higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

STRENGTH OF MATERIALS AND STRUCTURES N5

24 NOVEMBER 2016

This marking guideline consists of 8 pages.

QUESTION 1

1.1 $\sigma = \frac{F}{A} = \frac{78\times10^3\times4}{\pi\times25^{-2}}\surd = 158{,}9MPa\surd$

1.2 $E = \frac{\sigma}{\varepsilon} = \frac{F\times l}{A\times x} = \frac{78\times10^3\times50\times4}{\pi\times25^2\times0{,}051}\surd = 155{,}78GPa\surd$

1.3 $\sigma = \frac{F}{A} = \frac{158\times10^3\times4}{\pi\times25^2}\surd = 321{,}87MPa\surd$

1.4 $\%\,elongation = \frac{l_f - l_o}{l_o} = \frac{60{,}1-50\surd}{50}\times 100 = 20{,}2\%\surd$

1.5 $ea = \frac{A_0 - A_1}{A_0} = \frac{25^2-18^2\surd}{25^2}\times \%\,reduction\ in\ ar100 = 48{,}16\%$

(5 × 2) **[10]**

QUESTION 2

Initial stress in the rod

$$F_{rod} = F_{pipe}$$
$$\sigma_r \times A_r = \sigma_p \times A_p$$
$$\sigma_r = \frac{\sigma_p \times A_p}{A_r}$$
$$\sigma_r = \frac{13\times(38^2-26^2)}{22^2}\surd = 20{,}63MPa\surd$$

(2)

For the increased stress

$$F_p = F_r$$
$$\sigma_p \times A_p = \sigma_r \times A_r$$
$$\sigma_p = \frac{\sigma_r \times A_r}{A_p}$$
$$\sigma_p = \frac{\sigma_r \times 22^2\surd}{(38^2-26^2)}\surd = 0{,}63\sigma_r\surd$$

$$\Delta l_t = \Delta l_p + \Delta l_s$$
$$= \frac{\sigma_p \times l_p}{E_p} + \frac{\sigma_r \times l_r}{E_s}$$
$$1{,}5\times10^{-3}\surd = \frac{0{,}63\sigma_r \times 1{,}3}{200\times10^9}\surd + \frac{\sigma_r \times 1{,}3}{200\times10^9}\surd$$

$$\sigma_r = 141{,}58MPa\surd \qquad \sigma_p = 89{,}19MPa\surd$$

(8)
[10]

QUESTION 3

3.1

$$\frac{\sigma_s \times l_s}{E_s} + \frac{\sigma_c \times l_c}{E_c} = l \times \Delta t_c(\alpha_c - \alpha_s)$$

$$\frac{\sigma_s}{E_s} + \frac{\sigma_c}{E_c} = \Delta t_c(\alpha_c - \alpha_s)$$

$$F_s = F_c$$

$$\sigma_s A_s = \sigma_c A_c$$

$$\sigma_s = \frac{\sigma_c A_c}{A_s}$$

$$\sigma_s = \frac{\sigma_c \times 500\surd}{1480} = 0{,}3378\sigma_c\surd$$

$$\frac{0{,}3378\sigma_c}{200 \times 10^9}\surd + \frac{\sigma_c}{110 \times 10^9}\surd = 90(18 \times 10^{-6} - 12 \times 10^{-6})\surd$$

$$\sigma_c = 50{,}1MPa\surd \quad \sigma_s = 16{,}9MPa\surd$$

(6)

3.2 *Final length*

Consider steel

$$\Delta l_t = l_o \times \alpha_s \times \Delta t + x_s$$

$$\Delta l_t = 0{,}86 \times 12 \times 10^{-6} \times 90\surd + \frac{1{,}9 \times 10^6 \times 0{,}86}{200 \times 10^9}\surd$$

$$\Delta l_t = 0{,}00100147m\surd$$

$$l_f = 0{,}86 + 0{,}00100147 = 861mm\surd$$

(4)
[10]

QUESTION 4

$$W(h+x_1+x_2)=\frac{F^2\times l_1}{2A_1E}+\frac{F^2\times l_1}{2A_1E}$$
$$95\left(0{,}2+\frac{F\times l_1}{A_1E}+\frac{F\times l_2}{A_2E}\right)=\frac{F^2\times l_1}{2A_1E}+\frac{F^2\times l_2}{2A_2E}$$
$$95\left(0{,}2\surd+\frac{F\times 0{,}7\times 4}{\pi\times 0{,}018^2\times 210\times 10^9}\surd+\frac{F\times 0{,}3\times 4}{\pi\times 0{,}012^2\times 210\times 10^9}\surd\right)$$
$$=\frac{F^2\times 0{,}7\times 4}{2\pi\times 0{,}018^2\times 210\times 10^9}\surd+\frac{F^2\times 0{,}3\times 4}{2\pi\times 0{,}012^2\times 210\times 10^9}\surd$$

$$1{,}28965\times 10^{-6}F^2\surd-2{,}444\times 10^{-6}F^{-6}\surd-19=0$$ (9)

$$F=\frac{-(-2{,}444\times 10^{-6}\pm\sqrt{(-2{,}444\times 10^{-6})^2}-4\times 1{,}2865\times 10^{-8}\times(-19)}{2\times(1{,}2865\times 10^{-8})}$$
$$F=\frac{2{,}444\times 10^{-6}\pm 9{,}8881\times 10^{-4}}{2{,}573\times 10^{-8}}\surd=38{,}528kN\surd$$

$\sigma_{max}=\frac{38{,}525\times 10^3\times 4}{\pi\times 12^2}$ =340,64 MPa√

$$u_t=u_1+u_2$$

$$u_t=\frac{F^2\times l_1}{2A_1E}+\frac{F^2\times l_2}{2A_2E}$$
$$u_t=\frac{(38{,}525\times 10^3)^2\times 4}{2\pi\times 0{,}018^2\times 210\times 10^9}\surd\left(\frac{0{,}7}{0{,}018^2}\surd+\frac{0{,}3}{0{,}012^2}\surd\right)$$
$$=19{,}094J\surd$$ (4)

[13]

QUESTION 5

5.1

$$\theta=\frac{10{,}2\times T\times l}{Gd^4}$$
$$\frac{1}{57{,}3}\surd=\frac{10{,}2\times T\times 0{,}45}{0{,}85\times 10^9\times 0{,}03^4}\surd$$
$$T=261{,}78N.m\surd$$
$$T=\frac{\pi}{16}\times 56\times 10^6\times 0{,}03^3\surd$$
$$T=296{,}88N.m\surd$$
$$\therefore \textit{The torque to be applied is } 261{,}78N.m\surd$$ (6)

5.2 $T = \frac{\pi}{16}\tau \times d^3$

$261{,}78\surd = \frac{\pi}{16}\tau \times 0{,}03^3$

$\tau = 49{,}38MPa\surd$ (2)

5.3 $P = \frac{2\pi NT}{60}$

$P = \frac{2\pi \times 1200261{,}78}{60}\surd$

$P = 32{,}896kW\surd$ (2)

[10]

QUESTION 6

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

$I = \frac{\pi}{64}(0{,}214^4 - 0{,}018^4)\surd$

$I = 102{,}9445 \times 10^{-6} m^4\surd$ (2)

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

$k = \sqrt{\frac{(102{,}9445 \times 10^{-6}) \times 4}{(0{,}214^2 - 0{,}018^2)}}\surd$

$k = 2{,}8825 \times 10^{-3} m\surd$ (2)

$I = \frac{\sigma_c \times A}{1 + a\left(\frac{L}{K}\right)^2}$

$I = \frac{520 \times 10^6 \times \frac{\pi}{4} \times (0{,}214^2 - 0{,}018^2)\surd}{1 + \frac{1}{1600}\surd\left(\frac{5{,}42}{2{,}8825 \times 10^{-3}}\right)^2\surd}$

$I = 2{,}536MN\surd$ (4)

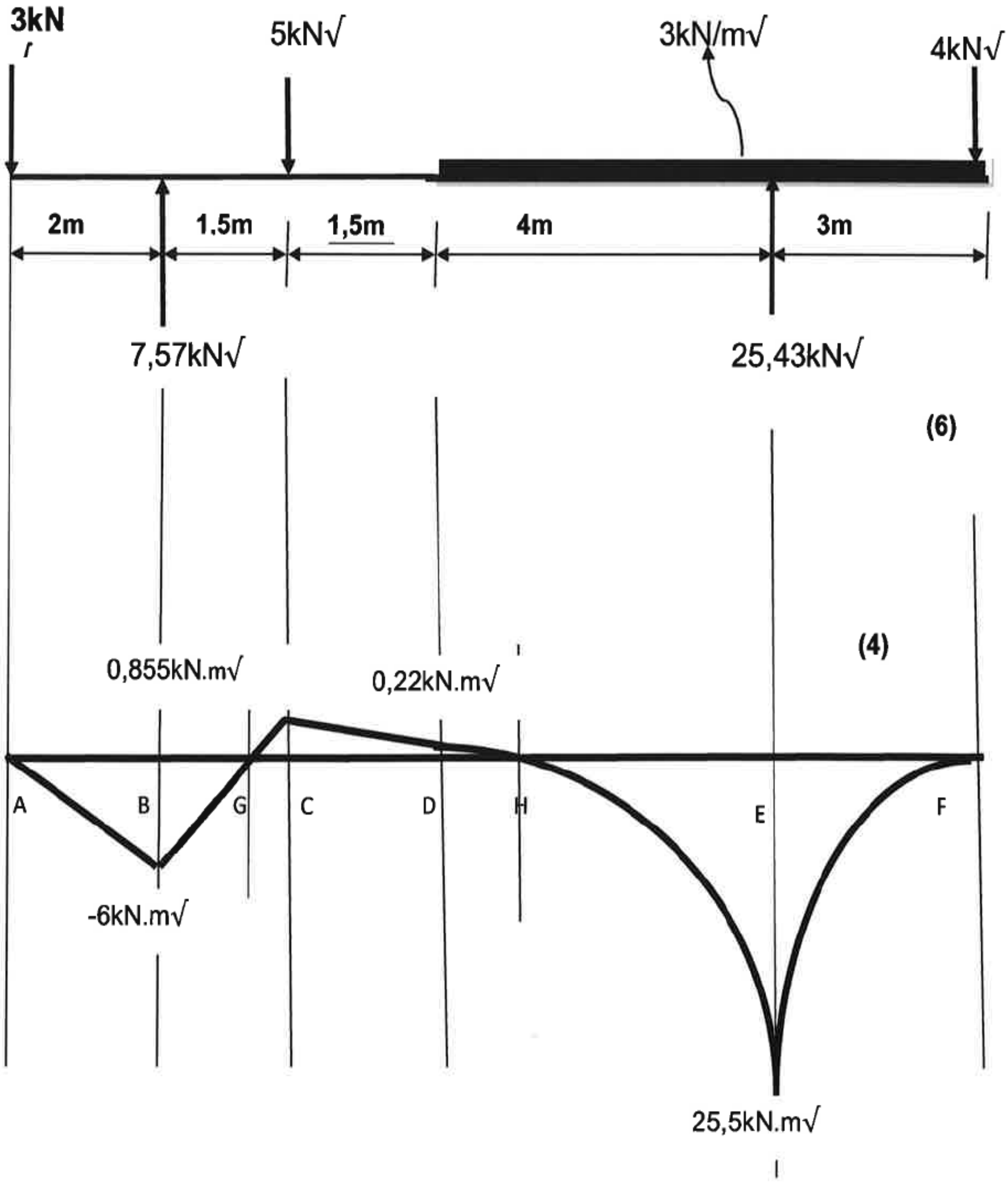
$\therefore Applied\ load = \frac{2{,}536}{3}\surd$

$= 845{,}373kN\surd$ (2)

[10]

QUESTION 7

7.1



7.2

BMb = -3 × 2 = -6 kNm√
BMc = -3 × 3,5 + 7,57 × 1,5 = 0,855 kNm√
BMd = -4 × 7 – 3 × 7^2/2 + 25,43 × 4 = 0,22 kNm√
BMe = -4 × 3 – 3 × 3^2/2 = -25,5 kNm√ (4)

7.3 **Point of inflection**

$$BM_G = 0$$

$-3x\surd + 7{,}57(x - 2)\surd = 0$
$-3x + 7{,}57x = 15{,}14$
$x = 3{,}313\text{m from the left support}\surd$ (3)

$BM_H = 0$
$-4 \times x - \frac{3x^2}{2}\surd + 25{,}43(x - 3)\surd = 0$
$-4 \times x - 1{,}5x^2 + 25{,}43x - 76{,}29 = 0$
$-1{,}5x^2 + 21{,}43x - 76{,}29 = 0$
$-1{,}5x^2 + 21{,}43x - 76{,}29 = 0$

$$x = \frac{-21{,}43 \pm \sqrt{21{,}43^2 - (4x)(-1{,}5)(-76{,}29)}}{-2(-1{,}5)}$$

$$= \frac{-21{,}43 \pm 1{,}2267}{-3}$$

$x = 7{,}64m$ $(\textit{outside boundries})$ or 6,73 m from the right
or 5,266 m from the left√ (3)

7.4 $Z = \frac{2{,}5 \times 10^3\surd}{60 \times 10^6} = 425 \times 10^{-6} m^3\surd$

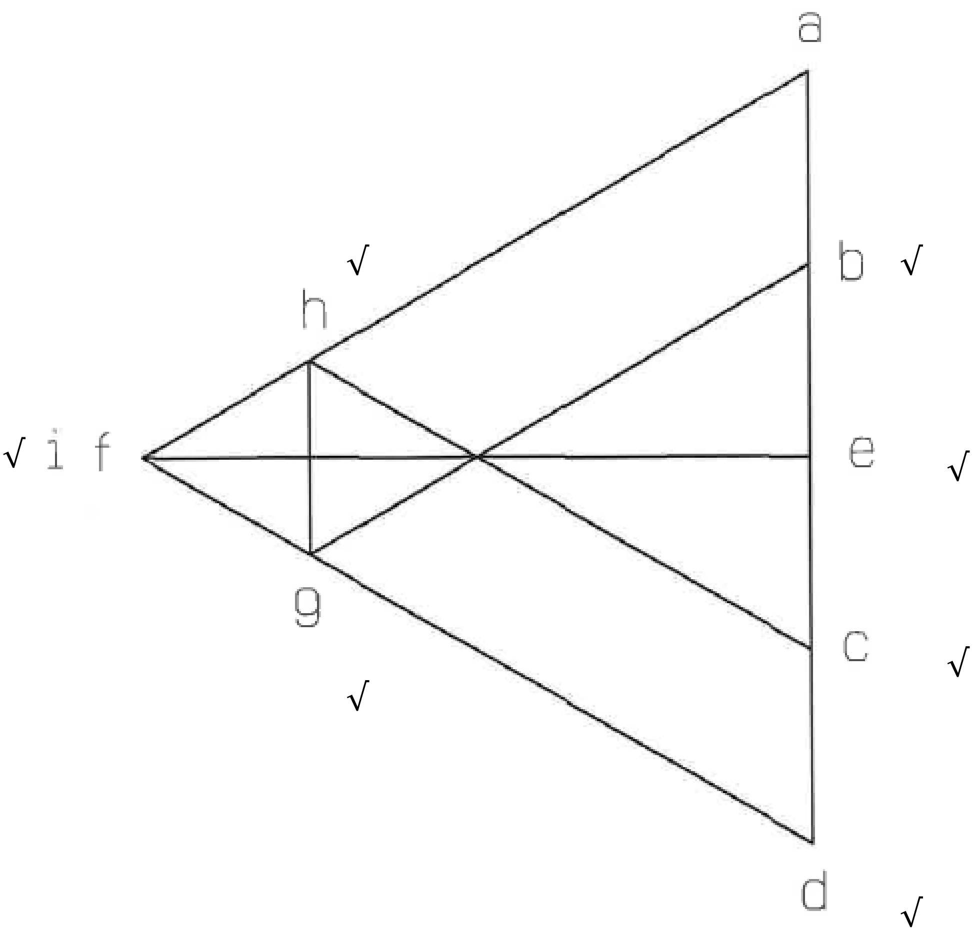
Selected beam is 254 × 146 × 37,2 kg/m channel√ (3)

7.5 $\sigma = \frac{m}{z} = \frac{25{,}5x10^3}{433x10^{-6}}\surd = 58{,}86\text{MPa}\surd$ (2)

[25]

QUESTION 8

8.1



(7)

8.2 AF = 20 kN (S)
FG = 5 kN (S)
BG = 15 kN (S)
GH = 5 kN (S)
FE = 17 kN (S)

(5)
[12]

TOTAL: 100