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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

14 AUGUST 2019

This marking guideline consists of 8 pages.

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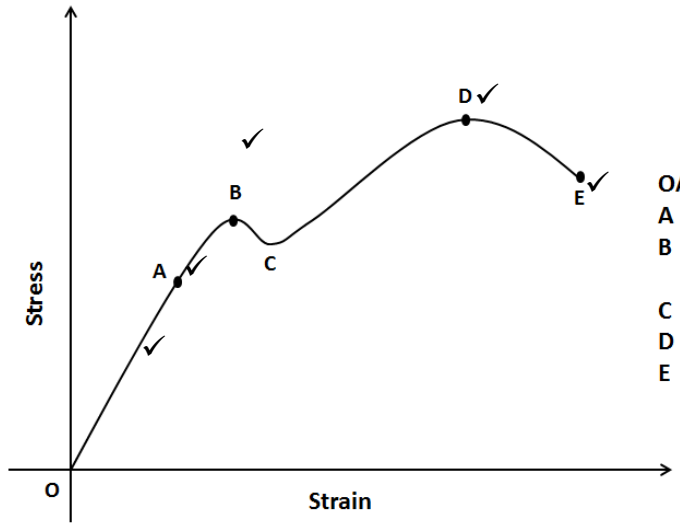
QUESTION 1

1.1



OA : Proportional limit
A : Elastic limit
B : Yield stress point/upper yield stress point
C : Lower yield stress point
D : Ultimate stress point
E : Breaking or rupture point

FIGURE 1 (5)

1.2 1.2.1

$$\sigma_{LOP} = \frac{F_{LOP}}{A_O} = \frac{32000}{1{,}327 \times 10^{-4}} = 241{,}145 MPa$$

1.2.2

$$X_{LOP} = \sigma_{LOP} \cdot \left(\frac{L}{E}\right)$$

$$0{,}22 \times 10^{-3} = 241{,}145 \times 10^{6} \cdot \left(\frac{0{,}07}{E}\right)$$

$$\therefore E = 76{,}728\ GPa$$

1.2.3

$$\sigma_{UTS} = \frac{F_{\max}}{A_O} = \frac{70000}{1{,}327 \times 10^{-4}} = 527{,}506\ MPa$$

1.2.4

$$\sigma_F = \frac{F_F}{A_F} = \frac{52000}{8{,}577 \times 10^{-5}} = 606{,}077\ MPa$$

1.2.5

$$\%\Delta X = \left(\frac{X}{L}\right).100 = \left(\frac{8{,}33}{13}\right).100 = 64{,}077\%$$

(5 × 2) (10)
[15]

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QUESTION 2

2.1 2.1.1

$$F_t = F_s$$

$$\sigma_t.(p-d).t = \frac{\pi}{4}.d^2.\tau.n.x \checkmark$$

$$115\times10^6.(p-0{,}02).0{,}014 \checkmark = \left(\frac{\pi}{4}\right).(0{,}02^2).(75\times10^6).(2).(1{,}75) \checkmark$$

$$\therefore p = 71{,}222 \approx 71\ mm \checkmark$$

(4)

2.1.2 Consider plate tension:

$$\eta_t = \left(\frac{p-d}{p}\right).100 \checkmark = \left(\frac{71-20}{71}\right).100 \checkmark = 71{,}83\% \checkmark$$

Consider shearing:

$$\eta_s = \frac{\frac{\pi}{4}.d^2.\tau.n.x \checkmark}{\sigma_t.t.p} = \frac{\frac{\pi}{4}.(0{,}02^2).(75\times10^6).(2).(1{,}75) \checkmark}{115\times10^6.(0{,}071).(0{,}014)} = 72{,}14\% \checkmark$$

Consider crushing:

$$\eta_c = \frac{\sigma_c.d.t.n \checkmark}{\sigma_t.t.p} = \frac{190\times10^6.(0{,}02).(0{,}014).(2) \checkmark}{115\times10^6.(0{,}014).(0{,}071)} = 93{,}08\% \checkmark$$

Safe joint efficiency $= 71{,}83\%$ ✓

(10)
[14]

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QUESTION 3

3.1 Consider the external load applied: F_t = 240 kN

$$X_1 = X_2 : \frac{F_1.L_1}{A_1.E_1} = \frac{F_2.L_2}{A_2.E_2} \checkmark$$

$$F_1 = \frac{2{,}827\times10^{-3}.(180\times10^{9})}{2{,}262\times10^{-3}.(90\times10^{9})}.F_2 \checkmark\checkmark$$

$$= 2{,}5.F_2 \xrightarrow{eq1} \checkmark$$

$$F_t = F_1 + F_2$$

$$240000 = 2{,}5.F_2 + F_2 \checkmark$$

$$\therefore F_2 = 68571{,}429\ N \checkmark$$

$$\therefore F_1 = 171428{,}571\ N \checkmark$$

$$\sigma_2 = \frac{F_2}{A_2} = \frac{68571{,}429}{2{,}262\times10^{-3}} \checkmark\checkmark = 30{,}315\ MPa(tensile) \checkmark$$

Consider the change in temperature: T_1 = 27°C

$$F_1 = F_2 : \sigma_1.A_1 = \sigma_2.A_2 \checkmark$$

$$\sigma_1.(2{,}827\times10^{-3}) = 30{,}315\times10^{6}.(2{,}262\times10^{-3}) \checkmark$$

$$\therefore \sigma_1 = 24{,}256\ MPa(tensile) \checkmark$$

$$\Delta t.(\alpha_1 - \alpha_2) = \frac{\sigma_1}{E_1} + \frac{\sigma_2}{E_2} \checkmark$$

$$\Delta t.(21\times10^{-6} - 16\times10^{-6}) \checkmark = \frac{24{,}256\times10^{6}}{180\times10^{9}} + \frac{30{,}315\times10^{6}}{90\times10^{9}} \checkmark$$

$$\therefore \Delta t = 94{,}318\ ^{\circ}C \checkmark$$

$$t_2 = 27 - 94{,}318 = -67{,}318\ ^{\circ}C \checkmark$$

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QUESTION 4

Configuration diagram

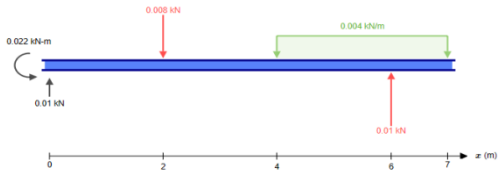

FIGURE 1

4.1

Shear-force Diagram ✓

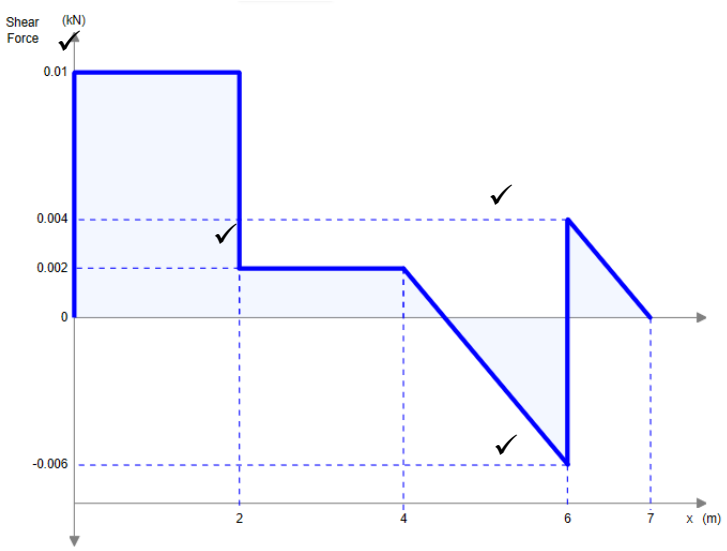

FIGURE 2 (5)

4.2

Bending-moment diagram ✓

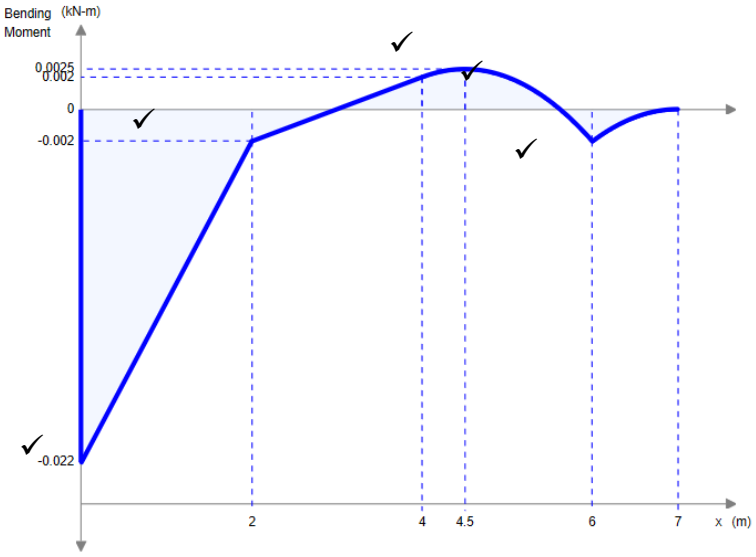

FIGURE 3 (6)

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4.3 $\tan\theta = \tan\theta$ ✓

$$\frac{2}{x} = \frac{5}{2-x}$$ ✓

$$2.(2-x) = 5.(x)$$

$$4 - 2.x = 5.x$$

$$x = 0{,}571\ m$$ ✓

$$\therefore 4{,}571\ m(\mapsto)$$ from fixed support ✓

(4)
[15]

QUESTION 5

5.1

$$\overline{y_T} = \frac{\overline{y_1}.A_1 + \overline{y_2}.A_2}{A_1 + A_2} = \frac{734{,}3.(1{,}23\times10^{-3}) + 341{,}75.(17{,}84\times10^{-3})}{1{,}23\times10^{-3} + 17{,}84\times10^{-3}} = 367{,}069\ mm\uparrow$$ ✓ ✓

$$\overline{x_T} = \frac{\overline{x_1}.A_1 + \overline{x_2}.A_2}{A_1 + A_2} = \frac{221{,}95.(1{,}23\times10^{-3}) + 126{,}85.(17{,}84\times10^{-3})}{1{,}23\times10^{-3} + 17{,}84\times10^{-3}} = 132{,}984\ mm\rightarrow$$ ✓ ✓

(4)

5.2

$$I_{XX_T} = \left[I_{X_1} + A_1.r_{y_1}\right] + \left[I_{X_2} + A_2.r_{y_2}\right]$$ ✓ ✓

$$= \left[2{,}176\times10^{-6} + 1{,}23\times10^{-3}.(0{,}367^2)\right] + \left[1363\times10^{-6} + 17{,}84\times10^{-3}.(0{,}025^2)\right]$$ ✓ ✓ ✓

$$= 1{,}681\times10^{-4} + 1{,}374\times10^{-3}$$

$$= 1{,}543\times10^{-3}\ m^4$$ ✓

(6)

5.3

$$I_{YY_T} = \left[I_{Y_1} + A_1.r_{x_1}\right] + \left[I_{Y_2} + A_2.r_{x_2}\right]$$

$$= \left[0{,}2528\times10^{-6} + 1{,}23\times10^{-3}.(0{,}089^2)\right] + \left[51{,}83\times10^{-6} + 17{,}84\times10^{-3}.(0{,}00613^2)\right]$$ ✓ ✓ ✓ ✓

$$= 9{,}988\times10^{-6} + 5{,}25\times10^{-5}$$

$$= 6{,}249\times10^{-5}\ m^4$$ ✓

(6)

5.4

$$Z_{\max} = \frac{I_{XX_T}}{y_{\max}} = \frac{1{,}543\times10^{-3}}{(0{,}684 + 0{,}102 - 0{,}367)} = 3{,}691\times10^{-3}\ m^3$$ ✓ ✓ ✓

$$Z_{\min} = \frac{I_{XX_T}}{y_{\min}} = \frac{1{,}543\times10^{-3}}{(0{,}367)} = 4{,}204\times10^{-3}\ m^3$$ ✓ ✓ ✓

(6)

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5.5

$$\sigma_{max} = \frac{M.\overline{y_{max}}}{I_{XX_T}}$$ ✓

$$145\times10^{6} = \frac{M.(0{,}684+0{,}102-0{,}367)}{1{,}543\times10^{-3}}$$ ✓

$$\therefore M = 535211{,}504\ N.m$$ ✓

$$\omega = (9{,}65+140)\times9{,}81 = 1468{,}067\ N/m$$ ✓

$$M = \frac{1}{4}.W.L + \frac{1}{8}.\omega.L^2$$ ✓

$$535211{,}504 = \frac{1}{4}.(W).(7) + \frac{1}{8}.(1468{,}067).(7^2)$$ ✓

$$\therefore W = 300{,}697\ N$$ ✓

(7)
[29]

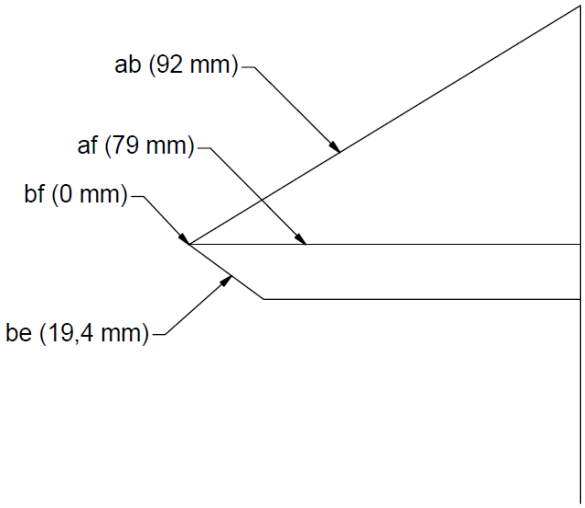
QUESTION 6

6.1 Take moments about LHS support:

$$R_D.(10) = 80.(7) + 120.(4)$$

$$\therefore R_D = 104\ N$$

$$\therefore R_A = 96\ N$$



Vector	Magnitude	Nature
ab	184 N ✓	S ✓
af	158 N ✓	T ✓
bf	0 N ✓	- ✓
be	39 N ✓	S ✓

A tolerance of ±2 N may be used.

Scale 1 mm = 2 N **[8]**

TOTAL: 100

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