THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (CIVIL) – LEVEL 05
Final Examination 2005/2006

036

CEU3302 – GEOTECHNICS AND STRUCTURAL MECHANICS

Time allowed: Three Hours

Date: Wednesday, 5th April, 2006 Time: 0930-1230

Answer five questions. Select at least TWO questions from Part A and Part B.
All questions carry equal marks.

PART A: GEOTECHNICS

You may attach the last sheet to your script.
Answer five questions. All questions carry equal marks.

1. The stress path parameters p and q are defined as: $p = \frac{\sigma_1 + \sigma_2}{2}$, $q = \frac{\sigma_1 - \sigma_2}{2}$.

   a) Sketch the stress paths with respect to total and effective stresses, for the tests:
      i) Unconfined Compression Test (2 points)
      ii) Unconsolidated Undrained Triaxial Loading Test. (3 points)
      iii) Consolidated Undrained Triaxial Loading Test. (3 points)
      The three sketches corresponding to the three tests should be plotted separately.
   b) On each sketch show Mohr-Coulomb failure envelope. (4 points)
   c) State the type of shear strength parameters one could determine using the said three tests (4 points)
   d) Explain their usefulness in ascertaining short-term and long-term stability of a soil stratum. (4 points)

2. The settlement under a footing constitutes immediate settlement, consolidation settlement and secondary settlement.

   a) Explain how immediate settlement is computed and the relevant parameters are determined. (4 points)
   b) Figures Q2(a) and (b) shows two types of plots used to determine the total consolidation settlement. **Use sheet provided at the end of this section.**

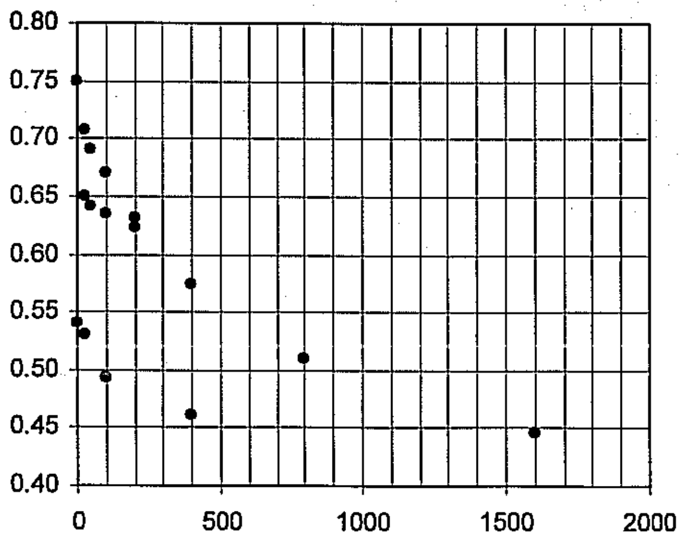


Figure Q2(a) e vs. σ'_v

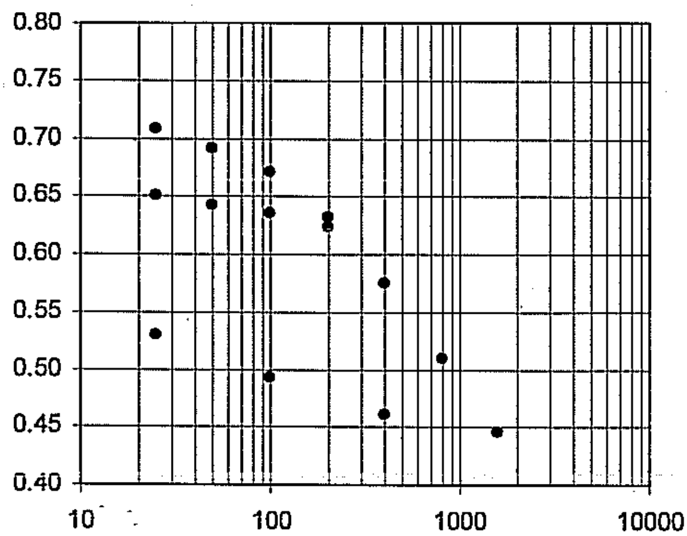


Figure Q2(b) e vs. $\log_{10} \sigma'_v$

i) Explain how the total consolidation settlement is computed using both methods. (6 points)

ii) Generate the in-situ e vs. $\log_{10} \sigma'_v$ curve using Figure Q2(b). The effective overburden stress is 60kPa. (10 points)

3. The Standard Penetration Test is widely used during Geotechnical Investigations.
   a) Define SPT – N. (3 points)
   b) Discuss the use of soil samples collected in the SPT split barrel. (6 points)
   c) Explain why SPT – N is corrected for overburden. (5 points)
   d) Describe three instances where SPT – N is used to assess strength or stability. (6 points)

4. Figure Q4 shows the details of a cantilever retaining wall. The shear strength parameters for the soil are $c' = 0$ and $\phi' = 35^0$. The saturated unit weight of soil is 18.5kN/m^3. The unit weight above the water table is 17.5kN/m^3. The unit weight of concrete is taken to be 23.6kN/m^3. If $\delta = 25^0$ on the base of the wall.
   a) Determine the factor of safety against sliding. (4 points)
   b) Determine the factor of safety against bearing capacity failure. (8 points)
   c) Determine the factor of safety against overturning. (4 points)
   d) Discuss the advantages and limitations of a cantilever retaining wall over a gravity retaining wall or a gabion retaining wall. (4 points)

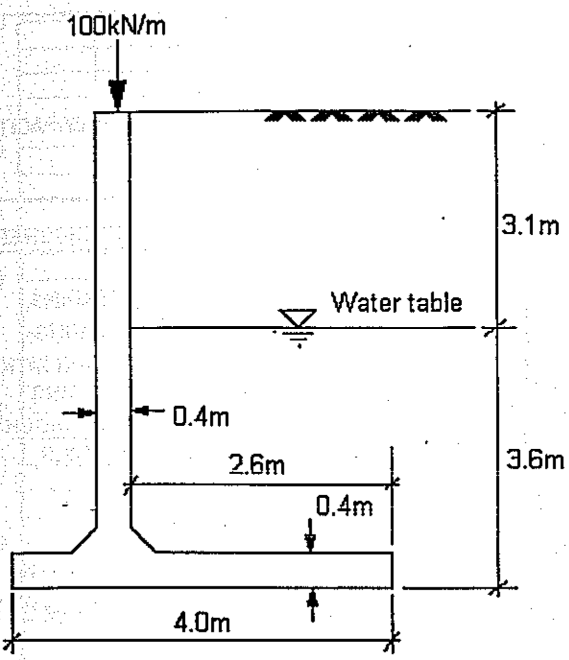


Figure Q4

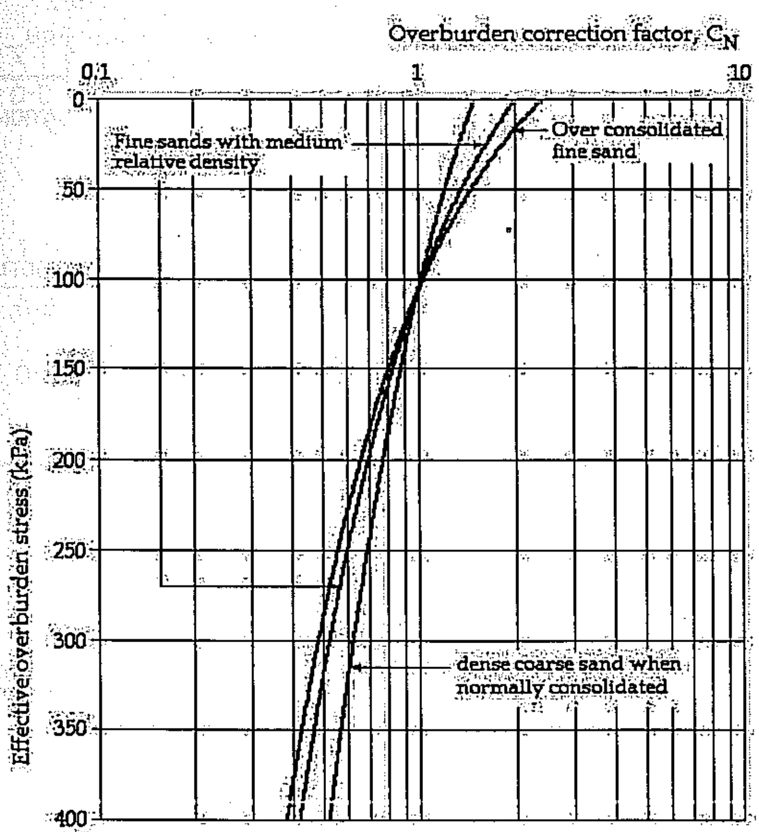
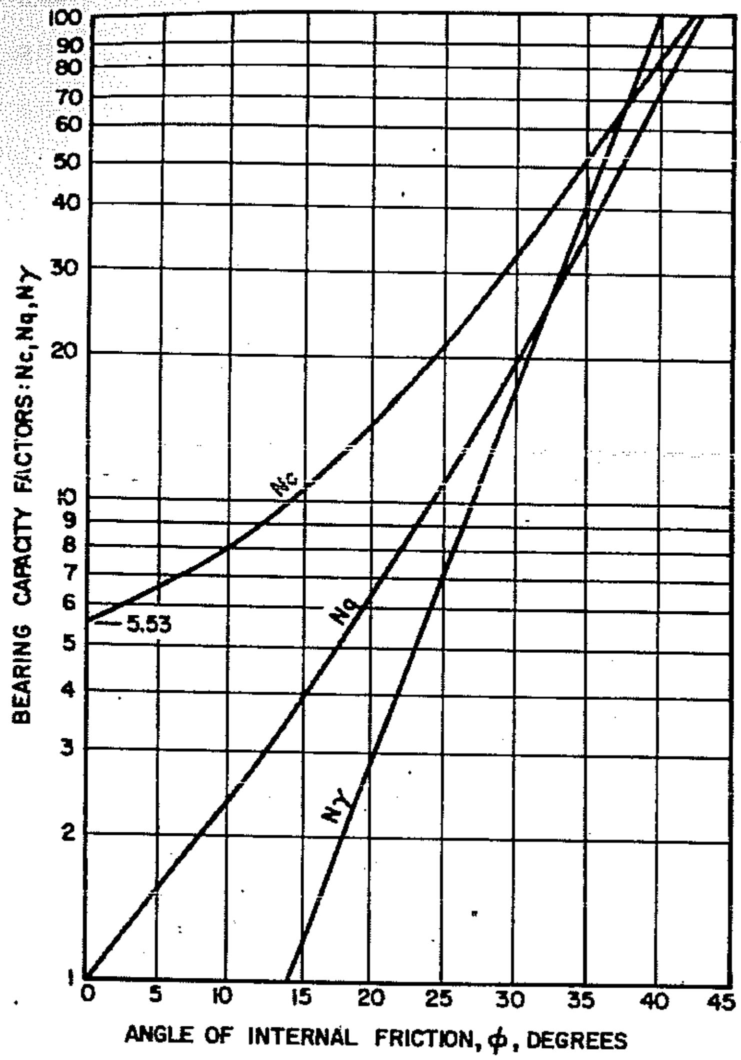
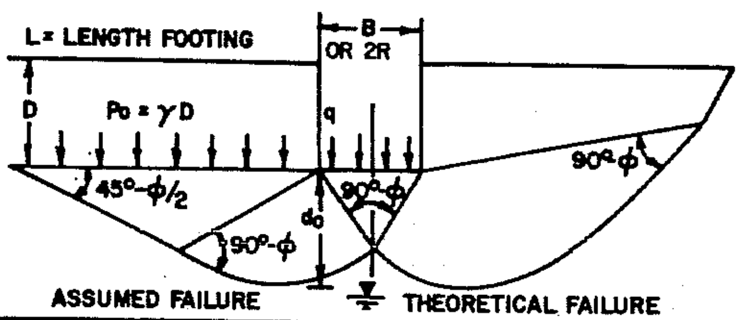


Figure Q3



ULTIMATE BEARING CAPACITY = q_{ult}



CONTINUOUS FOOTING; GENERAL CASE

$q_{ult} = q' + q''$

q' = PORTION OF BEARING CAPACITY ASSUMING WEIGHTLESS FOUNDATION SOIL

q'' = PORTION OF BEARING CAPACITY FROM WEIGHT OF FOUNDATION SOILS

$q' = cN_c + \gamma D N_q$

$q'' = \gamma \frac{B}{2} N_\gamma$

$q_{ult} = cN_c + \gamma D N_q + \frac{\gamma B}{2} N_\gamma$

SQUARE OR RECTANGULAR FOOTING

$q_{ult} = cN_c\,(1 + .3\frac{B}{L}) + \gamma D N_q + 0.4\gamma B N_\gamma$

CIRCULAR FOOTING: $R = B/2$

$q_{ult} = 1.3\,cN_c + \gamma D N_q + 0.6\gamma R N_\gamma$

FOR COHESIONLESS FOUNDATION SOILS ($c = 0$)

CONTINUOUS FOOTING:

$q_{ult} = \gamma D N_q + \frac{\gamma B}{2} N_\gamma$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = \gamma D N_q + 0.4\gamma B N_\gamma$

CIRCULAR FOOTING:

$q_{ult} = \gamma D N_q + 0.6\gamma R N_\gamma$

FOR COHESIVE FOUNDATION SOILS ($\phi = 0$)

CONTINUOUS FOOTING:

$q_{ult} = cN_c + \gamma D$

SQUARE OR RECTANGULAR FOOTING:

$q_{ult} = cN_c(1 + .3\frac{B}{L}) + \gamma D$

CIRCULAR FOOTING:

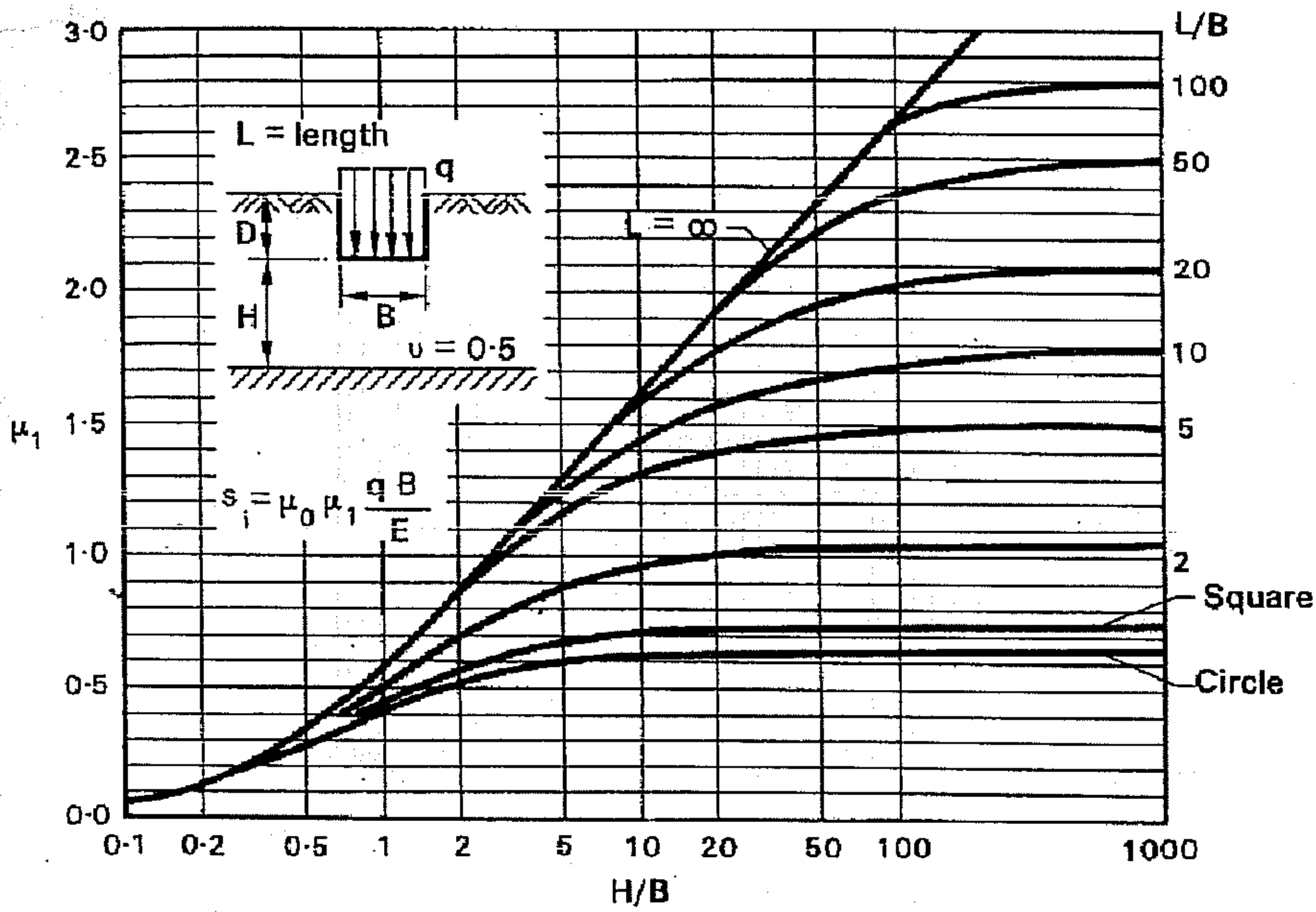
$q_{ult} = 1.3\,cN_c + \gamma D$

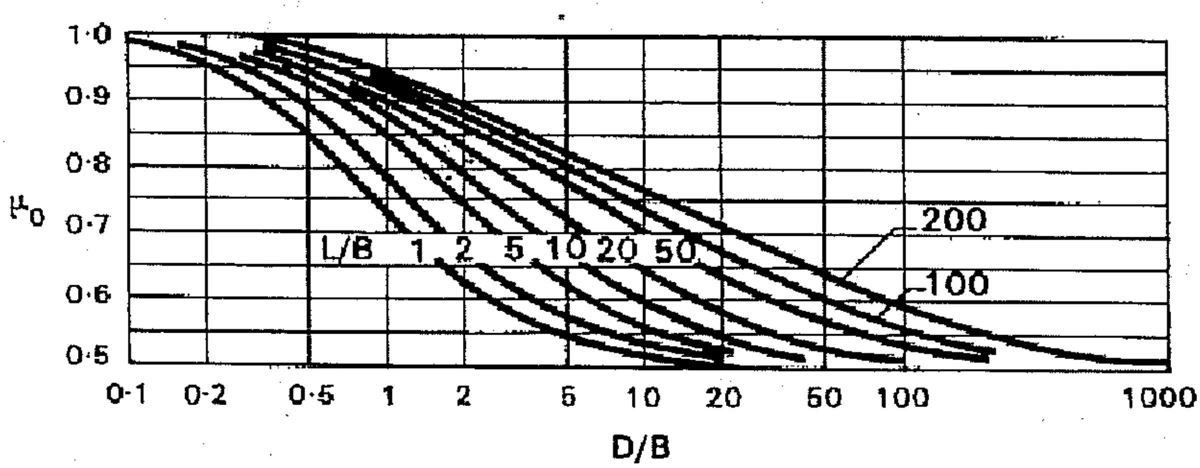
ASSUMED CONDITIONS:

1. $D \leq B$
2. SOIL IS UNIFORM TO DEPTH $d_o > B$.
3. WATER LEVEL LOWER THAN d_o BELOW BASE OF FOOTING.
4. VERTICAL LOAD CONCENTRIC.
5. FRACTION AND ADHESION ON VERTICAL SIDES OF FOOTING ARE NEGLECTED.
6. FOUNDATION SOIL WITH PROPERTIES c, ϕ, γ

FIGURE 1

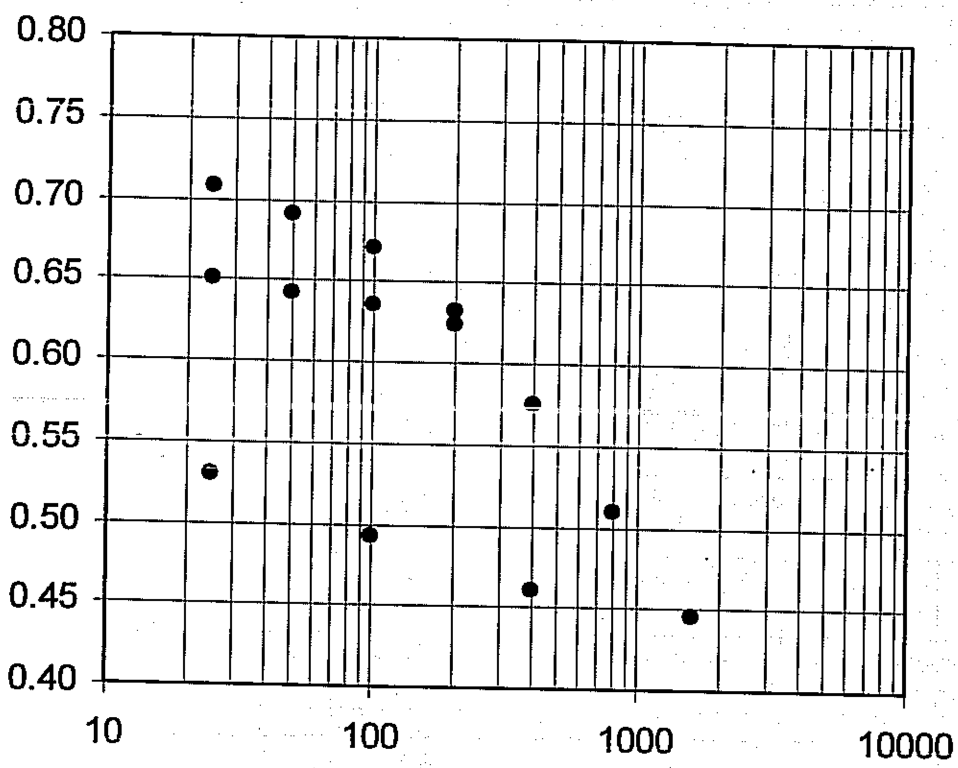
Ultimate Bearing Capacity of Shallow Footings With Concentric Loads


L = length
q
D
H
B
υ = 0·5
$s_i = \mu_0 \mu_1 \frac{qB}{E}$
L = ∞
L/B
100
50
20
10
5
2
Square
Circle
μ_1
3·0
2·5
2·0
1·5
1·0
0·5
0·0
0·1 0·2 0·5 1 2 5 10 20 50 100 1000
H/B


μ_0
1·0
0·9
0·8
0·7
0·6
0·5
L/B 1 2 5 10 20 50
200
100
0·1 0·2 0·5 1 2 5 10 20 50 100 1000
D/B

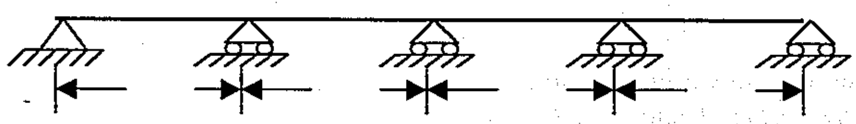
✂ ___________ Attach this sheet to your answer script

Index No. ___________



PART B: Structural Mechanics

5. Analyse the continuous beam shown below, using flexibility method, for
   (a) a uniformly distributed load of intensity q on all spans
   (b) a unit downward movement of support B
   and draw the bending moment diagram.
   The beam has a constant flexural rigidity EI.
   (You may use Table-1 to determine flexibility coefficients)



6. The components of stress at a point in a body are $\sigma_x = 0$; $\sigma_y = 300$; $\sigma_z = 100$; $\tau_{xy} = \tau_{xz} = 0$; $\tau_{yz} = 100\sqrt{3}$ N/m^2.

   Determine ;
   1. the stress invariants
   2. the principal stresses
   3. the direction cosines of the principal planes

7. A conical tank with semi-cone angle α and height **h** is filled with a liquid of specific weight γ. Show that the stress resultants are given by

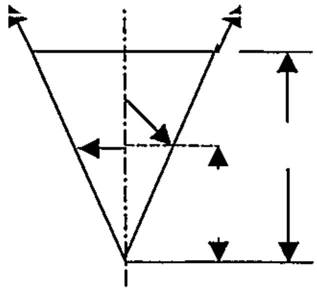
$$N_\theta = \frac{\gamma(h-y)yTan\alpha}{Cos\alpha}$$

$$N_\phi = \frac{\gamma y(h-\frac{2}{3}y)yTan\alpha}{2Cos\alpha}$$

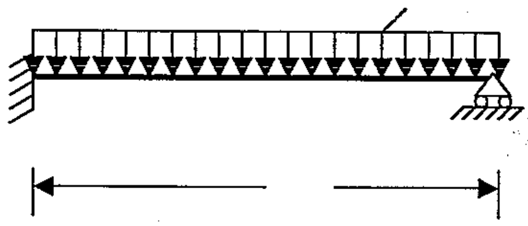
Also show that the maximum N_θ is when **y = d/2** and maximum N_Φ is at **y = 3d/4.**
Determine N_θ^{max} and N_Φ^{max}.

Membrane solution for shells of revolution is given by;

$$\frac{N_\theta}{R_2} + \frac{N_\varphi}{R_1} = -p_r$$



8. (a) Determine the collapse load for the fixed beam shown in the figure below, if the Plastic Moment Capacity of the beam is M_P.



(b) Determine the ultimate load for the propped cantilever shown in the figure below, if the Plastic Moment Capacity of the beam is M_P.

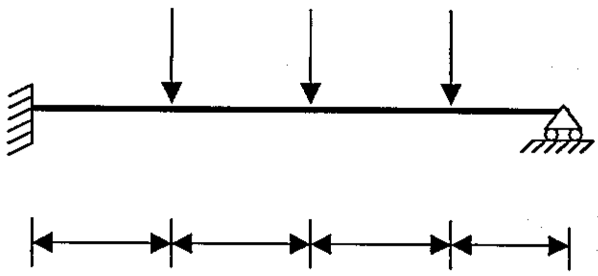
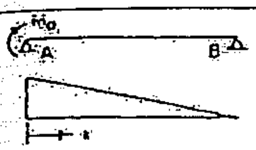
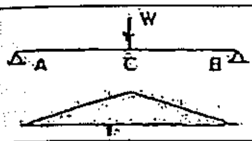
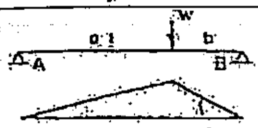
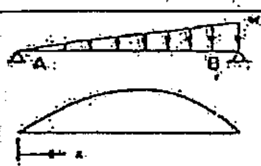
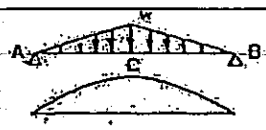
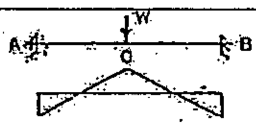
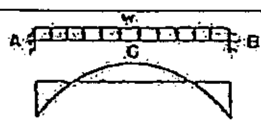
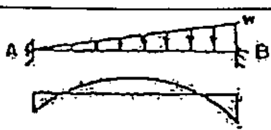
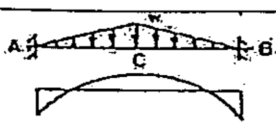


Table 1 Formulas for Beams

Structure	Shear	Moment	Slope	Deflection
Simply supported Beam				
	$S_A = -\frac{M_o}{L}$	M_o	$\theta_A = \frac{M_o L}{3EI}$ $\theta_B = -\frac{M_o L}{6EI}$	$Y_{max} = 0.062\frac{M_o L^2}{EI}$ $at\ x = 0.422L$
	$S_A = \frac{W}{2}$	$M_o = \frac{WL}{4}$	$\theta_A = -\theta_B = \frac{WL^2}{16EI}$	$Y_c = \frac{WL^3}{48EI}$
	$S_A = \frac{Wb}{L}$ $S_B = \frac{Wa}{L}$	$M_o = \frac{Wab}{L}$	$\theta_A = \frac{Wab}{6EIL}(L+b)$ $\theta_B = -\frac{Wab}{6EIL}(L+a)$	$Y_o = \frac{Wa^2b^2}{3EIL}$
	$S_A = \frac{WL}{2}$	$M_c = \frac{WL^2}{8}$	$\theta_A = -\theta_B = \frac{W\ L^3}{24EI}$	$Y_c = \frac{5WL^4}{384EI}$
	$S_A = \frac{WL}{6}$ $S_B = \frac{WL}{3}$	$M_{max} = 0.064Wl^2$ $at\ x = 0.577L$	$\theta_A = \frac{7WL^3}{360EI}$ $\theta_B = -\frac{8WL^3}{360EI}$	$Y_{max} = 0.00652\frac{WL^4}{EI}$ $at\ x = 0.519L$
	$S_A = \frac{WL}{4}$	$M_c = \frac{WL^2}{12}$	$\theta_A = -\theta_B = \frac{5W\ L^3}{192EI}$	$Y_c = \frac{WL^4}{120EI}$
Fixed Beams				
	$S_A = \frac{W}{2}$	$M_c = \frac{WL}{8}$	$\theta_A = \theta_B = 0$	$Y_c = \frac{WL^3}{192EI}$
	$S_A = \frac{Wb^2}{L^3}(3a+b)$ $S_B = \frac{Wa^2}{L^3}(3b+a)$	$M_A = -\frac{Wab^2}{L^2}$ $M_B = -\frac{Wba^2}{L^2}$	$\theta_A = \theta_B = 0$	$Y_o = \frac{Wa^3b^3}{3EIL^3}$
	$S_A = \frac{WL}{2}$	$M_A = M_B = -\frac{WL^2}{12}$	$\theta_A = \theta_B = 0$	$Y_c = \frac{WL^4}{384EI}$
	$S_A = \frac{3WL}{20}$ $S_B = -\frac{7WL}{20}$	$M_A = -\frac{WL^2}{30}$ $M_B = -\frac{WL^2}{20}$	$\theta_A = \theta_B = 0$	$Y_{max} = 0.00131\frac{WL^4}{EI}$ $at\ x = 0.525L$
	$S_A = \frac{WL}{4}$	$M_A = M_B = -\frac{5WL^2}{96}$	$\theta_A = \theta_B = 0$	$Y_c = \frac{0.7WL^4}{384EI}$

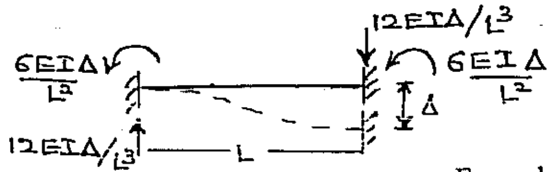
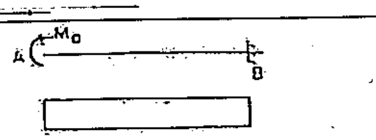
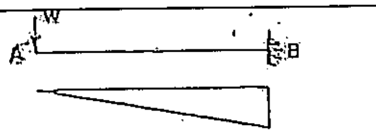
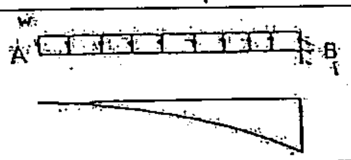
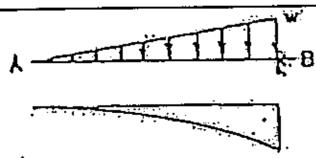
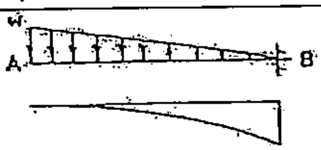
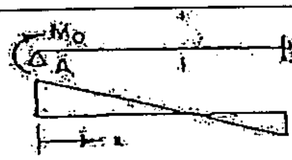
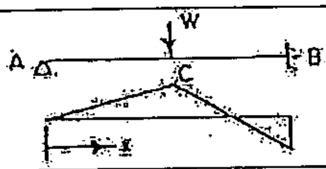
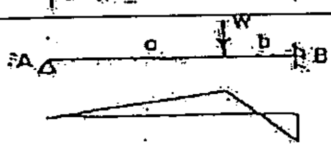
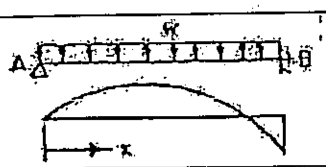
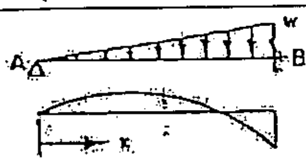
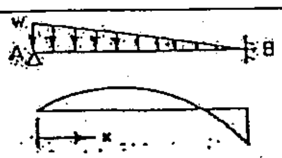


Table 1

Formulas for Beams

Structure	Shear	Moment	Slope	Deflection
		Cantilever Beam		
	0	M_o	$\theta_A = \frac{M_o L}{EI}$	$Y_A = \frac{M_o L^2}{2EI}$
	W	$M_B = -WL$	$\theta_A = -\frac{WL^2}{2EI}$	$Y_A = \frac{WL^3}{3EI}$
	$S_B = -WL$	$M_B = -\frac{WL^2}{2}$	$\theta_A = -\frac{WL^3}{6EI}$	$Y_A = \frac{WL^4}{8EI}$
	$S_B = -\frac{WL}{2}$	$M_B = -\frac{WL^2}{6}$	$\theta_A = -\frac{WL^3}{24EI}$	$Y_A = \frac{WL^4}{8EI}$
	$S_B = -\frac{WL}{2}$	$M_B = -\frac{WL^2}{2}$	$\theta_A = -\frac{WL^3}{8EI}$	$Y_A = \frac{11WL}{120E}$
		Propped Cantilever		
	$S_A = -\frac{3M_o}{2L}$	$M_B = -\frac{M_o}{2}$	$\theta_A = -\frac{M_o L}{4EI}$	$Y_{max} = \frac{M_o L}{27E}$ at $x =$
	$S_A = -\frac{3M_o}{2L}$	$M_B = -\frac{3WL}{16}$ $M_c = \frac{5WL}{32}$	$\theta_A = \frac{WL^2}{32EI}$	$Y_{max} = 0.00962$ at $x = 0.4$
	$S_A = \frac{Wb^2}{2L^3}(a+2L)$ $S_B = -\frac{Wa}{2L^3}(3L^2 - a^2)$	$M_B = -\frac{Wab}{L^2}(a+\frac{b}{2})$	$\theta_A = \frac{Wab^2}{4EIL}$	$Yo = \frac{Wa^2b^2}{12EIL^3}$
	$S_A = +\frac{3WL}{8}$	$M_B = -\frac{WL^2}{8}$	$\theta_A = \frac{WL^3}{48EI}$	$Y_{max} = 0.0054$ at $x =$
	$S_A = +\frac{WL}{10}$	$M_{max} = 0.03WL^2$ at $x = 0.447L$ $M_B = -\frac{WL^2}{15}$	$\theta_A = \frac{WL^3}{120EI}$	$Y_{max} = 0.00239$ at $x =$
	$S_A = +\frac{11WL}{40}$	$M_{max} = 0.0423WL^2$ at $x = 0.329L$ $M_B = -\frac{7WL^2}{120}$	$\theta_A = \frac{WL^3}{80EI}$	$Y_{max} = 0.00305$ at $x =$