higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1310**(E)**(N28)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

28 November 2016 (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 5 pages and a formula sheet of 3 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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NATIONAL CERTIFICATE
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. Subsections of questions must be kept together.
5. Draw a line after each completed subsection.
6. Start each question on a NEW page.
7. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

A thick hydraulic cylinder supports a load which causes a pressure of 80 mPa in the cylinder. The outside diameter is 250 mm and the maximum hoop stress in the material is limited to 130 MPa. Young's modulus for the material is 200 GPa and Poisson's ratio is 0,3.

Calculate:

1.1 The inside diameter of the cylinder (7)

1.2 The magnitude of the load that is supported (2)

1.3 The longitudinal stress in the cylinder wall (2)

1.4 The change in the outside diameter (2)
[13]

QUESTION 2: BENDING AND DEFLECTION

A cantilever is 5 m long and supports a uniformly distributed load of 4 kN/m over its full length. The deflection is limited to 12 mm and bending stress is limited to 120 MPa. Young's modulus for the material is 200 GPa.

Calculate:

2.1 The lightest parallel flange I-profile required (consider both limits) (8)

2.2 The actual maximum deflection and bending stress for the selected profile (2)

2.3 The maximum deflection if the load is carried over the first 4 m (3)
[13]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A hollow shaft with an outside diameter of 100 mm and an inside diameter of 50 mm is simply supported at its ends. The shaft supports its own weight of 500 N/m as well as an axial concentric tensile force. This combined effect causes the resultant stress at the top of the shaft to be zero and at the bottom of the shaft it is 80 MPa.

Calculate:

3.1 The magnitude of the axial force (5)

3.2 The length of the shaft (4)
[9]

QUESTION 4: RETAINING WALLS

A retaining wall with a trapezium shape retains water to the full height of 4 m. The top of the wall is 2 m wide and the base is 3 m. The density of the wall material is 2 100 kg/m^3.

Calculate:

4.1 The lateral force of the water and the vertical reaction of the ground (4)

4.2 The force moments and weight moments about the toe (3)

4.3 The position of the vertical reaction from the toe. Also state whether tension will occur in the wall. (3)

4.4 The maximum ground pressure beneath the wall (2)
[12]

QUESTION 5: FORCES IN STRUCTURAL FRAMEWORKS

The legs of a tripod are placed to form a triangle ABC where AB = 12 m, AC = 10 m and BC = 11 m. The legs of the tripod are of equal length and each is 10 m long. The tripod is to lift a weight of 50 kN at the apex.

5.1 Draw a top view and side view of the tripod to determine the position of the apex. Use a scale of 1 cm = 2 m. (6)

5.2 Draw vector diagrams to determine the magnitude and nature of the forces in each leg. Use a scale of 1 cm = 10 kN. Tabulate your answers. (9)
[15]

QUESTION 6: REINFORCED CONCRETE

A steel reinforced concrete beam has a T-profile. The flange has a thickness of 250 mm and the web is 350 mm wide. The effective depth of the 680 mm^2 steel reinforcement is 800 mm. The allowable stresses are 140 MPa for steel and 5 MPa for concrete. Assume the modular ratio to be 15. The maximum moment of resistance of the beam is 150 kNm and both materials reach their stress limits at the same time.

Calculate:

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 110 m apart and differ 7 m in length. Each cable supports 5 kN/m. The tension in the cable at the turning point is 1 239 kN.

Calculate:

7.1 The horizontal and vertical distance of the turning point from the lowest support (7)

7.2 The maximum tension in each cable (3)

7.3 The minimum diameter of a cable if the tensile stress is limited to 180 MPa (2)

7.4 The maximum slope of the cable (1)
[13]

QUESTION 8: COMBINED BENDING AND TWISTING OF SHAFTS

A solid shaft with a diameter of 100 mm must be able to support a maximum bending moment of 4 kNm and a maximum torque of 3 kNm. The maximum torque exceeds the mean torque by 15% and is transmitted at 600 r/min.

Calculate:

8.1 The equivalent torque (2)

8.2 The maximum shear stress in the shaft (2)

8.3 The equivalent bending moment (2)

8.4 The maximum principle stress in the shaft (2)

8.5 The maximum power that can be transmitted (2)

8.6 The dimensions of a hollow shaft for the same stresses if D = 2d (3)
[13]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

FORMULAE SHEET

Any applicable equation or formula may also be used.

$$\sigma_R = a + \frac{b}{x^2} \qquad \sigma_H = a - \frac{b}{x^2} \qquad p_i \frac{\pi}{4} d^2 = \sigma_L \frac{\pi}{4} (D^2 - d^2)$$

$$F_\mu = \mu \, p_c \, \pi \, D_c \, L \qquad \in = \frac{\sigma_H - \nu \, \sigma_R}{E} \qquad \delta d = \frac{d}{E} [\sigma_H - \nu \, \sigma_R]$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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$F_T = wy$

$F_H = wy_0$

$F_V = w\ell$

$y^2 = y_0^2 + \ell^2$

$F_T^2 = F_H^2 + F_V{}^2$

$x = y_o \ln\left[\frac{y+\ell}{y_o}\right]$

$F_V = wx$

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

$\ell = L + \frac{8\,d^2}{3\,L}$

$F_H = \frac{w\,x_1^2}{2\,d}$

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

$\ell_1 = x_1 + \frac{2\,d^2}{3\,x_1}$

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

$R = F_{Vc} + F_{Va}$

$M = \left(F_{Hc} - F_{Ha}\right)H$

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$M_e = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right]$

$M_e = \frac{\pi\,D^3}{32}\,\sigma_n$

$T_e = \sqrt{M^2 + T^2}$

$T_e = \frac{\pi\,D^3}{16}\,\tau$

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