higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

12 August 2021 (X-paper)
09:00–12:00

REQUIREMENTS: Hot-rolled structural steel tables (BOE8/3)

Drawing instruments and nonprogrammable calculators may be used.

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

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STRENGTH OF MATERIALS AND STRUCTURES N6
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. Use only a black or a blue pen.
5. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

A steel cylinder is shrunk onto a bronze cylinder to form a compound cylinder. The inner diameter of the bronze cylinder is 200 mm and the outer diameter is 300 mm. An internal pressure of 25 MPa is applied to the compound cylinder causing the resultant hoop stress at the inner diameter to become 5 MPa (tensile) and the resultant maximum hoop stress in the steel cylinder becomes 65 MPa (tensile).

Calculate each of the following:

1.1 Resultant radial stress at 300 mm diameter (5)

1.2 Resultant hoop stress in bronze at 300 mm diameter. (State the nature of the stress) (2)

1.3 Diameter where resultant hoop stress in bronze cylinder is zero (1)

1.4 Outer diameter of steel cylinder (5)
[13]

QUESTION 2: CABLE TENSION

A uniform flexible cable supports its own weight of 40 N/m between two supports differing 6 m in height. The sag in the cable is 4 m below the shorter support. The maximum tension in the cable is 6 kN.

Calculate each of the following:

2.1 Tension in cable at lower support (3)

2.2 Total length of cable (4)

2.3 Vertical reaction in shorter support if cable runs over frictionless pulley with 30° angle between anchor cable and support (3)

2.4 Tension in anchor cable at higher support if cable is fixed to saddle on rollers with 30° angle between anchor cable and support (2)
[12]

QUESTION 3: BENDING AND DEFLECTION

A steel pipe with an inside diameter equal to half the outside diameter is used as a cantilever with a length of 4 m. It carries a uniformly distributed load of 10 kN/m over the first 2,5 m from the fixed end as well as a concentrated load of 20 kN at the free end. The modulus of elasticity for the material is 200 GPa and the deflection at the free end is limited to 11 mm.

Calculate each of the following:

3.1 Required dimensions of pipe (8)

3.2 H-profile that can replace pipe for same deflection limit (1)

3.3 Maximum bending stress if selected H-profile is used (3)
[12]

QUESTION 4: COMBINED DIRECT AND BENDING STRESS

A chimney is made of a material with a density of 2 500 kg/m^3. It has an outside diameter of 3 m and an inside diameter of 2,5 m. The chimney is subjected to a wind force of 60 kN against the vertical side which is 15 m high.

Calculate each of the following:

4.1 Direct stress at base of chimney due to its own weight (3)

4.2 Bending stress due to wind force (3)

4.3 Maximum and minimum resultant stresses at chimney base. State the nature of the resultant stresses. (4)

4.4 Position of neutral axis from side of maximum stress (2)
[12]

QUESTION 5: RETAINING WALLS

A trapezium-shaped retaining wall with a height of 5 m and a density of 2 200 kg/m^3 retains water to the top of its vertical face. The top of the wall is 2 m wide. The minimum and maximum stresses at the heel and toe are 35,97 kPa and 107,91 kPa respectively (both compressive).

Consider 1 m length of the wall and calculate each of the following:

5.1 Width of base by considering stress limits (10)

5.2 Direct and bending stress values beneath the base (4)
[14]

QUESTION 6: FOUNDATIONS

A column supports a load of 2,5 MN on a base plate of 0,8 m × 1,2 m and is not fixed to the top tier of a grillage foundation. The top tier consists of five parallel flange I-sections and the bottom tier has ten parallel flange I-sections. The weight of the foundation is 500 kN and the allowable ground-bearing pressure is 187,5 kPa. The allowable bending stress in the beams is 100 MPa.

6.1 Calculate the area and length of square foundation. (2)

6.2 Select the lightest suitable I-section for the top tier. (3)

6.3 Calculate the minimum width required to space the I-sections in the top tier and state if the bottom tier will fit inside the given base plate dimensions. (2)

6.4 Select the lightest suitable I-section for the bottom tier. (3)

6.5 Calculate the actual bending stresses in the chosen profiles for the top and bottom tiers. (2)

[12]

QUESTION 7: REINFORCED CONCRETE

A reinforced concrete beam with a length of 4 m is simply supported at its ends and carries a uniformly distributed load over the full length as well as a concentrated load of 60 kN in the middle of the beam. The beam is rectangular in shape and the area of the steel reinforcing is 2×10^{-3} m^2. The effective depth of the reinforcing is 600 mm from the top of the beam. The stress limit for the concrete is 6 MPa and138 MPa for the steel. Assume the modular ratio to be 15.

Calculate each of the following:

7.1 Position of neutral axis from the top (3)

7.2 Moment of resistance of beam (2)

7.3 Magnitude of concentrated load (3)

7.4 Minimum width of beam (2)

7.5 Actual moment of resistance of the concrete (2)

7.6 Actual moment of resistance of the steel (2)

[14]

QUESTION 8: SPACE FRAMES

The legs of a tripod are each 6 m long and placed to form an isosceles triangle ABC with AB = AC = 5 m and BC = 6 m. The tripod supports a load of 30 kN from the apex.

Use scale 1 cm:1 m for the space diagram and 1 cm:5 kN for the vector diagram to answer the questions.

8.1 Draw a side and a top view of the tripod to the given scale. (4)

8.2 Draw vector diagrams to the given scale and determine the force in each leg. (7)
[11]

TOTAL: 100

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FORMULA SHEET

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

$$\theta = \frac{W \, L^2}{2 \, E \, I}$$

$$\Delta = \frac{W \, L^3}{3 \, E \, I}$$

$$M = W \, L$$

$$\theta = \frac{w \, L^3}{6 \, E \, I}$$

$$\Delta = \frac{w \, L^4}{8 \, E \, I}$$

$$M = \frac{w \, L^2}{2}$$

$$\theta = \frac{W \, L^2}{16 \, E \, I}$$

$$\Delta = \frac{W \, L^3}{48 \, E \, I}$$

$$M = \frac{W \, L}{4}$$

$$\theta = \frac{w \, L^3}{24 \, E \, I}$$

$$\Delta = \frac{5 \, w \, L^4}{384 \, E \, I}$$

$$M = \frac{w \, L^2}{8}$$

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

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

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

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

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

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

****

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

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

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

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

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

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

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

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

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

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

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

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

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

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