higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

2 December 2022

This marking guideline consists of 8 pages.

MJ

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QUESTION 1

1.1 $\delta = \frac{F}{A}$

$= \frac{78 \times 10^3}{\frac{\pi}{4}(0.03)^2}$ ✓

$= 110{,}347$ MPa✓

1.2 $E = \frac{\delta x L}{X}$

$= \frac{110.347 \times 10^6 \times 0.06}{0.052 \times 10^{-3}}$ ✓

$= 127{,}323$ GPa✓

Alternative

$E = \frac{F.l}{A.x} = \frac{78 \times 10^3 \times 0.06}{\frac{\pi}{4}(0.03)^2.0.052 \times 10^{-3}}$ ✓ $= 127{,}323$ GPa✓

1.3 $\delta = \frac{F}{A}$

$= \frac{158 \times 10^3}{\frac{\pi}{4}(0.03)^2}$ ✓

$= 223.524$ MPa✓

1.4 % elongation $= \frac{change\ in\ length}{original\ length} \times 100$

$= \frac{70{,}2-60}{60} \times 100$ ✓

$= 17\%$ ✓

1.5 % reduction in area $= \frac{Original\ area - Final\ area}{Original\ area} \times 100$

$= \frac{30^2 \times 19.5^2}{30^2} \times 100$ ✓

$= 57{,}75\%$ ✓

(5 × 2) **[10]**

QUESTION 2

2.1 $U = (\frac{F_1^2 L_1}{A_1 E_1} + \frac{F_2^2 L_2}{A_2 E_2})$

$10 = F^2(\frac{0,1 \times 4}{2\pi \times 0,04^2 \times 210 \times 10^9}$ ✓+ $\frac{0,08x4}{2\pi \times 0,03^2 \times 210 \times 10^9}$ ✓)

$F^2 = 2,179 \times 10^{10}$ ✓

$F = 147,624\ kN$✓

$\delta_2 = \frac{F_2}{A_2}$

$= \frac{147,612 \times 10^3}{\frac{\pi}{4}(0.03)^2}$✓

$= 208,828$ MPa✓

$\delta_1 = \frac{F_1}{A_1}$

$= \frac{147,612 \times 10^3}{\frac{\pi}{4}(0.04)^2}$✓

$= 117,465$ MPa✓ (8)

2.2 $F_S = 2F_G$✓

$= 2 \text{ x } 147,612 \times 10^3$

$= 295,224$ kN✓

$\delta_{S_{max}} = \frac{F_{S_2}}{A_2}$

$= \frac{295,224 \times 10^3}{\frac{\pi}{4}(0.03)^2}$✓

$= 417,657$ MPa✓ (4)

[12]

QUESTION 3

3.1 $\sigma_L = \frac{PD}{4t} = \frac{2 \times 10^6(1,8)}{4(18 \times 10^{-3})}$✓ $= 50\ MPa$✓ (2)

3.2 $\sigma_c = \frac{PD}{2t} = \frac{(2 \times 10^6)(1,8)}{2(18 \times 10^{-3})}$✓ $= 100\ MP$✓

$\varepsilon_L = \frac{\delta_L - \gamma\delta_c}{E} = \frac{50 \times 10^6 - 0,29(100 \times 10)^6}{200 \times 10^9}$✓ $= 105 \times 10^{-6}$✓

(4)

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3.3 $\Delta d = \frac{Pd^2}{4tE}(2-\gamma) = \frac{2 \times 10^6(1,8^2)}{4(18 \times 10^{-3})(200 \times 10^9)}(2-0,29)\checkmark = 0,7655\ mm\checkmark$ (2)

3.4 $\varepsilon_c = \frac{\delta_c - \gamma\delta_L}{E} = \frac{100 \times 10^6 - 0,29(50 \times 10^6)}{200 \times 10^9}\checkmark = 427,5 \times 10^{-6}\checkmark$

$\varepsilon_v = \varepsilon_L + 2\varepsilon_c = 105 \times 10^6 + 2(427,5 \times 10^{-6}) = 960 \times 10^{-6}\checkmark$ (3)

3.5 $V = \frac{\pi}{4}D^2L = \frac{\pi}{4}(1,8)^2(0,9)\checkmark = 2,290\ m^3\checkmark$

$\Delta V = \frac{PdV}{4tE}(5-4\gamma) = \frac{2 \times 10^6(1,8)(2,29)}{4(18 \times 10^{-3})(200 \times 10^9)}[5-4(0,29)]\checkmark = 2,198 \times 10^{-3}m^3\checkmark$ (4)

3.6 $V_{new} = V + \Delta V = 2,29 + 2,198 \times 10^{-3} = 2,292\ m^3\checkmark$ (1)

[16]

QUESTION 4

4.1 $x = \frac{A_1x_1 + A_2x_2}{A_t}$

$= \frac{(8,385 \times 10^{-3})(0,076)\checkmark + ((8,385 \times 10^{-3})(0,2336)\checkmark}{(8,385 \times 10^{-3} + 8,385 \times 10^{-3})\checkmark}$

$= 154,8 \times 10^{-3}m\checkmark$ (4)

4.2 $I_{xx_T} = I_{xx_1} + I_{xx_2}$

$= 131,8 \times 10^{-6} + 9,135 \times 10^{-6}\checkmark$

$= 140,935 \times 10^{-6}\ m^4\checkmark$ (2)

4.3 $I_{yy_T} = I_{yy_1} + I_{yy_2}$

$I_{yy_1} = I_{yy} + A_1r^2 = 9,135 \times 10^{-6} + (8,385 \times 10^{-3})(0,0788^2)\checkmark = 61,201 \times 10^{-6}m^4\checkmark$

$I_{yy_2} = I_{xx} + A_2r^2 = 131,8 \times 10^{-6} + (8,385 \times 10^{-3})(0,0788^2)\checkmark$
$= 183,866 \times 10^{-6}m^4\checkmark$

$I_{yy_T} = 245,067 \times 10^{-6}m^4\checkmark$ (5)

4.4 $$k = \sqrt{\frac{I_{xx_T}}{A_T}}$$

$$= \sqrt{\frac{140{,}935\times10^{-6}}{(8{,}385\times10^{-3}+ 8{,}385\times10^{-3})}}\checkmark$$

$$= 91{,}673\ mm\checkmark$$

$$l_e = \frac{l}{2} = \frac{6}{2} = 3\ m\checkmark$$

$$SR = \frac{l_e}{k}$$

$$= \frac{3}{91{,}673\times10^{-3}}\checkmark$$

$$= 32{,}725\checkmark$$ (5)

4.5 $$F = \frac{\delta . A_T}{1 + a(\frac{l_e}{k})^2}$$

$$= \frac{280X10^6\times(8{,}385\times10^{-3}+ 8{,}385\times10^{-3})\checkmark}{1+\frac{1}{7500}(\frac{3}{91{,}637\times10^{-3}})^2\checkmark}$$

$$= 4{,}108\ MN\checkmark$$ (3)

[18]

QUESTION 5

5.1 $$\theta_{AB} = \theta_{CD}$$

$$[\frac{10{,}2\ TL}{G(D^4-d^4)}]_{AB} = [\frac{10{,}2\ TL}{G(d^4)}]_{CD}$$

$$\frac{0{,}15}{0{,}04^4-0{,}03^4}\checkmark = \frac{0{,}24}{d_{CD}^4}\checkmark$$

$$d_{CD}^4 = \frac{0{,}24(0{,}04^4-0{,}03^4)}{0{,}15}\checkmark$$

$$d_{CD}^4 = 2{,}8\times10^{-6}\checkmark$$

$$d_{CD} = 40{,}91\ mm\checkmark$$ (5)

5.2 $\theta_{total} = \theta_{AB} + \theta_{BC} + \theta_{CD}$

$= [\frac{10,2\,TL}{G(D^4-d^4)}]_{AB} + [\frac{10,2\,TL}{G(d^4)}]_{BC} + [\frac{10,2\,TL}{G(d^4)}]_{CD}$

$= \frac{10,2 \times 500\ x\ 0,15}{80\times10^9(0,04^4-0,03^4)}$ ✓ $+\frac{10,2 \times 500 \times 0,15}{80\times10^9\times0,04^4}$ ✓$+\frac{10,2 \times 500 \times 0,24}{80X10^9\times0,0409^4}$ ✓

$= 0.0147 \times 57,3$✓

$= 0,84°$✓ (5)

[10]

QUESTION 6

6.1 $d_s = D_s - 2t$
$d_s = 50 - 2(10) = 30\ mm$✓

$F(\frac{1}{A_{sX}\,E_s} + \frac{1}{A_{B\,X}\,E_B}) = (\alpha_B - \alpha_S)\,\Delta T$

$F(\frac{4}{\pi(0,05^2\ -0,03^{2)}\,200\times10^9}$ ✓$+\frac{4}{\pi(0,025^2\,)\times\,100\times10^9}$ ✓$) = (19 \times 10^{-6} - 12 \times 10^{-6})100$✓

F = 28,744 kN✓

Stress of steel
$\delta = \frac{F}{A}$
$= \frac{28.744\times10^3}{\frac{\pi}{4}(0,05^2-0,03^2\,)}$✓

= 22,877 MPa (T)✓

Stress of brass
$\delta = \frac{F}{A}$

$= \frac{28.744X10^3}{\frac{\pi}{4}(0,025^2)}$✓
= 58,563 MPa (C)✓ (9)

6.2 $X_B = X_S$

$\delta_B = \frac{E_B \times \delta_S}{E_S}$

$= \frac{100 \times 10^9}{200 \times 10^9} \delta_S$✓

δ_B = 0,5 δ_S✓

$F_T = F_B + F_S$

50×10^3 = 0,5 $\delta_S \times \frac{\pi}{4}(0{,}025^2)$✓ + $\frac{\pi}{4}(0{,}05^2 - 0{,}03^{2)}\ \delta_S$✓

δ_S = 33,287 MPa (T)✓

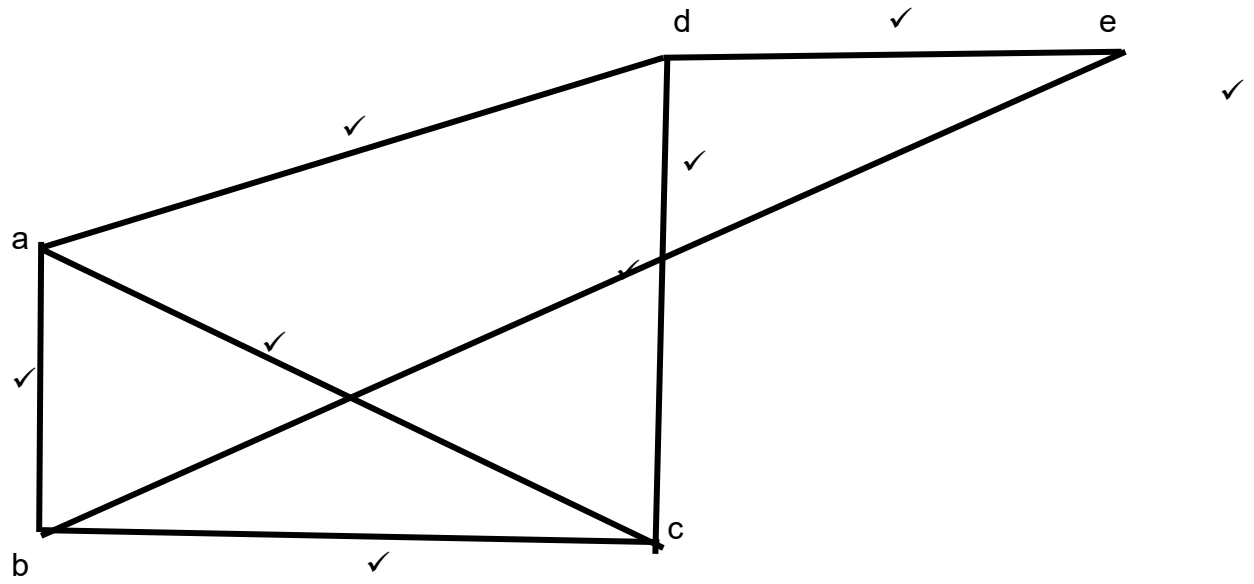
δ_B = 0,5 × 33,287

= 16,644 MPa(T)✓

Resultant stress of brass = -58.563 MPa +16,644 MPa✓
= 41,919 MPa (C)✓

Resultant stress of steel = 22,877 MPa + 33,287 MPa✓
= 56,164 MPa (T)✓ (10)
[19]

QUESTION 7



AD 16,3 KN (T)✓
DC = 16,3 KN (S)✓
ED = 11,2 KN (T)✓
EB =29,4 KN (S)✓
CB = 13,9 KN (S)✓
AC = 16 KN (T)✓

Do not mark the magnitude and nature of members in the absence of a vector diagram. **[14]**

TOTAL: 100

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