carries a load of 80 ton. The allowable soil pressure is 1.5 kg/cm^2. Use plain concrete of thickness 30 cm underneath the R.C footing. ($f_c = 50\ kg/cm^2$, $f_s = 1400\ kg/cm^2$, $k_1 = 0.361$, $k_2 = 1237$) (8)

c) Design a rectangular footing to support square column 40×40 cm carries a load of 120 ton. One side of the footing is limited to maximum length of 2.0 m. The ultimate bearing capacity of soil at foundation level is 5.0 kg/cm^2. The factor of safety equals to 2.5. (6)

Question (3): **[20]**

a) For what cases the following foundations may be used and explain why? (6)
i) Strap beam footing.
ii) Rectangular and trapezoidal combined footing.

b) Two columns 40×40 cm and 30×30 cm carrying loads of 90 and 60 ton respectively. The distance center to center of columns is 4.50 m. Design a combined footing if the footing should not project beyond the outer faces of the columns the allowable soil pressure is 1.20 kg/cm^2. ($f_c = 50\ kg/cm^2$, $f_s = 1800\ kg/cm^2$, $k_1 = 0.331$, $k_2 = 1241$) (7)

c) Design a combined footing for two columns: (7)
- A clear distance center to center = 3.50 m.
- Column (1): 40×40 cm carrying load = 80 ton.
- Column (2): 30×60 cm carrying load = 120 ton.
- The allowable pressure on soil = 2.0 kg/cm^2.

Question (4): **[20]**

a) Explain the main types of raft foundation and the methods of design of each type. (6)

Table 4-4 Bearing-capacity factors for the Meyerhof and Hansen bearing-capacity equations

Note that N_c and N_q are sa[illegible] [illegible]r both equations

ϕ, deg	N_c	N_q	$N_{\gamma(H)}$	N_q/N_c	$2 \tan \phi(1 - \sin \phi)^2$	$N_{\gamma(M)}$*
0	5.14	1.0	0	0.19	0	0
5	6.5	1.6	0.1	0.24	0.15	0.1
10	8.3	2.5	0.4	0.30	0.24	0.4
15	11.0	3.9	1.2	0.36	0.29	1.1
20	14.8	6.4	2.9	0.43	0.32	2.9
25	20.7	10.7	6.8	0.51	0.31	6.8
30	30.1	18.4	15.1	0.61	0.29	15.7
35	46.1	33.3	33.9	0.72	0.25	37.1
40	75.3	64.2	79.5	0.85	0.21	93.7
45	133.9	134.9	200.8	1.01	0.17	262.7
50	266.9	319.0	568.5	1.20	0.13	873.7

* $N_{\gamma(M)}$ = Meyerhof value.

Table 4-2 Bearing-capacity factors for the Terzaghi equations

Values of N_γ for ϕ of 34 and 48° are original Terzaghi values and used to back-compute $K_{p\gamma}$ for forward computations of N_γ by author

ϕ, deg	N_c	N_q	N_γ	$K_{p\gamma}$
0	5.7	1.0	0.0	10.8
5	7.3	1.6	0.5	12.2
10	9.6	2.7	1.2	14.7
15	12.9	4.4	2.5	18.6
20	17.7	7.4	5.0	25.0
25	25.1	12.7	9.7	35.0
30	37.2	22.5	19.7	52.0
34	52.6	36.5	36.0	
35	57.8	41.4	42.4	82.0
40	95.7	81.3	100.4	141.0
45	172.3	173.3	297.5	298.0
48	258.3	287.9	780.1	
50	347.5	415.1	1153.2	800.0

Table 4-5 Shape, depth, inclination, and other factors for use in the Hansen bearing capacity equation in Table 4-1

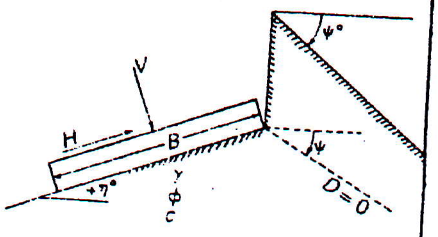
Table combined from Hansen (1970), De Beer (1970), and Vesic (1973). Primed factors for undrained (U) conditions and $\phi = 0$

Shape factors	Depth factors	Inclination factors	Ground factors (see figure)
$s'_c = 0.2B/L$ $s_c = 1 + N_q B/N_c L$	$d'_c = 0.4D/B$ $\quad D \le B$ $d'_c = 0.4 \tan^{-1} \frac{D}{B}$ $\quad D > B$	$i'_c = 0.5 - 0.5\sqrt{1 - H/A_f c_a}$ $i_c = i_q - (1 - i_q)/(N_q - 1)$	$g'_c = \psi°/147°$ for horizontal ground use $g'_c = 0.0$ $g_c = 1 - \psi°/147°$ $g_q = g_\gamma = (1 - 0.5 \tan \psi°)^5$
	$d_c = 1 + 0.4 \frac{D}{B}$ $\quad D \le B$ $d_c = 1 + 0.4 \tan^{-1} \frac{D}{B}$ $\quad D > B$		
$s_q = 1 + (B/L) \tan \phi$	$d_q = 1 + 2 \tan \phi(1 - \sin \phi)^2 \frac{D}{B}$ $\quad D \le B$ $d_q = 1 + 2 \tan \phi(1 - \sin \phi)^2 \tan^{-1} \frac{D}{B}$ $\quad D > B$	$i_q = \left(1 - \frac{0.5H}{V + A_f c_a \cot \phi}\right)^5$	Base factors (see figure) $b'_c = \eta°/147°$ for horizontal ground use $b'_c = 0.0$ $b_c = 1 - \eta°/147°$
$s_\gamma = 1 - 0.4B/L$	$d_\gamma = 1.00$ for all ϕ	Horizontal ground: $i_\gamma = \left(1 - \frac{0.7H}{V + A_f c_a \cot \phi}\right)^5$ Sloping ground: $i_\gamma = \left(1 - \frac{(0.7 - \eta°/450°)H}{V + A_f c_a \cot \phi}\right)^5$	$b_q = b_\gamma = \exp(-2\eta \tan \phi)$ η = radians for b_q

Table 4-5 cont'd

where A_f = effective footing contact area $B'L'$
L' = effective footing length = $L - 2e_L$
B' = effective footing width = $B - 2e_B$
D = depth of footing in ground
e_B, e_L = eccentricity of load with respect to center of footing area
c = cohesion of base soil
ϕ = angle of internal friction of soil
H, V = load components parallel and perpendicular to footing, respectively
$\tan \delta$ = coefficient of friction between footing and base soil {use $\delta = \phi$ for concrete poured on ground [Schultze and Horn (1967)]}
η, ψ = as shown in accompanying figure with positive directions shown

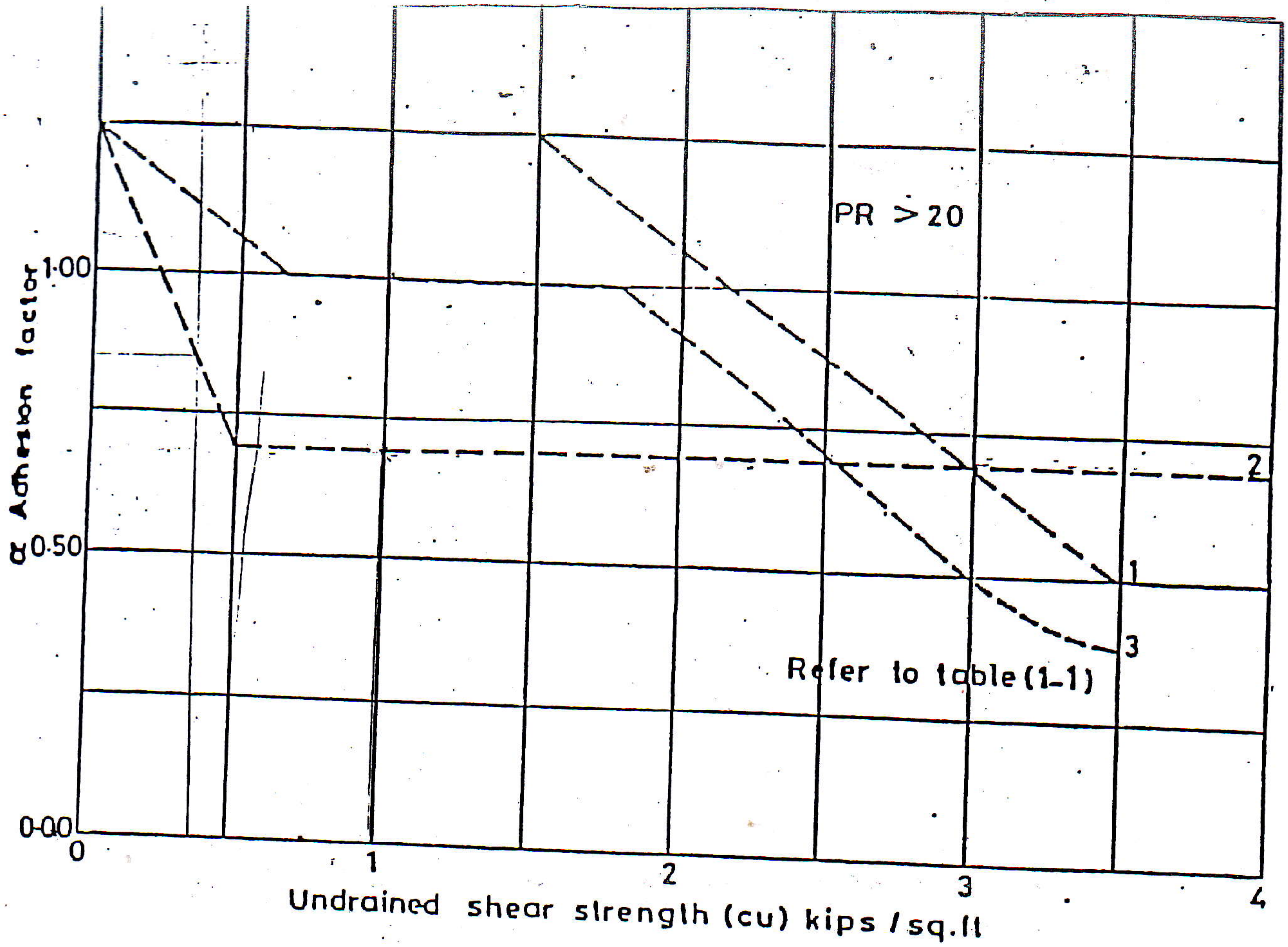
Notes: Do not use shape factors in combination with inclination factors. Use d_i and i_i only in combination or s_i with d_i, g_i and b_i. When triaxial ϕ is used for plane-strain conditions, one may adjust to obtain: $\phi_{ps} = 1.1\phi_{tr}$ (author's suggestion only for $\phi_{triaxial} > 30°$).



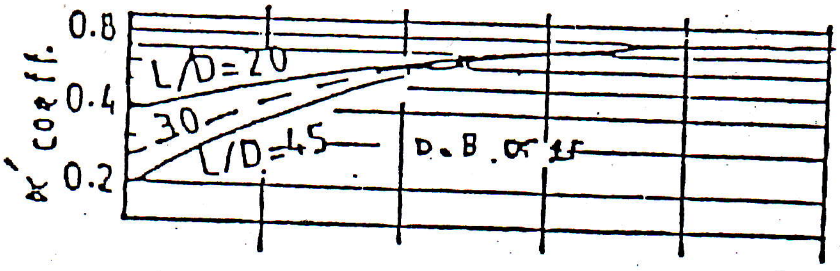
Limitations: $H \le V \tan \delta + c_a A_f$

$i_q, i_\gamma > 0$

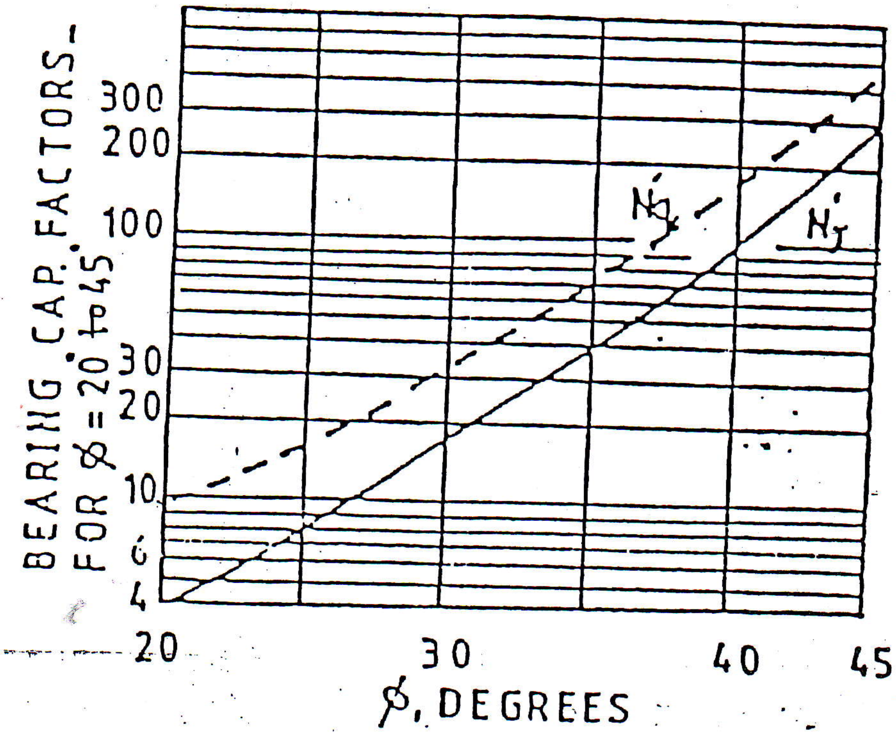
$\psi \le \phi$



PR > 20
1.00
0.50
0.00
α Adhesion factor
1
2
3
Refer to table (1-1)
0
1
2
3
4
Undrained shear strength (cu) kips / sq.ft



0.8
0.4
0.2
α' coeff.
L/D=20
30
L/D=45
D.B.or 1f



BEARING CAP. FACTORS
FOR φ = 20° to 45°
300
200
100
30
20
10
6
4
20
30
40
45
φ, DEGREES

b) Fig. (1) shows a plan of a framed structure and it is required to design a flat slab raft foundation for this building giving that: (8)
- Bearing capacity of soil = 4.0 t/m^2.
- all columns 45×45 cm.

c) Redesign the above raft foundation as slab with beams (explain the system of beams and draw B.M and S.F diagrams for one beam in both directions only). (6)

Question (5): **[20]**

a) Classify the different types of piles and for what cases a negative skin friction should be considered on surface of pile and why? (5)

b) Show how you would evaluate the following: (5)
   i) The efficiency of pile group.
   ii) Pile load test according to Egyptian code.

c) A column load is 400 ton and the soil profile shown in Fig. (2). The bottom of the pile cap would be at depth 1.50 m below ground surface, the diameter of the pile is 60 cm. It is required to: (10)
- Calculate the allowable bearing capacity of this pile (factor of safety equals to 3.0)
- Find the number and arrangement of concrete piles.
- Design the pile cap.

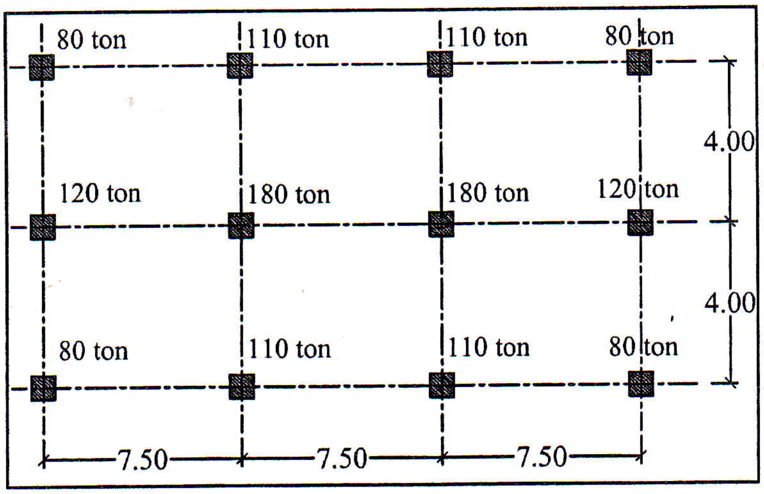


Fig (1)

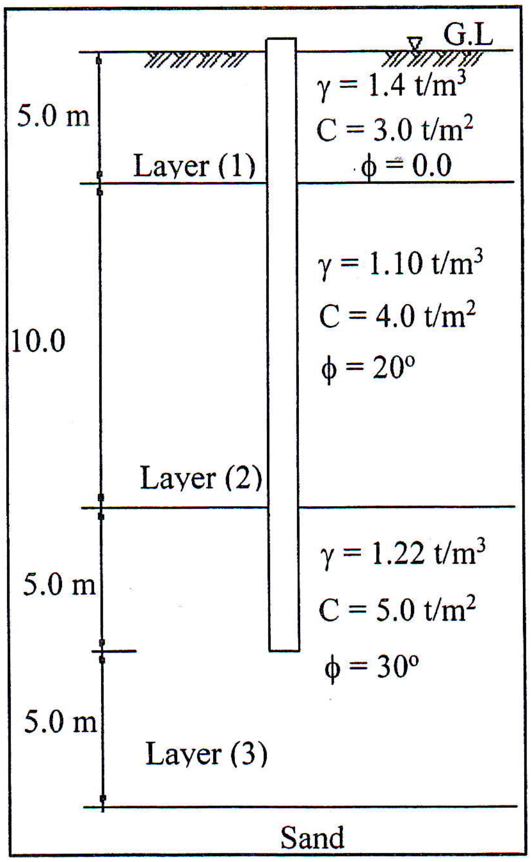


Fig (2)

With my best wishes,

Dr.Mohammed Abou Rayia