higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

8 December 2023

This marking guideline consists of 9 pages.

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QUESTION 1

1.1 Direct stress is a load applied per unit cross-sectional area✓ that resists the change in size.✓ (2)

1.2 1.2.1 $\delta_1 = \frac{F_1}{A_1}$

$= \frac{200X10^3}{\frac{\pi}{4}(0.0508^2 - 0.0254^2)}$✓

= 131,568 MPa✓ (2)

1.2.2 $\delta_2 = \frac{F_2}{A_2}$

$= \frac{200X10^3}{\frac{\pi}{4}(0.0508)^2}$✓

= 98,676 MPa✓ (2)

1.2.3 $x_{total} = x_1 + x_2$

$= \frac{F_1 L_1}{A_1 E_1} + \frac{F_2 L_2}{A_2 E_2}$

$= \frac{200X10^3 x\ 0{,}5084}{\frac{\pi}{4}(0.0508^2 - 0.0254^2)x200X10^9}$✓ $+ \frac{200X10^3 x\ 0{,}1016}{\frac{\pi}{4}(0.0508)^2 x200X10^9}$✓

$= 0{,}0668X10^{-3} + 0{,}251X10^{-3}$✓

= 0,3178 mm✓ (4)

1.2.4 $L_f = L_o + x$

$L_f = 610 + 0{,}3178$✓

$L_f = 610{,}3178\ mm$✓ (2)

[12]

QUESTION 2

2.1 $\delta = \frac{F}{A}$

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

$= \frac{125\ X\ 10^3}{215\ X\ 10^6}$

$= 0{,}581\ X\ 10^{-3}$ m²✓

$D = \sqrt{\frac{4x0.851X10^{-3}}{\pi}}$

= 27.2 mm✓ (2)

2.2 $x_{total} = x_1 + x_2 + x_3$

$0{,}29X10^{-3}$✓ $= \frac{125X10^3x\ 0{,}09✓}{\frac{\pi}{4}(0.05)^2x210X10^9✓} + \frac{125X10^3x\ L}{\frac{\pi}{4}(0.0272)^2x210X10^9}$✓ $+ \frac{125X10^3x\ 0{,}05}{\frac{\pi}{4}(0.05)^2x210X10^9}$✓

$L = 236{,}04\ mm$✓ (6)

2.3 $x_1 = \frac{125\ X\ 10^3x\ 0{,}09}{\frac{\pi}{4}(0.05)^2x210\ X\ 10^9}$✓

$= 27{,}283\ X\ 10^{-6}$ m✓

$x_2 = \frac{125X10^3x\ 0{,}2418}{\frac{\pi}{4}(0.0272)^2x210X10^9}$✓

$= 247{,}557\ X\ 10^{-6}$ m✓

$x_3 = \frac{125X10^3x\ 0{,}05}{\frac{\pi}{4}(0.05)^2x210X10^9}$✓

$= 15.1576\ X\ 10^{-6}$ m✓ (6)

2.4 $U_{total} = U_1 + U_2 + U_3 = \frac{F}{2}x_{total}$

$= \frac{125\ X\ 10^3}{2}x0{,}29\ X\ 10^{-3}$✓

= 18,125 J✓ (2)

[16]

QUESTION 3

3.1 $F(\frac{1}{A_C . E_C} + \frac{1}{A_S . E_S}) = (\alpha_c - \alpha_s)\ \Delta T$

$F(\frac{1}{735\ X\ 10^{-6} x 100\ X 10^9} + \frac{1}{2{,}5\ X\ 10^{-4}\ x\ 210\ X\ 10^9})$✓ $= (18\ X\ 10^{-6} - 12\ X\ 10^{-6})80$✓

F = 14.7 kN✓

Stress of copper

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

$= \frac{14.7X10^3}{735X10^{-6}}$✓

= 20.00 MPa (C)✓

Stress of steel

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

$= \frac{14.7\ X\ 10^3}{2.5\ X\ 10^{-4}}$✓

= 58.8 MPa (T)✓ (7)

3.2 $X_C = X_S$

$\delta_S = \frac{E_S x \delta_C}{E_C}$

$= \frac{210X10^9}{100X10^9}\delta_S$

δ_S = 2,1 δ_C✓

$F_T = F_C + F_S$

$40X10^3 = \delta_S x A_S + \delta_C x A_C$

$40X10^3$ = 2,1 $\delta_C\ x\ 735X10^{-6}$✓ $+\delta_C x 2{,}5X10^{-4}$✓

δ_C = 31,746 MPa (T) ✓

δ_S = 2,1 δ_C

δ_S = 66,67 MPa (T)✓

Resultant stress of copper = - 20,00 MPa +31,746 MPa✓
= 11.746 MPa (C)✓

Resultant stress of steel = 58.8 MPa + 66,67 MPa✓
= 125,47 MPa (T) ✓ (9)

[16]

QUESTION 4

4.1 $P = \frac{2\pi NT}{60}$

$T_{mean} = \frac{30\,P}{\pi N}$ D = 2d

$= \frac{30\,600\,000}{\pi x 130}$ ✓

T_{mean} = 44,074 kN.m✓

T_{max}= 44,074 kN.m x 1.18

= 52.007 kN.m✓

$T = \frac{\pi}{16}.\tau \ .\frac{D^4 - d^4}{D}$

$52{,}007X10^3 = \frac{\pi}{16}.60\ X10^6.\frac{(2d)^4 - d^4}{2d}$ ✓

$\frac{15}{2}d^3 = \frac{52{,}007X10^3.16}{\pi.60X10^6}$ ✓

$d = \sqrt[3]{\frac{52{,}007X10^3.16.2}{\pi.60X10^6.15}}$ ✓

d = 83.806 mm✓ D = 167,611 mm✓

$\theta_{total} = \frac{10{,}2\ TL}{G\ (D^4 - d^4)}$

$\frac{1}{57{,}3} = \frac{10{,}2\ x\ 52007\ x\ 4}{80X10^9(2d)^4 - d^4)}$ ✓

$16d^4 - d^4 = \frac{10{,}2\ .x52007\ x4x57{,}3}{80X10^9x1}$ ✓

$d = \sqrt[4]{\frac{10{,}2\ .x52007\ x4x57{,}3}{15x80X10^9x1}}$ ✓

d= 100.3 mm✓

D = 200.6 mm✓

$\therefore use\ D = 200{,}6\ mm\ and\ d = 100.3$ mm✓ (14)

$\theta = 1°$✓

$T_{MAX} = \frac{\pi}{16}(\frac{D^4 - d^4}{D})\tau_{MAX}$

$52{,}007X10^3 = \frac{\pi}{16}(\frac{0{,}2006^4 - 0{,}1003^4}{0{,}2006})\tau_{MAX}$ ✓

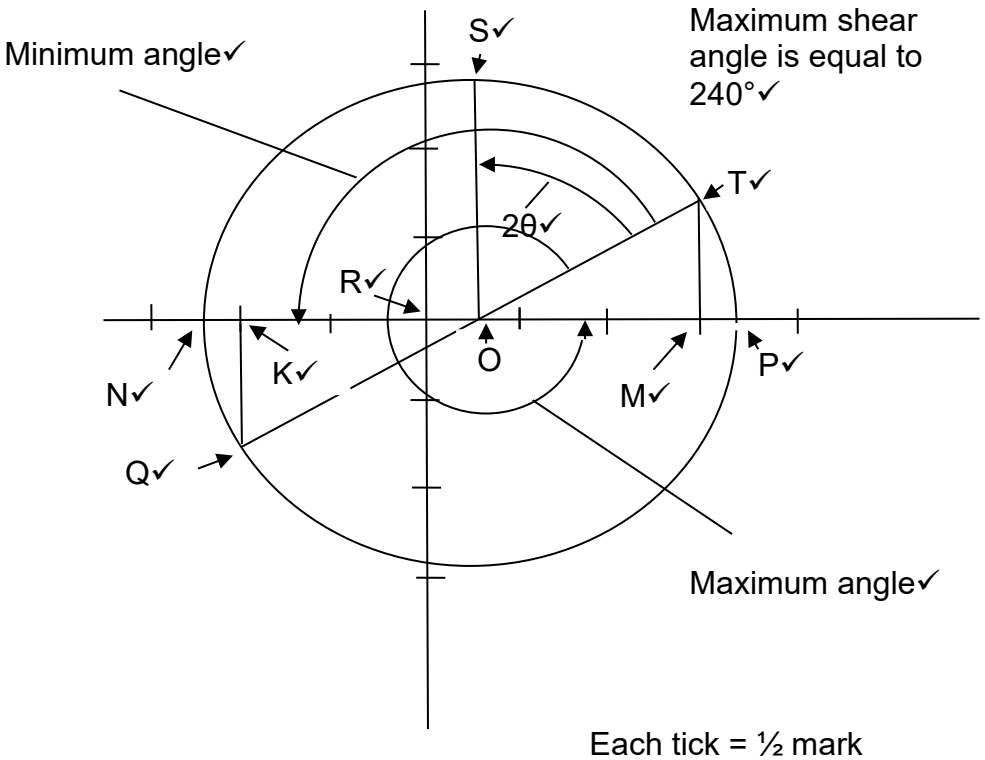
$52{,}007X10^3 = 1{,}486X10^3\tau_{MAX}$ ✓

$\tau_{MAX} = 35MPa$ ✓ (4)

[18]

QUESTION 5

5.1



Each tick = ½ mark (6)

5.2 5.2.1 $\delta_{min} = 24MPa$✓ (RN)

5.2.2 $\alpha = 75°$✓ (angle TON)

5.2.3 $\delta_{max} = 34MPa$✓ (RP)

5.2.4 $\beta = 165°$✓ (angle TOP)

5.2.5 $\tau_{max} = 29MPa$✓ (OS)

5.2.6 $\emptyset = 120°$✓ (angle POT)

(6 × 1) (6)
[12]

QUESTION 6

L = L_e = 4.4 m

SF= 3

A = $\frac{\pi}{4}(D^2 - d^2)$

= $\frac{\pi}{4}(0{,}22^2 - 0{,}02^2)$ ✓

= $0{,}0377\ m^2$✓

I = $\frac{\pi}{64}(0{,}22^4 - 0{,}02^4)$ ✓

= $114{,}98\ X\ 10^{-6} m^4$✓

k = $\sqrt{\frac{I}{A}}$

= $\sqrt{\frac{114{,}98\ X\ 10^{-6}}{0{,}0377}}$ ✓

= 55.226 mm✓

F = $\frac{\sigma x A}{1+\frac{1}{7500(\frac{Le}{k})^2}}$

F = $\frac{600X10^6 x 0{,}0377}{1+\frac{1}{7500}(\frac{4.4}{0{,}0552})^2}$ ✓

F = 12.246 MN✓

Safe load = $\frac{12.246\ \text{MN}}{3}$ ✓

= 4,082 MN✓ **[10]**

QUESTION 7

$\sum clockwise\ moment = \sum anti-clockwise\ moment$ at L

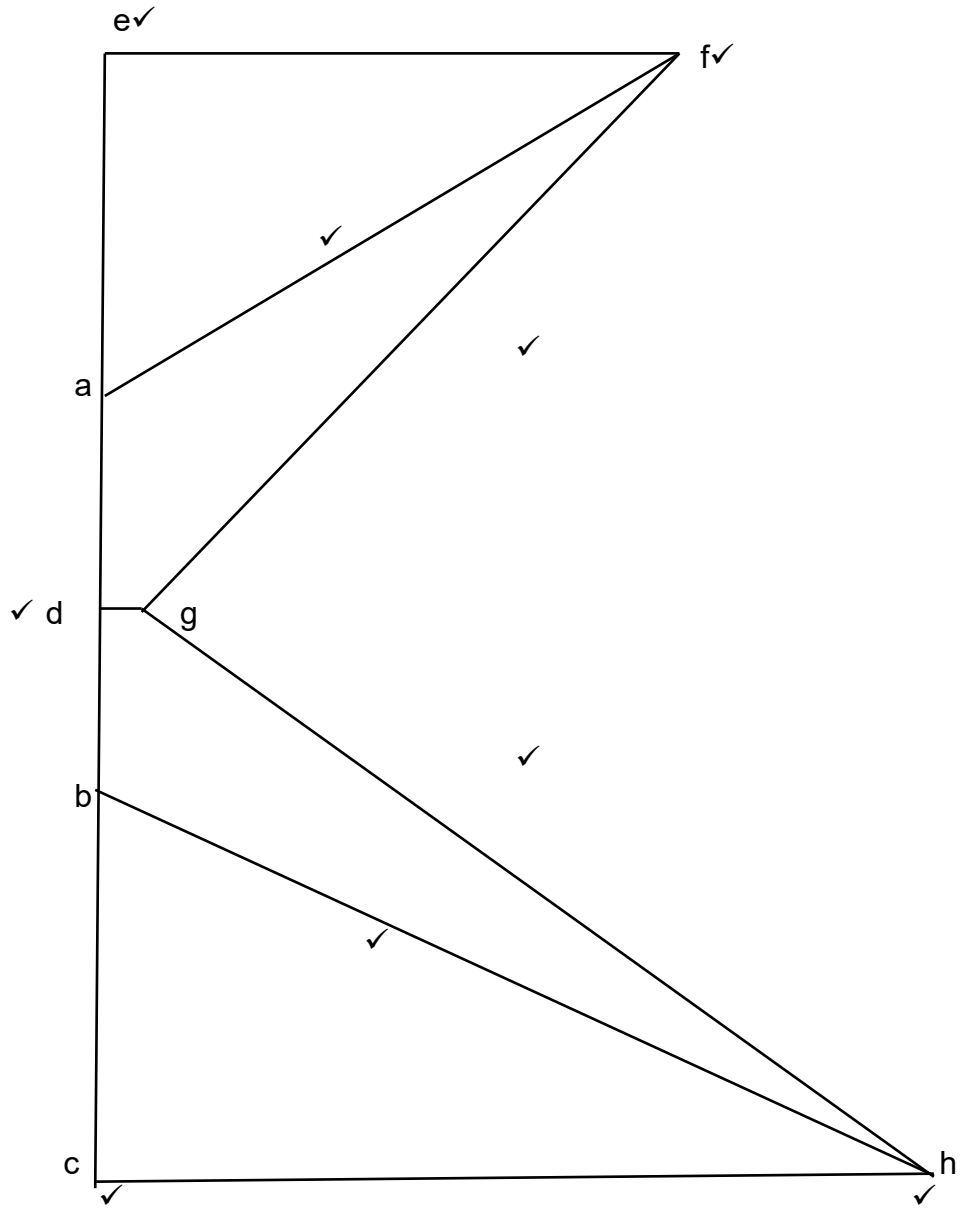
(5 × 7,5) +(4 × 20) = (15 × R) + (3 × 5)

R = 6,8 kN

$\sum clockwise\ moment = \sum anti-clockwise\ moment$ at R

(4 × 5) +(L × 15) = (5 × 7,5) +(3 × 20)

L = 5,2 kN



VECTOR DIAGRAM

AF = 5,8 kN (T)✓
EF = 5 kN (T)✓
FG = 7,1 kN (S)✓
GD = 0,2 kN (T)✓
GH = 9,6 kN (T)✓
HB = 8 kN (T)✓
HC = 6,9 kN (T)✓

DO NOT mark the magnitude and nature if a vector diagram is not provided. **[16]**

TOTAL: 100

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