higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

(8060076)

11 April 2018 (X-Paper)
09:00–12:00

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

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
STRENGHT OF MATERIALS AND STRUCTURES
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Questions may be answered in any order, but subsections must be kept together.
3. Draw a line after each completed subsection.
4. Each question must be started on a NEW page.
5. Use $g = 9{,}81\ m/s^2$
6. Write neatly and legibly.

QUESTION 1: THICK CYLINDERS

A solid steel shaft, 75 mm in diameter, is forced into a steel sleeve with a 125 mm external diameter. From a reading taken by an electrical strain gauge on the external circumference of the sleeve, the strain was found to be 168,75 x 10^{-6}.

Young's modulus for steel is 200 GPa and Poisson's ratio for steel is 0,29.

Calculate the following:

1.1 The maximum hoop stress in the sleeve (7)

1.2 The maximum hoop stress in the shaft (2)

1.3 The change in diameter of the shaft at the contact diameter (1)

1.4 The change in diameter of the sleeve at the contact diameter (1)

1.5 The shrinkage allowance (1)
[12]

QUESTION 2: BENDING AND DEFLECTION

A beam with a length of 6 m is simply supported at its ends and carries a uniformly distributed load of 12 kN/m over the full span. The beam is made up of two equal-leg angles which are welded back to back to form a 'T'-shape.

Young's modulus for the material is 200 GPa.

Calculate the following:

2.1 The selection of suitable equal-leg profiles if the maximum deflection allowed is 16 mm (4)

2.2 The actual deflection of the chosen beam (2)

2.3 The magnitude and nature of the maximum and minimum bending stresses in the beam (5)

2.4 The force in a prop that is placed in the centre of the beam if the prop is 5 mm lower than the supports (2)
[13]

QUESTION 3: COMBINED BENDING AND DIRECT STRESS

A short rectangular column with dimensions of 2 m by 1 m supports an eccentric load of 2 MN in the one quadrant. The position of the load is 500 mm from the XX-axis and 200 mm from the YY-axis.

Calculate the following:

3.1 The direct stress (1)

3.2 The bending stresses about the XX-axis and YY-axis (4)

3.3 The maximum and minimum resultant stresses (2)

3.4 The position of the neutral axis and then represent these values on a stress distribution diagram (6)
[13]

QUESTION 4: RETAINING WALLS

A trapezium-shaped dam wall with a height of 6 m retains water to a certain depth against the vertical face. The top of the wall is 2 m wide and the base is 3 m wide. The density of the wall material is 2 200 kg/m^3. The ground was tested and found to have an ultimate bearing capacity of 621 kPa. Consider 1 m length of the wall.

Calculate the following:

4.1 The resultant vertical reaction of the ground (3)

4.2 The weight moments about the toe (2)

4.3 The position of the resultant ground reaction from the toe if the safety factor for ground bearing pressure is 3. (4)

4.4 The maximum allowable height of the water for the given limit (4)
[13]

QUESTION 5: FOUNDATIONS

A short H-profile column supports a certain load which causes a compressive stress of 140 MPa at the base. The square base plate with 800 mm sides is fixed to the top tier. The foundation is square and has side lengths of 3 m each. The top tier consists of three parallel flange I-sections of 457 x 191 x 98,3 kg/m. The allowable bending stress in the beams is 180 MPa. The weight of the foundation is 200 kN and the allowable ground bearing pressure is 200 kPa.

Calculate the following:

5.1 The maximum bending moment allowed (2)

5.2 Select the H-profile required for the column and then calculate the actual stress at the base (5)

5.3 The minimum number of 305 x 165 x 40,5 kg/m parallel flange I-sections required in the bottom tier (3)

5.4 The actual bending stress in the I-sections in the bottom tier (1)

[11]

QUESTION 6: REINFORCED CONCRETE

A reinforced concrete T-beam is used as a cantilever and carries a concentrated load of 6 kN at the free end. The flange is 1 m wide and 200 mm thick and the web has a width of 200 mm. The effective depth of the 800 mm^2 steel reinforcing is 800 mm from the compressive side. The stress limit for steel is 140 MPa and for concrete 7 MPa, and the modular ratio is 15.

Calculate the following:

6.1 The position of the neutral axis by taking moments about the neutral axis (3)

6.2 The maximum allowable moment of resistance of the beam (3)

6.3 The actual stress in the concrete (2)

6.4 The bending moment carried by each material (4)

[12]

QUESTION 7: TENSION IN CABLES

A cable supporting its own weight of 13 kN has a total length of 650 m. The minimum tension in the cable is 30 kN and the cable forms an angle of 15^{o} to the horizontal at the highest support. The supports are different in length.

Calculate the following:

7.1 The tension at the two supports (6)

7.2 The resultant reaction on the highest support in magnitude and direction if the cable goes over a frictionless pulley and the angle between the anchor cable and the support is 30^{o} (6)

7.3 The bending moment on the longest support if its length is 20 m (2)
[14]

QUESTION 8: COMBINED BENDING AND TWISTING OF SHAFTS

A solid shaft is simply supported at its ends over a length of 4 m and is subjected to an equivalent bending moment of 3 kNm and an equivalent torque of 2 kNm. The maximum principal and shear stresses are 90 MPa and 60 MPa respectively.

Calculate the following:

8.1 The minimum diameter required for the shaft and state your reason (6)

8.2 The maximum uniformly distributed load the beam may carry (3)

8.3 The actual principal and shear stresses in the shaft (3)
[12]

TOTAL: 100

STRENGTH OF MATERIALS AND STRUCTURES N6

FORMULA SHEET

Any applicable equation or formula may be used.

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

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

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

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

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

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

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

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

****

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

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

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

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

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

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

****

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

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

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

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

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

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$F_T = wy$

$F_H = wy_0$

$F_V = w\ell$

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

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

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

$F_V = wx$

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

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

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

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

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

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

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

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

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

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

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

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

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