higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

STRENGTH OF MATERIALS AND STRUCTURES N6

29 November 2022

This marking guideline consists of 8 pages.

MJ

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QUESTION 1

1.1 Solied Shaft

$\sigma_{H_{MAX}} = 160MPa\ (c) = \sigma_{R_{MAX}}$ ✓

$Cast\ iron\ hub$

$\sigma_{H_{MAX}} = -120 \times 10^6 = a - \frac{b}{{d_c}^2}$

$= -120 \times 10^6 = a - \frac{b}{(0,1)^2}$

$= -120 \times 10^6 = a - 100b \ldots\ldots\ldots\ldots\ldots (1)$ ✓

$\sigma_{R_{MIN}} = 0 = a + \frac{b}{D^2}$

$= 0 = a + \frac{b}{(0,14)^2}$

$= a = -51,02b \ldots\ldots\ldots\ldots\ldots (2)$ ✓

$eq\ (2) in\ eq\ (1)$

$-120 \times 10^6 = -51,02b - 100b$

$b = 794,597 \times 10^3$ ✓

$\therefore a = -51,02(794597) = -40,54 \times 10^6$ ✓

$\sigma_{R_{MAX}} = a + \frac{b}{{d_c}^2} = -40,54 \times 10^6 + \frac{794,597 \times 10^3}{(0,1)^2}$ ✓

$= 38,92MPa$ ✓

$\therefore \sigma_{Radial_{max}}\ for\ both\ hub\ and\ shaft = 38,92MPa$ ✓ (8)

1.2 $F_\mu = P_o \times (\pi D_c L) \times \mu$

$= (38,92 \times 10^6)(\pi)(0,1)(0,11)(0,25)$ ✓

$= 336,242kN$ ✓ (2)

1.3 $T_\mu = F_\mu \times \frac{D_c}{2} = (336242)\left(\frac{0,1}{2}\right) = 16,812kNm$ ✓

(1)
[11]

QUESTION 2

$$I = \frac{\pi}{64}(D^4 - d^4) = \frac{\pi}{64}(2^4 - d^4) = 785{,}398 \times 10^{-3} - 49{,}087 \times 10^{-3}d^4 \checkmark$$

$$W = \rho g v = (7800)(9{,}81)(4)A = 306{,}072 \times 10^3 A\ N \checkmark$$

$$\sigma_D = \frac{W}{A} = \frac{306{,}072 \times 10^3 A}{A} = 306{,}072\ kPa \checkmark$$

$$A_{eff} = 0{,}6A_p = 0{,}6(2 \times 4) = 4{,}8\ m^2 \checkmark$$

$$F_{wind} = PA_{eff} = (2{,}5 \times 10^3)(4{,}8) = 12\ kN \checkmark$$

$$M = F \times e = (12 \times 10^3)(2) = 24\ kNm \checkmark$$

$$\sigma_B = \frac{M_{\bar{y}}}{I} = \frac{(24 \times 10^3)(1) \checkmark}{785{,}398 \times 10^{-3} - 49{,}087 \times 10^{-3}d^4}$$

$$= \frac{24 \times 10^3}{785{,}398 \times 10^{-3} - 49{,}087 \times 10^{-3}d^4} \checkmark$$

$$\sigma_D = \sigma_B$$

$$306{,}072 \times 10^3 = \frac{24 \times 10^3}{785{,}398 \times 10^{-3} - 49{,}087 \times 10^{-3}d^4} \checkmark$$

$$785{,}398 \times 10^{-3} - 49{,}087 \times 10^{-3}d^4 = 78{,}413 \times 10^{-3} \checkmark$$

$$d^4 = 14{,}403$$

$$d = 1{,}948\ m \checkmark$$

$$t = \frac{D - d}{2} = \frac{2 - 1{,}948}{2} = 26\ mm \checkmark$$ **[12]**

QUESTION 3

3.1

$$M = \frac{w\ell^2}{2} - \frac{w\ell^2}{2} = \frac{2 \times 10^3}{2}(4^2 - 2^2) \checkmark = 12\ kNm \checkmark$$

$$Z_{total} = \frac{M}{\sigma_B} = \frac{12 \times 10^3}{120 \times 10^6} = 100 \times 10^{-6} m^3 \checkmark$$

$$Z_{each} = \frac{100 \times 10^{-6}}{2} = 50 \times 10^{-6} m^3 \checkmark$$

$$120 \times 55 \times 13{,}4\ kg/m \checkmark$$ (5)

3.2 $\Delta = \left[\frac{w\ell^4}{8EI} + \frac{w\ell^3}{6EI} \times \ell\right] - [\frac{w\ell^4}{8EI} + \frac{w\ell^3}{6EI} \times \ell$

$11 \times 10^{-3} = \left[\frac{(2\times10^3)(4^4)}{8(200\times10^9)I} + \frac{(2\times10^3)(4^3)}{6(200\times10^9)} \times 2\right]$✓

$-[\frac{(2\times10^3)(2^4)}{8(200\times10^9)I} + \frac{(2\times10^3)(2^3)}{6(200\times10^9)I} \times 4]$ ✓

$11 \times 10^{-3} = \frac{533{,}333 \times 10^{-9}}{I} - \frac{73{,}333 \times 10^{-9}}{I}$ ✓

$I_{total} = 41{,}818 \times 10^{-6}\ m^4$ ✓

$I_{each} = 20{,}909 \times 10^{-6}\ m^4$ ✓

$220 \times 80 \times 29{,}4\ kg/m$ ✓ (6)

3.3 $220 \times 80 \times 29{,}4\ kg/m$ ✓$satify\ both\ conditions$ ✓ (2)
[13]

QUESTION 4

4.1 $F_{t_A} = wy_A$

$Y_A = \frac{360}{12} = 30\ m$ ✓

$Y_B = Y_A - h = 30 - 5 = 25\ m$ ✓

$Y_A{}^2 = Y_O{}^2 + \ell_A{}^2$

$30^2 = Y_O{}^2 + \ell_A{}^2 \ldots\ldots\ldots\ldots (1)$ ✓

$Y_B{}^2 = Y_O{}^2 + \ell_B{}^2$

$25^2 = Y_O{}^2 + (40 - \ell_A)^2 \ldots\ldots\ldots\ldots (2)$ ✓

$eq\ (1) - eq\ (2)$

$30^2 - 25^2 = \ell_A{}^2 - (40 - \ell_A)^2$ ✓

$275 = \ell_A{}^2 - 1600 + 80\ell_A - \ell_A{}^2$

$\ell_A = 23{,}438\ m$ ✓

$30^2 = Y_O{}^2 + (23{,}438)^2$

$Y_O = 18{,}73\ m$ ✓

$d = Y_B - Y_O = 25 - 18{,}73 = 6{,}27\ m$ ✓ (8)

4.2 $\ell_A = Y_O \tan\theta$

$\theta = \tan^{-1}(\frac{23,438}{18,73})$ ✓ $= 51,37°$ ✓ (2)

[10]

QUESTION 5

5.1 $W_T = \sigma_1 \times A_f = (160 \times 10^3)(4^2) = 2,56\ MN$ ✓

$W = W_T - W_f = 2,56 \times 10^6 - (20 \times 1000 \times 9,81) = 2363,8\ kN$ ✓

$M = \frac{W}{8L}(L - \ell)^2 = \frac{2363.8 \times 10^3}{8(4)}(4 - 0,8)^2 = 756,416\ kNm$ ✓ (3)

5.2 $Z = \frac{M}{\sigma_B \times n_t} = \frac{756416}{(180 \times 10^6)(4)} = 1050,58 \times 10^{-6} m^3$ ✓

$406 \times 178 \times 59,8\ kg/m$ ✓ (2)

5.3 $w = b \times n_t + spacing(n_t - 1)$
$= 177,6 \times 4 + 75(4 - 1)$ ✓
$= 935,4\ mm$ ✓ (2)

5.4 $M = \frac{W}{8L}[L - \ell]^2$

$= \frac{2363,8 \times 10^3}{8(4)}[4 - 0,9354]^2$

$= 693,759\ kNm$ ✓

$Z_e = \frac{M}{\sigma_B \times n_b} = \frac{693759}{(180 \times 10^6)(12)} = 321,185 \times 10^{-6}\ m^3$ ✓

$305 \times 102 \times 28,6\ kg/m$ ✓ (3)

5.5 $SF = \frac{W}{2L}[L - \ell]$

$= \frac{2363,8 \times 10^3}{2(4)}[4 - 0,8] = 945,52\ kN$ ✓

$A = htn_t$

$= (406,4 \times 10^{-3})(7,8 \times 10^{-3})(4) = 12,68 \times 10^{-3} m^2$ ✓

$\tau = \frac{SF}{A} = \frac{945,52 \times 10^3}{12,68 \times 10^{-3}} = 74,568\ MPa$ ✓ (3)

5.6 $SF = \frac{W}{2L}[L - \ell]$

$= \frac{2363,8\times10^3}{2(4)}[4 - 0,9354] = 905,513kN$ ✓

$A = htn_b$

$= (308,9 \times 10^{-3})(6,1 \times 10^{-3})(12) = 22,612 \times 10^{-3}m^2$ ✓

$$\tau = \frac{SF}{A} = \frac{905,513 \times 10^3}{22,612 \times 10^{-3}} = 40,046MPa$$ ✓

(3)
[16]

QUESTION 6

6.1 $W_1 = \rho gA\ell = 2200 \times 9,81 \times 3 \times 1 \times 1 = 64,746\ kN$ ✓
$W_2 = \rho gA\ell = 2200 \times 9,81 \times 2 \times 1 \times 1 = 43,164\ kN$ ✓
$W_g = \rho gA\ell = 1600 \times 9,81 \times 2 \times 0,8 \times 1 = 25,114\ kN$✓
$V = W_1 + W_2 + W_g = 133,024\ kN$ ✓ (4)

6.2 $W{\sim}M = W_1x_1 + W_2x_2 = 64746 \times 0,5 + 43164 \times 2\ + 25114 \times 2$✓
$= 168,929\ kNm$ ✓ (2)

6.3 $F{\sim}M = \frac{\rho gh^2C_\mu}{2} \times \frac{h}{3} + phC_\mu \times \frac{h}{2}$
$F{\sim}M = \frac{1600 \times 9,81 \times 1,8^2 \times 0,333}{2} \times 0,6$✓ $+ 2000 \times 1,8 \times 0,333 \times 0,9$ ✓
$F{\sim}M = 6167,304\ N$ ✓ (3)

6.4 $Vx + F{\sim}M = W{\sim}M$
$133024 \times x + 6167,304\ = 168929$ ✓
$x = 1,224\ m$ ✓
$e = \frac{B}{2} - x = 1,5 = 1,224 = 276\ mm$✓
$e < \frac{B}{6}\ \ \therefore the\ wall\ is\ safe\ against\ tension$✓ (4)
[13]

QUESTION 7

7.1

$A_s = \frac{\pi d^2}{4} \times N° = \frac{\pi(0,02)^2}{4} \times 5 = 1,571 \times 10^{-3} m^2$ ✓

$\frac{en^2}{2} = mA_s(d-n)$

$\frac{0,08n^2}{2} = \left(\frac{210}{14}\right)(1,571 \times 10^{-3})(0,67-n)$ ✓

$0,04n^2 = 15,789 \times 10^{-3} - 23,565 \times 10^{-3}n$ ✓

$n = 399,334\ mm$ ✓ (4)

7.2

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

$\frac{\sigma_s}{\sigma_c} = \frac{15(0,67-0,399334)}{0,3993334}$ ✓

$\sigma_s = 10,167\ \sigma_c$ ✓

$M_s = \sigma_s A_s(d-n)$

$M_s = \sigma_s(1,571 \times 10^{-3})(0,67-0,399334)$

$M_s = 0,5 \times 7 \times 10^6 \times 0,15 \times 0,129 \times 0,257$ ✓

$M_s = 425,216 \times 10^{-6}\sigma_s$ ✓

$M_c = \frac{1}{2}\sigma_c\ en\frac{2}{3}n$

$M_c = \frac{1}{2}\sigma_c(0,08)\frac{2}{3}(0,399334)^2$ ✓

$M_c = 4,252 \times 10^{-3}\sigma_c$ ✓

$M_{max} = M_c + M_s$

$140 \times 10^3 = 4,252 \times 10^{-3}\sigma_c + 425,216 \times 10^{-6}\sigma_s$ ✓

$140 \times 10^3 = 4,252 \times 10^{-3}\sigma_c + 425,216 \times 10^{-6}(10,167\ \sigma_c)$

$\sigma_c = 16,326 MPa$ ✓

$\sigma_s = 10,167\ (16,326) = 165,988 MPa$ ✓ (9)

[13]

QUESTION 8

8.1 $T_{MAX} = (T_1 - T_2)R = (2400 - 1000)0{,}15 = 210\ Nm$ ✓

$M_{MAX} = (T_1 + T_2)L = (2400 + 1000)0{,}15 = 544\ Nm$ ✓

$T_e = \sqrt{{T_{MAX}}^2 + {M_{MAX}}^2} = \sqrt{(210)^2 + (544)^2}$ ✓ $= 583{,}126\ Nm$ ✓ (4)

8.2 $T_e = \frac{\pi}{16} D^3 \tau_{MAX}$

$583{,}126 \times 10^{-6} = \frac{\pi}{16} D^3 (45 \times 10^6)$ ✓

$D^3 = 65{,}996 \times 10^{-6}$

$D = 40{,}412\ mm$ ✓ (2)

8.3 $M_e = \frac{1}{2}[M + T_e] = \frac{1}{2}[544 + 583{,}126]$ ✓ $= 563{,}563\ Nm$ ✓ (2)

8.4 $M_e = \frac{\pi}{32} D^3 \sigma_n$

$563{,}563 = \frac{\pi}{32} D^3$ ✓

$D^3 = 57{,}404 \times 10^{-6}$

$D = 38{,}576\ mm$ ✓ (2)

8.5 $D = 40{,}412\ mm$ ✓
It will withstand both stresses ✓ (2)
[12]

TOTAL: 100

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