higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

29 NOVEMBER 2019 (X-Paper)
09:00–12:00

REQUIREMENTS: **Hot-rolled structural steel sections BOE 8/2**

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and a formula sheet of 3 pages.

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TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Questions can be answered in any order, but sub-sections must be kept together.
5. All calculations must have at least THREE steps (formula, substitution and answer with SI-unit).
6. Draw a line after each completed subsection.
7. Start each question on a NEW page.
8. Use $g = 9{,}81\ m/s^2$
9. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

Two hollow cylinders were shrunk together to form a compound cylinder with an inner diameter of 100 mm and an outer diameter of 400 mm. This caused an intermediate pressure at the common diameter of 200 mm. After the cylinders were shrunk together, an internal pressure of 30 MPa was applied to the compound cylinder causing the resultant hoop stress at the inner diameter to reach 46 MPa (compressive).

Calculate the following:

1.1 The resultant stresses in the inner cylinder at 200 mm (6)

1.2 The resultant stresses in the outer cylinder at 200 mm and 400 mm (6)

1.3 Sketch a stress distribution diagram to indicate the magnitude and nature of the resultant stresses through the compound cylinder walls (4)

[16]

QUESTION 2: BENDING AND DEFLECTION

A steel pipe, having an inside diameter equal to half the outside diameter, is used as a cantilever with a length of 2,5 m. It carries a uniformly distributed load of 20 kN/m over the first 1,25 m from the fixed end as well as a concentrated load of 2 kN at the free end. The deflection at the free end is limited to 7 mm.
The modulus of elasticity for the material is 200 GPa

Calculate the following:

2.1 The required dimensions of the pipe (8)

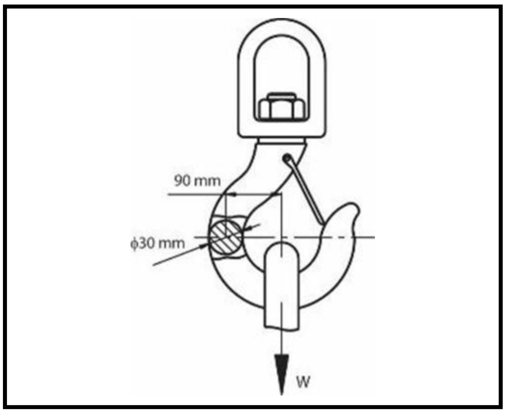
2.2 Choose the lightest taper flange I-profile that can replace the pipe for the same deflection limit (1)

2.3 The maximum bending stress if the selected I-profile is used (3)

[12]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A crane hook has a circular cross-section 30 mm in diameter as shown below. The distance that the load is applied from the centroid is 90 mm. The tensile stress in the material of the crane hook may not exceed 90 MPa.



Calculate the following:

3.1 The maximum mass that may be lifted (7)

3.2 The minimum stress in the hook in magnitude and nature (4)
[11]

QUESTION 4: RETAINING WALLS

A retaining wall with a rectangular cross-section retains water against its vertical face for its full height. The base is 2,1 m wide. The density of the wall material is 2 500 kg/m^3. Consider 1 m length of the wall.

Calculate the following:

4.1 The height of the wall if the vertical ground reaction is 0,6 m from the toe (6)

4.2 The factor of safety for overturning (3)

4.3 The maximum and minimum ground pressure beneath the base (state natures) (4)
[13]

QUESTION 5: FOUNDATIONS

A short column made from a H-section 305 × 305 × 137 kg/m is 4 m long and supports an axial concentric load. The load causes a compressive stress of 9 MPa on top of the column. The foundation is 1,2 m × 1,2 m square and has a weight of 25 kN. The ground has a density of 1 600 kg/m^3 and an angle of repose of 30^o.

Calculate the following:

5.1 The ultimate ground bearing pressure required for a safety factor of 3 (6)

5.2 The thickness of the foundation (2)

5.3 The depth of the foundation from the ground level (2)
[10]

QUESTION 6: REINFORCED CONCRETE

A steel reinforced concrete beam has a T-profile. The flange has a thickness of 100 mm and the web is 270 mm wide. The effective depth of the 6 400 mm^2 steel reinforcement is 380 mm from the top. The allowable stresses are 140 MPa for steel and 8 MPa for concrete. Assume the modular ratio to be 15. The maximum moment of resistance of the beam is 300 kNm and both materials must reach their stress limits at the same time.

Calculate the following:

6.1 The position of the neutral axis from the top of the beam (2)

6.2 The actual bending moments carried by the steel and concrete (3)

6.3 The stress in the concrete at the bottom of the flange (2)

6.4 The minimum width required for the flange (5)
[12]

QUESTION 7: TENSION IN CABLES

The supports of a suspension bridge are 36 m apart and on the same level. The sag of the cables is 3 m. The roadway has a total weight of 3 024 kN.

Calculate the following:

7.1 The weight per metre carried by each of the two main cables (1)

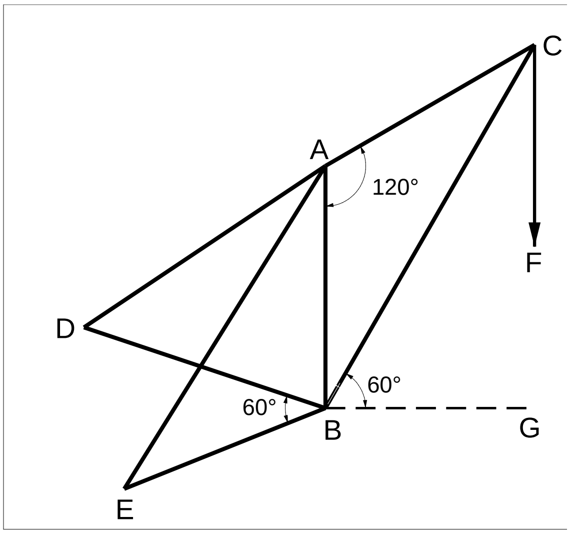
7.2 The minimum and maximum tension in each cable (3)

7.3 The diameter required for the cable if the ultimate tensile stress for the material is limited to 320 MPa. Use a safety factor of 8. (3)

7.4 The tension in the cable 10 m from the support measured horizontally (3)
[10]

QUESTION 8: STRUCTURAL FRAMEWORKS

A Derrick crane is shown in the FIGURE below . The support AB and the struts EB and DB have a length of 4 m each. Point B is supported on horizontal rollers. The crane arm BC forms an angle of 60° with the horizontal line BG as shown.



FIGURE

Refer to FIGURE 1 and do the following:

8.1 Draw a top and front view of the crane in order to show all the true lengths of all the members if the horizontal angle EBG is 150° (4)

Use a scale of 1 cm = 1 m for the space diagram

8.2 Draw vector diagrams of all the forces if the force 'F' is 50 kN (6)

Use a scale of 1 cm = 10 kN for the vector diagrams.

8.2 Tabulate the magnitude and nature of each member and the reaction at B. (6)
[16]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

FORMULAE SHEET

Any applicable equation or formula may be used.

$$\sigma_R = a + \frac{b}{x^2}$$

$$\sigma_H = a - \frac{b}{x^2}$$

$$p_i \frac{\pi}{4} d^2 = \sigma_L \frac{\pi}{4} (D^2 - d^2)$$

$$F_\mu = \mu\, p_c\, \pi\, D_c\, L$$

$$\in = \frac{\sigma_H - \nu\, \sigma_R}{E}$$

$$\delta d = \frac{d}{E}[\sigma_H - \nu\, \sigma_R]$$

$$\Delta d = D_c \left[\left(\frac{\sigma_{H1} - \nu_1 \sigma_{RC}}{E_1}\right) - \left(\frac{\sigma_{H2} - \nu_2 \sigma_{RC}}{E_2}\right)\right]$$

$$\Delta d = \frac{D_c}{E}[\sigma_{H1} - \sigma_{H2}]$$

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$$M = \frac{W\, a\, b}{L}$$

$$\theta = \frac{W\, L^2}{2\, E\, I} \qquad \Delta = \frac{W\, L^3}{3\, E\, I} \qquad M = W\, L$$

$$\theta = \frac{w\, L^3}{6\, E\, I} \qquad \Delta = \frac{w\, L^4}{8\, E\, I} \qquad M = \frac{w\, L^2}{2}$$

$$\theta = \frac{W\, L^2}{16\, E\, I} \qquad \Delta = \frac{W\, L^3}{48\, E\, I} \qquad M = \frac{W\, L}{4}$$

$$\theta = \frac{w\, L^3}{24\, E\, I} \qquad \Delta = \frac{5\, w\, L^4}{384\, E\, I} \qquad M = \frac{w\, L^2}{8}$$

****

$$F_w = \frac{1}{2} \rho \, g \, H^2 \qquad F_g = \frac{1}{2} C_\mu \; \rho \, g \, H^2 \qquad F_p = C_\mu \; p \, H$$

$$C_\mu = \frac{1 - Sin\phi}{1 + Sin\phi} \qquad Vx + \Sigma F - M = \Sigma W - M \qquad \sigma_r = \frac{V}{B} \pm \frac{6\,V\,e}{B^2}$$

$\sigma_r = \dfrac{2\,V}{3\,x}$ (*x=afstand vanaf toon/distance from toe*)

$$V.F./F.O.S. = \frac{\Sigma W - M}{\Sigma F - M} \qquad V.F/F.O.S. = \frac{\sigma_{Uiterste/Ultimate}}{\sigma_{Mak/Max}} \qquad V.F./F.O.S. = \frac{F_\mu}{\Sigma F - Kragte/Forces}$$

****

$$M = \frac{W}{8}[L - \ell] \qquad M = \frac{W}{8\,L}[L - \ell]^2$$

$$d = \frac{\sigma_1}{\rho \, g}\left[\frac{1 - Sin\phi}{1 + Sin\phi}\right]^2 \qquad SF = \frac{W}{2\,L}[L - \ell]$$

****

$$\frac{\sigma_s}{\sigma_c} = \frac{m(d-n)}{n} \qquad \frac{b\,n^2}{2} = m\,A_s\,(d-n)$$

$$M = \frac{1}{2}\sigma_c\, b\, n\, \ell_a \qquad M = \sigma_s\, A_s\, \ell_a \qquad \ell_a = d - \frac{n}{3}$$

$$m\,A_s(d-n) = A_1\left(n - \frac{t}{2}\right) + A_2\left(\frac{n-t}{2}\right) \qquad \sigma_{cl} = \frac{\sigma_c\,(n-t)}{n}$$

$$M_s = \sigma_s\, A_s\,(d-n) \qquad M_c = \left[\frac{1}{2}\sigma_c\, b\, n\left(\frac{2}{3}n\right)\right] - \left[\frac{1}{2}\sigma_{cl}\,(b-e)(n-t)\left\{\frac{2}{3}(n-t)\right\}\right]$$

$$M_{Maks/Max} = M_s + M_c$$

****

$$F_T = wy \qquad F_H = wy_0 \qquad F_V = w\ell$$

$$y^2 = y_0^2 + \ell^2 \qquad F_T^2 = F_H^2 + F_V{}^2 \qquad x = y_o \ln\left[\frac{y+\ell}{y_o}\right]$$

$$F_V = wx \qquad F_H = \frac{w\,L^2}{8\,d} \qquad \ell = L + \frac{8\,d^2}{3\,L}$$

$$F_H = \frac{w\,x_1^2}{2\,d} \qquad F_H = \frac{w\,(L-x_1)^2}{2\,(d+h)}$$

$$\ell_1 = x_1 + \frac{2\,d^2}{3\,x_1} \qquad \ell_2 = (L-x_1) + \frac{2\,(d+h)^2}{3\,(L-x_1)}$$

$$R = F_{Vc} + F_{Va} \qquad M = \left(F_{Hc} - F_{Ha}\right)H$$

****

$$M_e = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right] \qquad M_e = \frac{\pi\,D^3}{32}\,\sigma_n$$

$$T_e = \sqrt{M^2 + T^2} \qquad T_e = \frac{\pi\,D^3}{16}\,\tau$$

$$\frac{\text{Vervang}}{\text{Replace}}\ D^3\ \frac{\text{met}}{\text{with}}\ \frac{D^4 - d^4}{D}$$