



**higher education  
& training**

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

# **MARKING GUIDELINE**

**NATIONAL CERTIFICATE**

**NOVEMBER EXAMINATION**

**STRENGTH OF MATERIALS AND STRUCTURES N6**

**28 NOVEMBER 2016**

**This marking guideline consists of 9 pages.**

**QUESTION 1**

$$1.1 \quad \sigma_{Hmin} = \sigma_{Hmax} - \sigma_R = -130 + 80 = -50 \text{ MPa} \checkmark$$

$$\text{at } 250 \text{ mm: } -50 \times 10^6 = a - \frac{b}{0,25^2} \dots \dots \dots (1) \checkmark$$

$$0 = a + \frac{b}{0,25^2} \dots \dots \dots (2) \checkmark$$

$$(1) + (2): -50 \times 10^6 = 2a$$

$$a = -25 \times 10^6 \checkmark$$

$$b = 1,5625 \times 10^6 \checkmark$$

$$\text{at inner diameter: } 80 \times 10^6 = a + \frac{b}{d^2}$$

$$80 \times 10^6 = -25 \times 10^6 + \frac{1,5625 \times 10^6}{d^2} \checkmark$$

$$d = 0,122 \text{ m} \checkmark \quad (7)$$

$$1.2 \quad W = p \times A = 80 \times 10^6 \times \pi \times 0,061^2 \checkmark = 934,998 \text{ kN} \checkmark \quad (2)$$

$$1.3 \quad \sigma_L = \frac{pd^2}{D^2 - d^2} = \frac{80 \times 10^6 \times 0,122^2}{0,25^2 - 0,122^2} \checkmark = 25 \text{ MPa} \checkmark \quad (2)$$

$$1.4 \quad \delta d = \frac{d}{E} (\sigma_H - \nu \sigma_R) = \frac{0,122}{200 \times 10^9} (-50 \times 10^6 - 0,3 \times 0) \checkmark = -62,5 \times 10^{-6} \text{ m} \checkmark \quad (2)$$

**[13]**

**QUESTION 2**

2.1 *deflection limit:*  $y = \frac{wL^4}{8EI}$

$$12 \times 10^{-3} = \frac{4 \times 10^3 \times 5^4}{8 \times 200 \times 10^9 \times I} \checkmark$$

$$I = 130,208 \times 10^{-6} \text{ m}^4 \checkmark$$

*choose channel profile 381 x 102 x 55,1 kg/m* ✓

*stress limit:*  $M = \frac{wL^2}{2} = \frac{4 \times 10^3 \times 5^2}{2} = 50 \text{ kNm}$  ✓

$$z = \frac{M}{\sigma} = \frac{50 \times 10^3}{120 \times 10^6} = 416,667 \times 10^{-6} \text{ m}^3 \checkmark$$

*choose channel profile 280 x 95 x 41,8 kg/m* ✓

*correct channel for both limits is 381 x 102 x 55,1 kg/m* ✓ ✓ (8)

2.2  $y = \frac{wL^4}{8EI} = \frac{4 \times 10^3 \times 5^4}{8 \times 200 \times 10^9 \times 149,1 \times 10^{-6}} = 10,48 \text{ mm}$  ✓

$$\sigma = \frac{M}{z} = \frac{50 \times 10^3}{782,8 \times 10^{-6}} = 63,873 \text{ MPa}$$
 ✓ (2)

2.3  $y_1 = \frac{wl_1^4}{8EI} = \frac{4 \times 10^3 \times 4^4}{8 \times 200 \times 10^9 \times 149,1 \times 10^{-6}} = 4,292 \text{ mm}$  ✓

$$y_2 = \frac{wl_1^3 \times l_2}{6EI} = \frac{4 \times 10^3 \times 4^3 \times 1}{6 \times 200 \times 10^9 \times 149,1 \times 10^{-6}} = 1,431 \text{ mm}$$
 ✓

$$y_T = y_1 + y_2 = 4,292 + 1,431 = 5,732 \text{ mm}$$
 ✓ (3)

**[13]**

**QUESTION 3**

$$3.1 \quad A = \pi(R^2 - r^2) = \pi(0,05^2 - 0,025^2) = 5,89 \times 10^{-3} \text{ m}^2 \checkmark$$

$$\sigma_{Rmin} = \sigma_d - \sigma_b = 0$$

$$\sigma_d = \sigma_b \dots \dots \dots (1) \checkmark$$

$$\sigma_{Rmax} = \sigma_d + \sigma_b \dots \dots \dots (2) \checkmark$$

$$(1) \text{ into } (2): 80 = \sigma_d + \sigma_d$$

$$\sigma_d = 40 \text{ MPa} \checkmark$$

$$F = \sigma_d \times A = 40 \times 10^6 \times 5,89 \times 10^{-3} = 235,619 \text{ kN} \checkmark \quad (5)$$

$$3.2 \quad I = \frac{\pi}{64} (D^4 - d^4) = \frac{\pi}{64} (0,1^4 - 0,05^4) = 4,602 \times 10^{-6} \text{ m}^4 \checkmark$$

$$\sigma_b = \sigma_d = 40 \text{ MPa} \checkmark$$

$$M = \frac{\sigma_b \times I}{Y} = \frac{40 \times 10^6 \times 4,602 \times 10^{-6}}{0,05} = 3,682 \text{ kNm} \checkmark$$

$$L = \sqrt{\frac{8M}{w}} = \sqrt{\frac{8 \times 3,682 \times 10^3}{500}} = 7,675 \text{ m} \checkmark$$

(4)  
[9]

**QUESTION 4**

$$4.1 \quad F_w = \frac{\rho g h^2}{2} = \frac{1\,000 \times 9,81 \times 4^2}{2} = 78,48 \text{ kN} \checkmark$$

$$W_1 = \rho g A l = 2\,100 \times 9,81 \times 0,5 \times 1 \times 4 = 41,202 \text{ kN} \checkmark$$

$$W_2 = \rho g A l = 2\,100 \times 9,81 \times 2 \times 4 = 164,808 \text{ kN} \checkmark$$

$$V = W_1 + W_2 = 41,202 + 164,808 = 206,01 \text{ kN} \checkmark \quad (4)$$

$$4.2 \quad F \sim M = F_w \times \frac{h}{3} = 78,48 \times \frac{4}{3} = 104,64 \text{ kNm} \checkmark$$

$$W \sim M = W_1 x_1 + W_2 x_2 = 41,202 \times 0,667 + 104,808 \times 2 \checkmark = 357,084 \text{ kNm} \checkmark \quad (3)$$

$$4.3 \quad Vx + F \sim M = W \sim M$$

$$206,01x + 104,64 = 357,084 \checkmark$$

$$x = 1,225 \text{ m from toe} \checkmark$$

$$\text{no tension because } x > \frac{B}{3} \checkmark \quad (3)$$

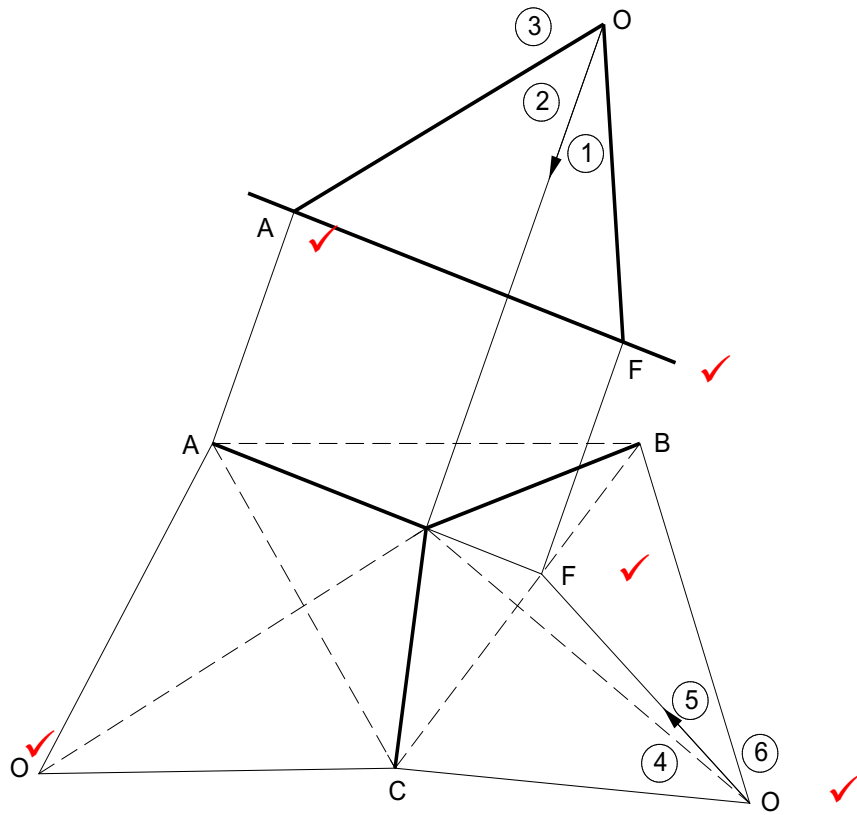
$$4.4 \quad e = 0,5B - x = 1,5 - 1,225 = 0,275 \text{ m} \checkmark$$

$$\sigma_{max} = \frac{V}{B} + \frac{6Ve}{B^2} = \frac{206,01}{3} + \frac{6 \times 206,01 \times 0,2275}{3^2} = 106,384 \text{ kPa} \checkmark \quad (2)$$

**[12]**

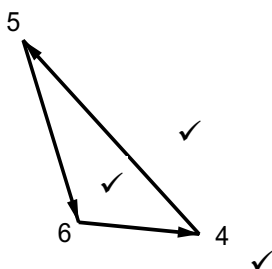
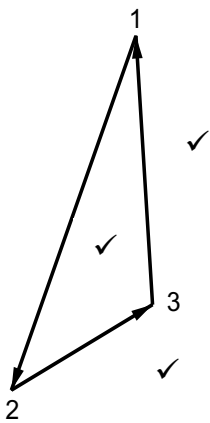
**QUESTION 5**

5.1



(6)

5.2



| MEMBERS  | MAGNITUDE | NATURE |
|----------|-----------|--------|
| OA (2-3) | 22,8 kN√  | Strut√ |
| OB (5-6) | 17 kN√    | Strut√ |
| OC (6-4) | 25,3 kN√  | Strut√ |

(9)  
[15]**QUESTION 6**

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

$$\frac{140}{5} = \frac{15(0,8-n)}{n} \quad \checkmark$$

$$n = 0,279 \text{ m} \quad \checkmark$$

(2)

$$6.2 \quad M_s = \sigma_s A_s (d-n) = 140 \times 10^6 \times 680 \times 10^{-6} (0,8 - 0,279) \quad \checkmark = 49,593 \text{ kNm} \quad \checkmark$$

$$M_c = M - M_s = 150 - 49,593 = 100,407 \text{ kNm} \quad \checkmark$$

(3)

$$6.3 \quad \sigma_{c1} = \frac{\sigma_c(n-t)}{n} = \frac{5(0,279-0,25)}{0,25} \quad \checkmark = 0,521 \text{ MPa} \quad \checkmark$$

(2)

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

$$100\,407 = \frac{5 \times 10^6 \times b \times 0,279^2}{3} - \frac{0,521 \times 10^6 \times (b-0,35)(0,279-0,25)^2}{3} \quad \checkmark$$

$$100\,407 = 129\,779,8918b \quad \checkmark - 146,71b \quad \checkmark + 51,349 \quad \checkmark$$

$$b = 0,774 \text{ m} \quad \checkmark$$

(5)  
[12]

**QUESTION 7**

7.1

$$F_H = \frac{wx_1^2}{2d}$$

$$1\,239 = \frac{5x_1^2}{2d} \quad \checkmark$$

$$d = 2,0178 \times 10^{-3} x_1^2 \dots \dots \dots (1) \checkmark$$

$$F_H = \frac{w(L - x_1)^2}{2(d + h)}$$

$$1\,239 = \frac{5(L - x_1)^2}{2(d + 7)} \dots \dots \dots (2) \checkmark$$

$$(1) \text{ into } (2): 1\,239 = \frac{5(L - x_1)^2}{2(2,0178 \times 10^{-3} x_1^2 + 7)} \checkmark$$

$$x_1^2 + 3\,469,2 = 12\,100 - 220x_1 + x_1^2 \quad \checkmark$$

$$x_1 = 39,231 \text{ m} \quad \checkmark$$

$$d = 2,0178 \times 10^{-3} \times 39,231 = 3,105 \text{ m} \checkmark \quad (7)$$

$$7.2 \quad x_2 = L - x_1 = 110 - 39,231 = 70,769 \text{ m} \checkmark$$

$$F_{V2} = wx_2 = 5 \times 70,769 = 353,845 \text{ kN} \checkmark$$

$$F_T = \sqrt{F_H^2 + F_V^2} = \sqrt{1\,239^2 + 353,845^2} = 1\,288,537 \text{ kN} \checkmark \quad (3)$$

$$7.3 \quad A = \frac{F_T}{\sigma} = \frac{1\,288,537 \times 10^3}{180 \times 10^6} = 7,159 \times 10^{-3} \text{ m}^2 \checkmark$$

$$d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4 \times 7,159 \times 10^{-3}}{\pi}} = 95,47 \text{ mm} \checkmark \quad (2)$$

$$7.4 \quad \theta = \tan^{-1} \frac{F_V}{F_H} = \tan^{-1} \frac{353,845}{1\,239} = 15,939^\circ \checkmark \quad (1)$$

**[13]**



**QUESTION 8**

$$8.1 \quad T_e = \sqrt{T^2 + M^2} = \sqrt{3^2 + 4^2} \checkmark = 5 \text{ kNm} \checkmark \quad (2)$$

$$8.2 \quad \tau = \frac{16T_e}{\pi d^3} = \frac{16 \times 5 \times 10^3}{\pi \times 0,1^3} \checkmark = 25,465 \text{ MPa} \checkmark \quad (2)$$

$$8.3 \quad M_e = 0,5 \left( M + \sqrt{T^2 + M^2} \right) = 0,5(4 + 5) \checkmark = 4,5 \text{ kNm} \checkmark \quad (2)$$

$$8.4 \quad \sigma_b = \frac{32M_e}{\pi d^3} = \frac{32 \times 4,5 \times 10^3}{\pi \times 0,1^3} \checkmark = 45,837 \text{ MPa} \checkmark \quad (2)$$

$$8.5 \quad T_m = \frac{T}{1,15} = \frac{3}{1,15} = 2,609 \text{ kNm} \checkmark$$

$$P = 2\pi NT_m = 2\pi \times 10 \times 2,609 = 163,909 \text{ kW} \checkmark \quad (2)$$

$$8.6 \quad \frac{D^4 - d^4}{D} = d^3$$

$$\frac{(2d)^4 - d^4}{2d} = 0,1^3 \checkmark$$

$$d = 51,0873 \text{ mm} \checkmark$$

$$D = 102,1746 \text{ mm} \checkmark$$

(3)  
[13]

**TOTAL: 100**