higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1570**(E)**(A8)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

8 April 2016 (X-Paper)
9:00–12:00

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

Scientific calculators may be used.

This question paper consists of 5 pages and 1 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. Rule off across the page on completion of each question.
5. Start each question on a NEW page.
6. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

A steel cylinder with an outer diameter of 300 mm is shrunk onto another steel cylinder with an inner diameter of 100 mm and an outer diameter of 200 mm. The limit for the hoop stress for the inner cylinder is 180 MPa and the hoop stress for the outer cylinder is limited to 200 MPa.

Young's modulus for steel is 200 GPa and Poisson's ratio is 0,3.

Calculate the following:

1.1 The maximum allowable pressure at the contact diameter (11)

1.2 The change in the inner diameter of the inner cylinder (2)
[13]

QUESTION 2: BENDING AND DEFLECTION

A parallel flange I-section 406 x 178 x 74,8 kg/m is simply supported over a total length of 4 m. The maximum allowable bending stress in the material is 180 MPa and Young's modulus is 200 GPa. The deflection is limited to 11 mm.

Calculate the following:

2.1 The maximum distributed load that can be supported (consider both limits) (7)

2.2 The actual stress and deflection due to the calculated distributed load (3)

2.3 The force in a prop if it is placed in the middle of the beam and if it is 3 mm lower than the supports (3)
[13]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A beam consisting of a channel of 300 x 100 x 46,2 kg/m is simply supported at its ends over a length of 4 m. The channel is loaded with its longest side vertical and it supports a concentrated load of 40 kN at 1 m from the one support. In addition to the vertical load it also supports a horizontal tensile load of 60 kN that is applied on the centroid of the channel. (Ignore the weight of the channel.)

Calculate the following:

3.1 The resultant stresses on the top and bottom of the beam (state the nature) (9)

3.2 The position of the neutral axis from the top of the beam and indicate this on a stress distribution diagram (4)
[13]

QUESTION 4: RETAINING WALLS

A retaining wall with a right angle triangle cross-section retains water against its vertical face for its full height of 5 m. The density of the wall material is 2 400 kg/m^3 and the coefficient of friction for the base is 0,4. Consider 1 m length of the wall.

Calculate the following:

4.1 The base width if no tension is allowed in the wall (6)

4.2 The factor of safety for overturning and state if it is within the limit (4)

4.3 The factor of safety for sliding and state if it is within the limit (3)
[13]

QUESTION 5: FORCES IN STRUCTURAL FRAMEWORKS

The legs of a tripod are each 6 m long and are 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 a scale of 1 cm = 1 m for the space diagram and 1 cm = 5 kN for the vector diagram.

5.1 Draw a side and top view of the tripod to the given scale. (2)

5.2 Draw vector diagrams to the given scale and determine the force in each leg. (7)
[9]

QUESTION 6: REINFORCED CONCRETE

A steel reinforced beam is simply supported at its ends. The T-beam has a flange that is 500 mm wide and 80 mm thick. The web is 200 mm wide and the effective depth of the reinforcement is 600 mm from the top of the beam. The area of the reinforcement is 200 mm^2. The maximum allowable stresses for the steel and concrete are 140 MPa and 5,2 MPa respectively. Assume the modular ratio is 15.

Calculate the following:

6.1 The position of the neutral axis by taking moments about the neutral axis (4)

6.2 The maximum bending moment that the beam can handle (5)

6.3 The actual stress in the concrete (2)

6.4 The actual moment of resistance of the concrete (2)

6.5 The actual moment of resistance of the steel (2)
[15]

QUESTION 7: TENSION IN CABLES

A cable hangs between supports which differ 7 m in length. The turning point of the cable is 6 m below the lowest support. The cable has a weight of 10 N/m and the tension at the turning point is 250 N.

Calculate the following:

7.1 The tension at the TWO supports (5)

7.2 The length of the cable (3)

7.3 The distance between the supports (3)

7.4 The distance from the turning point where the tension is 350 N (3)
[14]

QUESTION 8: COMBINED BENDING AND TWISTING OF SHAFTS

A hollow shaft with an outside diameter of 100 mm and an inside diameter of 50 mm transmits power at 300 r/min while supporting a bending moment of 5 kNm. The maximum torque exceeds the average torque by 15%. The bending stress is limited to 100 MPa.

Calculate the following:

8.1 The equivalent bending moment

8.2 The equivalent torque

8.3 The maximum allowed torque

8.4 The shear stress in the shaft

8.5 The maximum power that can be transmitted

(5 x 2) **[10]**

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

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

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

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

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

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

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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 = distance from toe)*

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

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

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

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

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

$M_{Max} = M_s + M_c$

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$F_T = wy$

$F_H = wy_0$

$F_V = w\ell$

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

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

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

$F_V = wx$

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

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

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

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

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

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

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

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

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

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

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

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

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