higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGHT OF MATERIALS AND STRUCTURES N6

29 NOVEMBER 2019

This marking guideline consists of 8 pages.

QUESTION 1

1.1 $$at\ 100\ mm: a - \frac{b}{0{,}1^2} = 46 \times 10^6 \ldots\ldots\ldots (1)\ \checkmark$$

$$at\ 100\ mm: a + \frac{b}{0{,}1^2} = 30 \times 10^6 \ldots (2)\ \checkmark$$

$$(1) + (2): 2a = 76 \times 10^6$$

$$a = 38 \times 10^6\ \checkmark$$
$$b = -0{,}08 \times 10^6\ \checkmark$$

$$at\ 200\ mm:\ \sigma_H = a - \frac{b}{0{,}2^2}$$

$$= 38 \times 10^6 - \frac{-0{,}08 \times 10^6}{0{,}2^2}$$

$$\sigma_H = 40\ MPa\ (compressive)\ \checkmark$$

$$at\ 200\ mm:\ \sigma_R = a + \frac{b}{0{,}2^2}$$

$$= 38 \times 10^6 + \frac{-0{,}08 \times 10^6}{0{,}2^2}$$

$$\sigma_R = 36\ MPa\ (compressive)\ \checkmark$$ (6)

1.2 $$at\ 200\ mm: \quad a + \frac{b}{0{,}2^2} = 36 \times 10^6 \ldots\ldots\ldots (3)\ \checkmark$$

$$at\ 400\ mm: a + \frac{b}{0{,}4^2} = 0 \ldots\ldots\ldots\ldots\ldots\ldots (4)\ \checkmark$$

$$(3) - (4): 25b - 6{,}25b = 36 \times 10^6$$

$$b = 1{,}92 \times 10^6\ \checkmark$$
$$a = -12 \times 10^6\ \checkmark$$

$$at\ 200\ mm:\ \sigma_H = a - \frac{b}{0{,}2^2}$$

$$= -12 \times 10^6 - \frac{1{,}92 \times 10^6}{0{,}2^2}$$

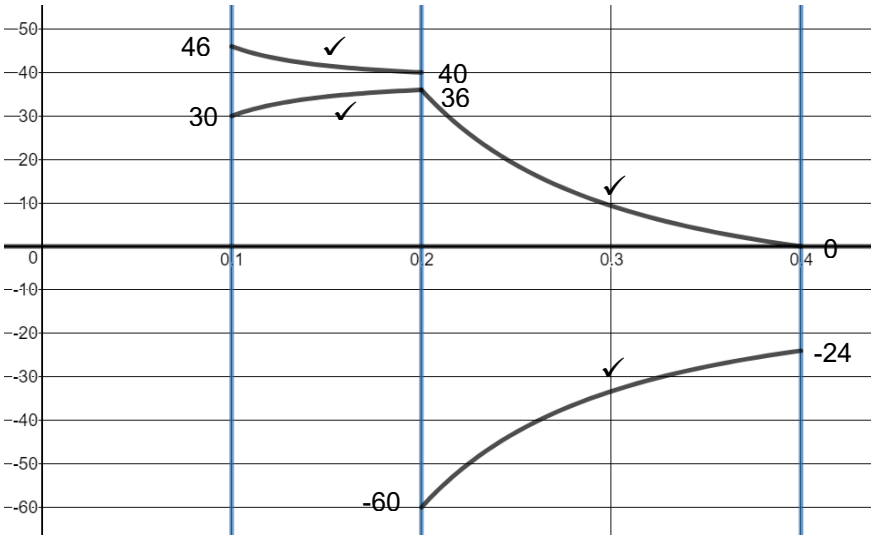
$$\sigma_H = -60\ MPa\ (tensile)\ \checkmark$$

$$at\ 400\ mm:\ \sigma_H = a - \frac{b}{0{,}4^2}$$

$$= -12 \times 10^6 - \frac{1{,}92 \times 10^6}{0{,}4^2}$$

$$\sigma_H = -24\ MPa\ (tensile)\ \checkmark$$ (6)

1.3



(4)
[16]

QUESTION 2

2.1 $$y_1 = \frac{wl_1^4}{8EI} + \frac{wl_1^3 \times l_2}{6EI}$$

$$= \frac{20 \times 10^3 \times 1{,}25^4}{8 \times 200 \times 10^9 \times I} + \frac{20 \times 10^3 \times 1{,}25^3 \times 1{,}25}{6 \times 200 \times 10^9 \times I} \checkmark$$

$$y_1 = \frac{71{,}208 \times 10^{-9}}{I} \checkmark$$

$$y_2 = \frac{FL^3}{3EI} = \frac{2 \times 10^3 \times 2{,}5^3}{3 \times 200 \times 10^9 \times I} = \frac{52{,}083 \times 10^{-9}}{I} \checkmark$$

$$y_T = y_1 + y_2$$

$$7 \times 10^{-3} = \frac{71{,}208 \times 10^{-9}}{I} + \frac{52{,}083 \times 10^{-9}}{I} \checkmark$$

$$I = 17{,}613 \times 10^{-6} m^4 \checkmark$$

$$I = \frac{\pi(D^4 - d^4)}{64}$$

$$17{,}613 \times 10^{-6} = \frac{\pi((2d)^4 - d^4)}{64} \checkmark$$

$$d = 70\ mm \checkmark$$
$$D = 140\ mm \checkmark$$

(8)

2.2 $For\ I = 17{,}613 \times 10^{-6} m^4\ select\ 203 \times 102 \times 25{,}3\ kg/m$ (1)

2.3 $M = FL + \frac{wl^2}{2}$

$= 2 \times 10^3 \times 2{,}5 + \frac{20 \times 10^3 \times 1{,}25^2}{2}$ ✓

$M = 20{,}625\ kNm$ ✓

$\sigma = \frac{M}{Z} = \frac{20{,}625 \times 10^3}{226{,}1 \times 10^{-6}} = 91{,}221\ MPa$ ✓ (3)

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QUESTION 3

3.1 $A = \pi r^2 = \pi \times 0{,}015^2 = 706{,}858 \times 10^{-6}\ m^2$ ✓

$\sigma_d = \frac{F}{A} = \frac{F}{706{,}858 \times 10^{-6}} = 1414{,}711F$ ✓

$I = \frac{\pi d^4}{64} = \frac{\pi \times 0{,}03^4}{64} = 39{,}761 \times 10^{-9}\ m^4$ ✓

$\sigma_b = \frac{F \times e \times Y}{I} = \frac{F \times 0{,}09 \times 0{,}015}{39{,}761 \times 10^{-9}} = 33953{,}055F$ ✓

$\sigma_{Rmax} = \sigma_d + \sigma_b$

$90 \times 10^6 = 1414{,}711F + 33953{,}055F$ ✓

$F = 2544{,}69\ N$ ✓ $\leftrightarrow m = 259{,}4\ kg$ ✓ (7)

3.2 $\sigma_d = 1414{,}711F = 3{,}6\ MPa\ (tensile)$ ✓

$\sigma_b = 33953{,}055F = 86{,}4\ MPa$ ✓

$\sigma_{min} = \sigma_b - \sigma_d = 82{,}8\ MPa$ ✓ $(compressive)$ ✓ (4)

[11]

QUESTION 4

4.1 $W = \rho g A l = 2500 \times 9{,}81 \times 2{,}1 \times h \times 1 = 51502{,}5h$ ✓

$F_w = \frac{\rho g h^2}{2} = \frac{1000 \times 9{,}81 \times h^2}{2} = 4905h^2$ ✓

$Moments\ about\ the\ toe\text{:}\ V \times x_R + F_g \times \frac{h}{3} = W \times x_1$

$51502{,}5h \times 0{,}6$ ✓ $+\ 4905h^2 \times 0{,}333h$ ✓ $= 51502{,}5h \times 1{,}05$ ✓

$h = 3{,}765\ m$ ✓ (6)

4.2 $W{\sim}M = W \times x_1 = (51502{,}5 \times 3{,}765) \times 1{,}05 = 203{,}601\ kNm$ ✓

$F{\sim}M = F_w \times \frac{h}{3} = 4905h^2 \times \frac{h}{3} = 4905 \times 3{,}765^2 \times \frac{3{,}765}{3} = 87{,}257\ kNm$ ✓

$FOS = \frac{W{\sim}M}{F{\sim}M} = \frac{203{,}601}{87{,}257} = 2{,}3\ (safe)\ > 2$ ✓ (3)

4.3 $e = 0{,}5B - x = 1{,}05 - 0{,}6 = 0{,}45\ m$ ✓

$V = W = 51502{,}5h = 51502{,}5 \times 3{,}765 = 193{,}905\ kN$ ✓

$\sigma_{max} = \frac{V}{B} + \frac{6Ve}{B^2} = \frac{193{,}905}{2{,}1} + \frac{6 \times 193{,}905 \times 0{,}45}{2{,}1^2} = 211{,}053\ kPa\ (comp)$ ✓

$\sigma_{min} = \frac{V}{B} - \frac{6Ve}{B^2} = \frac{193{,}905}{2{,}1} - \frac{6 \times 193{,}905 \times 0{,}45}{2{,}1^2} = -26{,}382\ kPa\ (tensile)$ ✓ (4)

[13]

QUESTION 5

5.1 $W_c = 137 \times 9{,}81 \times 4 = 5{,}376\ kN$ ✓

$F_c = \sigma A = 9 \times 10^6 \times 17{,}42 \times 10^{-3} = 156{,}78\ kN$ ✓

$W_T = F_c + W_c + W_f = 156{,}78 + 5{,}376 + 25 = 187{,}156\ kN$ ✓

$p = \frac{W_T}{A} = \frac{187{,}156 \times 10^3}{1{,}2^2} = 129{,}969\ kPa$ ✓

$\sigma_{ult} = p \times FOS = 129{,}969 \times 3$ ✓ $= 389{,}908\ kPa$ ✓ (6)

5.2 $t = \frac{L - l}{\sqrt{2}} = \frac{1{,}2 - 0{,}5}{\sqrt{2}}$ ✓ $= 0{,}495\ m$ ✓ (2)

5.3 $d = \frac{p}{\rho g}\left(\frac{1 - \sin\theta}{1 + \sin\theta}\right)^2 = \frac{138{,}889 \times 10^3}{1600 \times 9{,}81}\left(\frac{1 - \sin 30}{1 + \sin 30}\right)^2$ ✓ $= 0{,}983\ m$ ✓ (2)

[10]

QUESTION 6

6.1 $$\frac{\sigma_s}{\sigma_c} = \frac{m(d-n)}{n}$$

$$\frac{140}{8} = \frac{15(0{,}38-n)}{n}$$ ✓

$$n = 0{,}175\,m$$ ✓ (2)

6.2 $$M_s = \sigma_s A_s (d-n) = 140 \times 10^6 \times 6400 \times 10^{-6}(0{,}38-0{,}175)$$ ✓

$$M_s = 183{,}335\,kNm$$ ✓

$$M_c = M - M_s = 300 - 183{,}335 = 116{,}665\,kNm$$ ✓ (3)

6.3 $$\sigma_{c1} = \frac{\sigma_c(n-t)}{n} = \frac{8(0{,}175-0{,}1)}{0{,}175}$$ ✓ $= 3{,}439\,MPa$ ✓ (2)

6.4 $$M_c = \frac{1}{2}\sigma_c bn\frac{2}{3}n - \frac{1}{2}\sigma_{c1}(b-e)(n-t)\frac{2}{3}(n-t)$$

$$116665 = \frac{8 \times 10^6 \times b \times 0{,}175^2}{3} - \frac{3{,}439 \times 10^6 \times (b-0{,}27)(0{,}175-0{,}1)^2}{3}$$ ✓

$$116665 = 82026{,}0355b$$ ✓ $- 6513{,}665b$ ✓ $+ 1758{,}69$ ✓

$$b = 1{,}522\,m$$ ✓ (5)

[12]

QUESTION 7

7.1 $w = \frac{3024}{2 \times 36} = 42\ kN/m$ ✓ (1)

7.2 $F_H = \frac{wx^2}{2d} = \frac{42 \times 10^3 \times 18^2}{2 \times 3} = 2268\ kN$ ✓

$F_v = wx = 21 \times 10^3 \times 18\ = 378\ kN$ ✓

$F_T = \sqrt{F_H^2 + F_v^2} = \sqrt{2268^2 + 378^2} = 2299{,}284\ kN$ ✓ (3)

7.3 $\sigma = \frac{\sigma_{ult}}{FOS} = \frac{320}{8} = 40\ MPa$ ✓

$A = \frac{F}{\sigma} = \frac{2299{,}284 \times 10^3}{40 \times 10^6} = 57{,}482 \times 10^{-3} m^2$ ✓

$d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{57{,}482 \times 10^{-3}}{\pi}} = 27{,}1\ mm$ ✓ (3)

7.4 $At\ 10\ m\ from\ lower\ support: x_2 = 18 - 10 = 8\ m$ ✓

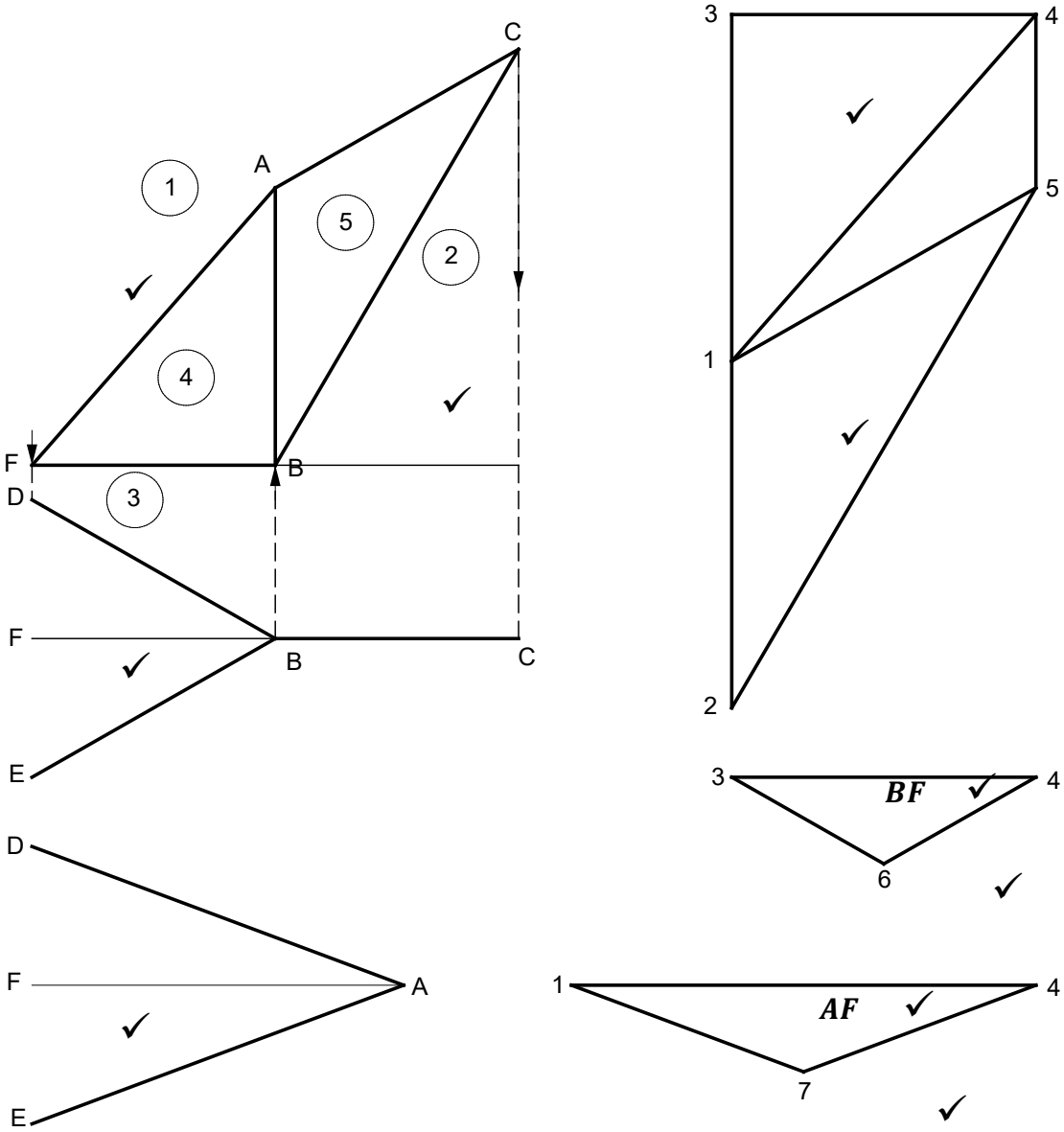
$F_{v2} = wx_2 = 21 \times 10^3 \times 8 = 168\ kN$ ✓

$F_{T2} = \sqrt{F_H^2 + F_{v2}^2} = \sqrt{2268^2 + 168^2} = 2274{,}214\ kN$ ✓ (3)

[10]

QUESTION 8

8.1 **SPACE DIAGRAMS** 8.1 and 8.2 **VECTOR DIAGRAMS**



(10)

8.3

MEMBER	MAGNITUDE	NATURE
AB (4-5)	25 kN √	Strut √
AC (1-5)	50 kN √	Tie √
BC (2-5)	86,6 kN √	Strut √
DB (3-6) and EB (6-4)	25 kN √	Strut √
DA (1-7) and EA (7-4)	35,4 kN √	Tie √
R_B (2-3)	100 kN √	Upwards√

(6)

(**NOTE**: √ = **Half mark**) **[16]**

TOTAL: 100