



**higher education  
& training**

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

# **NASIENRIGLYN**

**NATIONALE SERTIFIKAAT**

**STERKTE EN STRUKTUURLEER N6**

**11 APRIL 2018**

**Hierdie nasienriglyn bestaan uit 9 bladsye.**

## VRAAG 1

$$1.1 \quad \sigma_H = \varepsilon \times E = 168,75 \times 10^{-6} \times 200 \times 10^9 \checkmark = 33,75 \text{ MPa} \checkmark$$

$$\text{at } 125 \text{ mm} : a - \frac{b}{0,125^2} = -33,75 \times 10^6 \dots\dots\dots (1) \checkmark$$

$$\text{at } 125 \text{ mm} : a + \frac{b}{0,125^2} = 0 \dots\dots\dots (2) \checkmark$$

$$(1) + (2) : \quad 2a = -33,75 \times 10^6$$

$$a = -16,875 \times 10^6 \checkmark$$

$$b = 263,672 \times 10^3 \checkmark$$

$$\text{at } 75 \text{ mm} : \sigma_{Hmax} = a - \frac{b}{0,075^2}$$

$$= -16,875 \times 10^6 - \frac{263,672 \times 10^3}{0,075^2}$$

$$\sigma_{Hmax} = -63,75 \text{ MPa (tensile)} \checkmark \quad (7)$$

$$1.2 \quad \text{at } 75 \text{ mm} : \sigma_R = a + \frac{b}{0,075^2}$$

$$= -16,875 \times 10^6 + \frac{263,672 \times 10^3}{0,075^2}$$

$$\sigma_R = 30 \text{ MPa} \checkmark$$

$$\sigma_H = \sigma_R = 30 \text{ MPa} \checkmark \quad (2)$$

$$1.3 \quad \delta d_1 = \frac{D\varepsilon}{E} (\sigma_H - \nu \times \sigma_R)$$

$$= \frac{0,075}{200 \times 10^9} (30 \times 10^6 - 0,29 \times 30 \times 10^6)$$

$$\delta d_1 = 7,9875 \times 10^{-6} \text{ m} \checkmark \quad (1)$$

$$\begin{aligned}
 1.4 \quad \delta d_2 &= \frac{D_c}{E} (\sigma_H - \vartheta \times \sigma_R) \\
 &= \frac{0,075}{200 \times 10^9} (-63,75 \times 10^6 - 0,29 \times 30 \times 10^6) \\
 \delta d_2 &= -27,16875 \times 10^{-6} \text{ m } \checkmark
 \end{aligned} \tag{1}$$

$$\begin{aligned}
 1.5 \quad \Delta d &= \delta d_1 - \delta d_2 \\
 &= 7,9875 \times 10^{-6} - (-27,16875 \times 10^{-6}) \\
 \Delta d &= 35,156 \times 10^{-6} \text{ m } \checkmark
 \end{aligned} \tag{1}$$

**[12]**

**VRAAG 2**

$$\begin{aligned}
 2.1 \quad \Delta &= \frac{5wL^4}{384EI} \\
 0,016 &= \frac{5 \times 12 \times 10^3 \times 6^4}{384 \times 200 \times 10^9 \times I} \checkmark \\
 I &= 63,281 \times 10^{-6} \text{ m}^4 \checkmark = 31,641 \times 10^{-6} \text{ per beam } \checkmark \\
 \text{Choose } &200 \times 200 \times 24 \text{ kg/m } \checkmark
 \end{aligned} \tag{4}$$

$$\begin{aligned}
 2.2 \quad \Delta &= \frac{5wL^4}{384EI} \\
 &= \frac{5 \times 12 \times 10^3 \times 6^4}{384 \times 200 \times 10^9 \times 66,62 \times 10^{-6}} \checkmark \\
 \Delta &= 15,198 \text{ mm } \checkmark
 \end{aligned} \tag{2}$$

$$2.3 \quad M = \frac{wL^2}{8} = \frac{12 \times 10^3 \times 6^2}{8} = 54 \text{ kNm} \quad \checkmark$$

$$\sigma_{max} = \frac{MY}{I} = \frac{54 \times 10^3 \times 0,1416}{66,62 \times 10^{-6}} = 114,776 \text{ MPa} \quad \checkmark \text{ (tensile)} \quad \checkmark$$

$$\sigma_{min} = \frac{MY}{I} = \frac{54 \times 10^3 \times 0,0584}{66,62 \times 10^{-6}} = 47,337 \text{ MPa} \quad \checkmark \text{ (compressive)} \quad \checkmark \quad (5)$$

$$2.4 \quad \Delta = \frac{FL^3}{48EI}$$

$$(15,198 - 5) \times 10^{-3} \checkmark = \frac{F \times 6^3}{48 \times 200 \times 10^9 \times 66,62 \times 10^{-6}}$$

$$F = 30,196 \text{ kN} \quad \checkmark \quad (2)$$

**[13]**

**VRAAG 3**

$$3.1 \quad \sigma_D = \frac{F}{A} = \frac{2 \times 10^6}{2 \times 1} = 1 \text{ MPa} \quad \checkmark \quad (1)$$

$$3.2 \quad I_{XX} = \frac{1 \times 2^3}{12} = 0,667 \times 10^{-6} \text{ m}^4 \quad \checkmark$$

$$I_{YY} = \frac{2 \times 1^3}{12} = 0,167 \times 10^{-6} \text{ m}^4 \quad \checkmark$$

$$\sigma_{XX} = \frac{FeY}{I} = \frac{2 \times 10^6 \times 0,5 \times 1}{0,667 \times 10^{-6}} = 1,5 \text{ MPa} \quad \checkmark$$

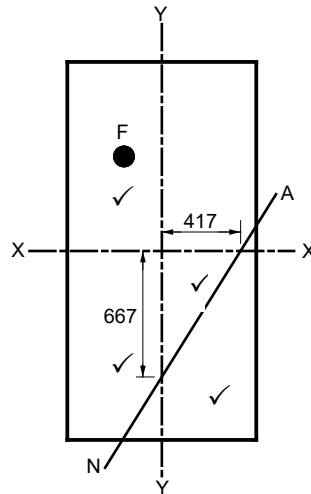
$$\sigma_{YY} = \frac{FeX}{I} = \frac{2 \times 10^6 \times 0,2 \times 0,5}{0,667 \times 10^{-6}} = 1,2 \text{ MPa} \quad \checkmark \quad (4)$$

$$3.3 \quad \sigma_{max} = \sigma_D + \sigma_{XX} + \sigma_{YY} = 1 + 1,5 + 1,2 = 3,7 \text{ MPa} \text{ (compressive)} \quad \checkmark$$

$$\sigma_{min} = \sigma_D - \sigma_{XX} - \sigma_{YY} = 1 - 1,5 - 1,2 = -1,7 \text{ MPa} \text{ (tensile)} \quad \checkmark \quad (2)$$

$$3.4 \quad Y = \frac{I_{XX}}{A \times e} = \frac{0,667}{2 \times 0,5} = 0,667 \text{ m (from the XX - axis)} \checkmark$$

$$X = \frac{I_{YY}}{A \times e} = \frac{0,167}{2 \times 0,2} = 0,417 \text{ m (from the YY - axis)} \checkmark$$

(6)  
[13]**VRAAG 4**

$$4.1 \quad W_1 = \rho g A l = 2200 \times 9,81 \times 2 \times 6 \times 1 = 258,984 \text{ kN} \checkmark$$

$$W_2 = \rho g A l = 2200 \times 9,81 \times 0,5 \times 1 \times 6 \times 1 = 64,746 \text{ kN} \checkmark$$

$$V = W_1 + W_2 = 323,73 \text{ kN} \checkmark \quad (3)$$

$$4.2 \quad W - M = W_1 x_1 + W_2 x_2 \\ = 258,984 \times 2 + 64,746 \times 0,667 \checkmark$$

$$W - M = 561,132 \text{ kNm} \checkmark \quad (2)$$

$$4.3 \quad \sigma_{max} = \frac{\sigma_{ult}}{FOS} = \frac{621}{3} = 207 \text{ kPa} \checkmark$$

$$\sigma_{max} = \frac{V}{B} + \frac{6Ve}{B^2}$$

$$207 = \frac{323,73}{3} + \frac{6 \times 323,73 \times e}{3^2} \checkmark$$

$$e = 0,459 \text{ m} \checkmark$$

$$x = 0,5B - e = 1,5 - 0,459 = 1,041 \text{ m} \checkmark \quad (4)$$

$$4.4 \quad V \times x_R + F_M = W_M \text{ (taking moments about the toe)}$$

$$323,73 \times 1,041 + F_M = 561,132 \checkmark$$

$$F_M = 224,172 \text{ kNm} \checkmark$$

$$F_M = \frac{\rho g h^2}{2} \times \frac{h}{3}$$

$$224,172 = \frac{10^3 \times 9,81 \times h^3}{6} \checkmark$$

$$h = 5,156 \text{ m} \checkmark$$

(4)

[13]

**VRAAG 5**

$$5.1 \quad M = \sigma \times Z \times n = 180 \times 1959 \times 3 \checkmark = 1057,86 \text{ kNm} \checkmark$$

(2)

$$5.2 \quad M = \frac{W_c(L-l)^2}{8L}$$

$$1057,86 = \frac{W_c(3-0,8)^2}{8 \times 3} \checkmark$$

$$W_c = 5245,587 \text{ kN} \checkmark$$

$$A_c = \frac{W_c}{\sigma_c} = \frac{5245,587 \times 10^3}{140 \times 10^6} = 37,468 \times 10^{-3} \text{ m}^2 \checkmark$$

Select 356 × 406 × 340 kg/m ✓

$$\sigma = \frac{W}{A} = \frac{5245,587 \times 10^3}{43,27 \times 10^{-3}} = 121,229 \text{ MPa} \checkmark$$

(5)

$$5.3 \quad l = 3 \times 192,5 + 2 \times 75 = 728,4 \text{ mm} \checkmark$$

$$n = \frac{M}{\sigma \times Z} = \frac{1057,86 \times 10^3}{180 \times 10^6 \times 562,9 \times 10^{-6}} = 10,44 \checkmark \text{ say } 11 \checkmark$$

(3)

$$5.4 \quad \sigma = \frac{M}{Z \times n} = \frac{1057,86 \times 10^3}{562,9 \times 10^{-6} \times 11} = 170,846 \text{ MPa} \checkmark$$

(1)

[11]

## VRAAG 6

$$6.1 \quad \frac{en^2}{2} = mA_s(d-n)$$

$$\frac{0,2 \times n^2}{2} = 15 \times 800 \times 10^{-6}(0,8-n) \checkmark$$

$$100 \times 10^{-3} n^2 = 12 \times 10^{-3} - 9,6 \times 10^{-3} n \checkmark$$

$$n = 301,72 \text{ mm} \checkmark \quad (3)$$

$$6.2 \quad l_\alpha = d - \frac{n}{3} = 0,18 - \frac{0,0968}{3} = 0,148 \text{ m}$$

$$M = 0,5\sigma_c A_c l_\alpha = 0,5 \times 7 \times 10^6 \times 0,2 \times 0,302 \times 0,699 = 147,722 \text{ kNm} \checkmark$$

$$M = \sigma_s A_s l_\alpha = 140 \times 10^6 \times 800 \times 10^{-6} \times 0,699 = 78,336 \text{ kNm} \checkmark$$

Therefore maximum  $M = 78,336 \text{ kNm} \checkmark$  (3)

$$6.3 \quad M_c = 0,5\sigma_c A_c l_\alpha$$

$$78,336 \times 10^3 = 0,5 \times \sigma_c \times 450 \times 0,2 \times 0,302 \times 0,699 \checkmark$$

$$\sigma_c = 3,712 \text{ MPa} \checkmark \quad (2)$$

$$6.4 \quad M_c = 0,5\sigma_c A_c \times \frac{2}{3}n$$

$$= 0,5 \times 3,712 \times 10^6 \times 0,2 \times 0,302 \times \frac{2}{3} \times 0,302 \checkmark$$

$$M_c = 22,528 \text{ kNm} \checkmark$$

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

$$= 140 \times 10^6 \times 800 \times 10^{-6} (0,8 - 0,302) \checkmark$$

$$M_s = 55,807 \text{ kNm} \checkmark \quad (4)$$

[12]

**VRAAG 7**

$$7.1 \quad y_0 = \frac{F_H}{w} = \frac{30 \times 10^3}{20} = 1500 \text{ m} \quad \checkmark$$

$$F_{T2} = \frac{F_H}{\cos \theta} = \frac{30 \times 10^3}{15} = 31,0583 \text{ kN} \quad \checkmark$$

$$l_2 = y_0 \tan \theta = 1500 \times \tan 15 = 401,924 \text{ m} \quad \checkmark$$

$$l_1 = l_T - l_2 = 650 - 401,924 = 248,0762 \text{ m} \quad \checkmark$$

$$y_1 = \sqrt{l_1^2 + y_0^2} = \sqrt{248,0762^2 + 1500^2} = 1520,376 \text{ m} \quad \checkmark$$

$$F_{T1} = wy_1 = 20 \times 1520,376 = 30,408 \text{ kN} \quad \checkmark \quad (6)$$

$$7.2 \quad F_{V2} = F_H \tan \theta = 30 \times 10^3 \times \tan 15 = 8,0385 \text{ kN} \quad \checkmark$$

$$F_{V\alpha} = F_{T2} \sin \alpha = 31,0583 \times 10^3 \times \sin 60 = 26,897 \text{ kN} \quad \checkmark$$

$$R_V = F_{V2} + F_{V\alpha} = 8,0385 + 26,897 = 34,936 \text{ kN} \quad \checkmark$$

$$F_{H\alpha} = F_{T2} \cos \alpha = 31,0583 \times 10^3 \cos 60 = 15,529 \text{ kN} \quad \checkmark$$

$$R_H = F_{Hc} - F_{H\alpha} = 30 \times 10^3 - 15,529 \times 10^3 = 14,471 \text{ kN} \quad \checkmark$$

$$R = \sqrt{R_H^2 + R_V^2} = \sqrt{14,471^2 + 34,936^2} = 37,814 \text{ kN} \quad \checkmark \quad (6)$$

$$7.3 \quad M = R_H \times H = 14,471 \times 20 \quad \checkmark = 289,417 \text{ kNm} \quad \checkmark \quad (2)$$

**[14]**

**VRAAG 8**

$$8.1 \quad d = \sqrt[3]{\frac{16T_e}{\pi \times \tau}} = \sqrt[3]{\frac{16 \times 2 \times 10^3}{\pi \times 60 \times 10^6}} \quad \checkmark = 55,371 \text{ mm} \quad \checkmark$$

$$d = \sqrt[3]{\frac{32M_e}{\pi \times \sigma}} = \sqrt[3]{\frac{32 \times 3 \times 10^3}{\pi \times 90 \times 10^6}} \quad \checkmark = 69,763 \text{ mm} \quad \checkmark$$

*Minimum diameter required = 69,763 mm*  $\checkmark$   
*This diameter will satisfy both stress limits*  $\checkmark$  (6)



$$8.2 \quad M_g = 0,5(M + T_g)$$

$$3 = 0,5(M + 2) \quad \checkmark$$

$$M = 4 \text{ kNm} \quad \checkmark$$

$$w = \frac{8M}{L^2} = \frac{8 \times 4}{4^2} = 2 \text{ kN/m} \quad \checkmark$$

(3)

$$8.3 \quad \sigma = 90 \text{ MPa} \quad \checkmark$$

$$\tau = \frac{16T_g}{\pi d^3} = \frac{16 \times 2 \times 10^3}{\pi \times 0,0698^3} \quad \checkmark = 30 \text{ MPa} \quad \checkmark$$

(3)

[12]

**TOTAAL: 100**