higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N5

23 April 2021

This marking guideline consists of 5 pages.

QUESTION 1

1.1 $\sigma_{max} = \frac{F}{A_{least}} = \frac{70\ 000}{\frac{\pi}{4}.(0{,}04^2 - 0{,}022^2)} = 79{,}863\ MPa$ ✓✓✓✓ (4)

1.2 $\sigma_{min} = \frac{F}{A_{max}} = \frac{70\ 000}{\frac{\pi}{4}.(0{,}04^2)} = 55{,}704\ MPa$ ✓✓✓ (3)

1.3 $\varepsilon_H = \frac{\sigma_H}{E} = \frac{79{,}863 \times 10^6}{190 \times 10^9} = 4{,}203 \times 10^{-4}$ ✓✓

$\varepsilon_S = \frac{\sigma_S}{E} = \frac{55{,}704 \times 10^6}{190 \times 10^9} = 2{,}932 \times 10^{-4}$ ✓✓

$\varepsilon_T = \varepsilon_H + \varepsilon_S = 4{,}203 \times 10^{-4} + 2{,}932 \times 10^{-4} = 7{,}135 \times 10^{-4}$ ✓✓ (7)

1.4 $X_H = \frac{\varepsilon_H}{L} = \frac{4{,}203 \times 10^{-4}}{(0{,}124 - 0{,}08)} = 9{,}552 \times 10^{-3}$ ✓✓✓✓ (4)

1.5 $U_H = \frac{1}{2}.F.X_H = \frac{1}{2}.(70\ 000).\left(9{,}552 \times 10^{-3}\right) = 334{,}32\ J$ ✓✓✓✓ (4)

[22]

QUESTION 2

2.1 $A_S = \frac{\pi}{4}.\left(0{,}015^2\right).3 = 5{,}301 \times 10^{-4}\ m^2$

$A_T = \frac{\pi}{4}.\left(0{,}15^2\right) = 17{,}671 \times 10^{-3}\ m^2$

$A_C = A_T - A_S = 17{,}141 \times 10^{-3}\ m^2$ ✓

$F_T = F_C + F_S = 300\ 000\ N$ ✓

$X_C = X_S$

$\frac{F_C.L_C}{A_C.E_C} = \frac{F_S.L_S}{A_S.E_S}$ ✓

$\therefore F_C = \left(\frac{17{,}141 \times 10^{-4}.\ (18 \times 10^9)}{5{,}301 \times 10^{-4}.\ (210 \times 10^9)}\right).F_S$ ✓

$\therefore F_C = 0{,}277.F_S$ ✓

$F_T = 0{,}277.F_S + F_S = 300\ 000\ N$ ✓

$\therefore F_S = 234\ 896{,}058\ N$ ✓

$\therefore F_C = 300\ 000 - 234\ 896{,}058 = 65\ 103{,}943\ N$ ✓

$\therefore \sigma_C = \frac{65\ 103{,}943}{17{,}141 \times 10^{-3}} = 3{,}798\ MPa$ ✓✓

$\therefore \sigma_S = \frac{234\ 896{,}058}{5{,}301 \times 10^{-4}} = 443{,}117\ MPa$ ✓✓

(14)

2.2 $X_C = X_S$ ✓

$\frac{\sigma_c.L_C}{E_C} = \frac{\sigma_S.L_S}{E_S}$ ✓

$\therefore \sigma_S = \frac{210 \times 10^9.(6{,}23 \times 10^6)}{18 \times 10^9} = 72{,}683\ MPa$ ✓

$F_C + F_S = 800\ 000$ ✓

$\sigma_C.A_C + \sigma_S.A_S = 800\ 000$

$6{,}23 \times 10^6.(0{,}0176 - A_S) + 72{,}683 \times 10^6.A_S = 800\ 000$ ✓ ✓

$\therefore A_S = \frac{800\ 000 - 109\ 648}{66{,}453 \times 10^6} = 10{,}389 \times 10^{-3}\ m^2$ ✓ (8)

2.3 $m = \frac{E_S}{E_C} = \frac{210}{18} = 11{,}667 \approx 12$ ✓ ✓ ✓

(Steel is 12 x stronger than concrete) (3)

[25]

QUESTION 3

$t = \frac{p_i.D}{2.\sigma_t.\eta} = \frac{4 \times 10^6.(3{,}2)}{2.(120 \times 10^6).(0{,}75)} = 0{,}071\ m = 71{,}111\ mm$ ✓ ✓ ✓ ✓

(4)

[4]

QUESTION 4

4.1

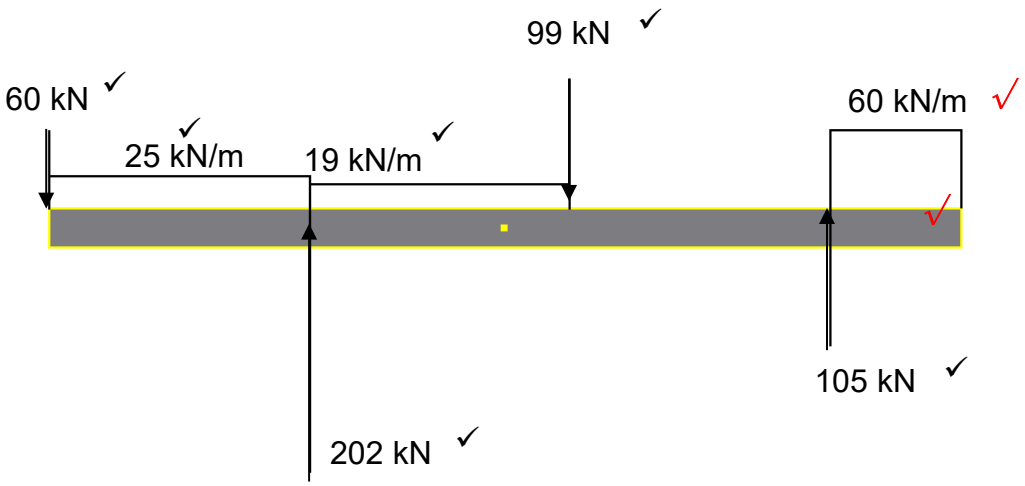

FIGURE 1 (8)

4.2 $BM_B = 60.(2) + 25.(2).\left(\frac{2}{2}\right) = 170\ kN/m$ ✓ ✓

$BM_C = 60.(4) + 25.(2).\left(\frac{2}{2} + 2\right) - 202.(2) + 19.(2).\left(\frac{2}{2}\right) = 24\ kN/m$ ✓ ✓ ✓

(5)

[13]

QUESTION 5

$I_{X1} = \frac{1}{12}.(0{,}1).\left(0{,}006^3\right) = 18 \times 10^{-9}$
$I_{X2} = 15{,}13 \times 10^{-6}$ ✓
$I_{XT} = 2.\left(18 \times 10^{-9}\right) + 15{,}13 \times 10^{-6} = 15{,}134 \times 10^{-6}$ ✓ ✓ ✓

$I_{X1} = \frac{1}{12}.(0{,}006).\left(0{,}1^3\right) = 0{,}5 \times 10^{-6}$
$I_{Y2} = 1{,}385 \times 10^{-6}$ ✓
$I_{YT} = 2.\left(0{,}5 \times 10^{-6}\right) + 1{,}385 \times 10^{-6} = 2{,}385 \times 10^{-6}$ ✓ ✓

$\therefore I_{least} = 2{,}385 \times 10^{-6}$ ✓

$A_T = 2.(0{,}1 \times 0{,}006) + 2{,}73 \times 10^{-3} = 3{,}93 \times 10^{-3}$
$L_E = 12 \times 0{,}5 = 6\,m$ ✓ ✓

$k = \sqrt{\frac{2{,}385 \times 10^{-6}}{3{,}93 \times 10^{-3}}} = 0{,}025$ ✓ ✓
$SR = \frac{6}{0{,}025} = 243{,}559$ ✓ ✓

$P_R = \frac{\sigma.A}{1+a.(SR^2)} = \frac{125 \times 10^6 .(3{,}93 \times 10^{-3})}{1+a.(243{,}559^2)} = 110\,000\,N$ ✓ ✓ ✓
$\therefore a = 5{,}843 \times 10^{-5}$ ✓ **[19]**

QUESTION 6

Consider the shear stress limit:
$T = \frac{\pi.D^3.\tau}{16} = \frac{\pi.(0{,}063^3).(55 \times 10^6)}{16} = 2700{,}314\,Nm$ ✓ ✓ ✓

Consider the angle of twist limit:
$T = \frac{\pi.D^4.G.\theta}{32.L} = \frac{\pi.(0{,}063^4).(70 \times 10^9).\left(\frac{1}{57{,}3}\right)}{32.(0{,}6)} = 3\,148{,}867\,Nm$ ✓ ✓ ✓ ✓

Maximum torque:
$T = 2\,700{,}314\,Nm\ (smalled\ value)$ ✓

The smaller torque value will ensure that both shear stress and angle of twist are within the given limits. ✓ ✓ **[10]**

QUESTION 7

7.1	• Protective coating; • Cathodic protection	(Any other relevant answer)	(2)
7.2	• Electroplating • Galvanising • Anodising • Chroming • Metal spray •	(Any other relevant answer)	(5) **[7]**
		TOTAL:	**100**