

2 Wapeningsberekening

$$h = 180 \text{ mm} \quad d_t = 44 \text{ mm} \quad d_b = 44 \text{ mm} \quad d_v = 136 \text{ mm}$$

$$n_{xx} = 0,00 \text{ kN/m} \quad n_{yy} = 0,00 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = 3,165 \text{ kNm/m} \quad m_{yy} = 18,33 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

$$v_x = 0,09 \text{ kN/m} \quad v_y = 0,00 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_o = \sqrt{v_x^2 + v_y^2} = \sqrt{0,09^2 + 0,00^2} = 0,09 \text{ kN/m}$$

$$\tan \varphi_o = \frac{v_y}{v_x} = \frac{0,00}{0,09} = 0,000 \quad \varphi_o = 0,0$$

$$\sin \varphi_o = 0,000 \quad \cos \varphi_o = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{s1x} / (b_w d) = 67 / (1000 \times 147) = 0,000455$$

$$\rho_{ly} = A_{s1y} / (b_w d) = 310 / (1000 \times 147) = 0,00211$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_o + \rho_{ly} \sin^2 \varphi_o = 0,000455 \leq 0,02$$

$$n_{nm} = n_{xx} \cos^2 \varphi_o + n_{yy} \sin^2 \varphi_o + n_{xy} \sin 2 \varphi_o = 0,00 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{147}} = 2,166 > 2,0 \rightarrow k = 2,0$$

$$V_{Rd,c} = [C_{Rd,c} k (100 \rho_l f_{ck})^{1/3} + k_1 \sigma_{cp}] b_w d = \dots(6.2.a)$$

$$= [0,12 \times 2 \times (100 \times 0,000455 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 147 \times 10^{-3} = 34,2 \text{ kN}$$

$$v_{min} = 0,035 k^{3/2} f_{ck}^{1/2} = 0,035 \times 2^{3/2} \times 20^{1/2} = 0,443 \text{ MPa} \dots(6.3N)$$

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 147 \times 10^{-3} = 65,08 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(34,2; 65,08) = 65,08 \text{ kN}$$

$v_o < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-3,16}{0,136} + (1 - 0,50) \times 0,00 = -23,29 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-18,33}{0,136} + (1 - 0,50) \times 0,00 = -134,84 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,136} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

$$n_{ot} = |n_{xyt}| = 0,00 \text{ kN/m}$$

$$1: n_{xxt} > -n_{ot} \quad n_{yyt} > -n_{ot} \quad \text{nee}$$

$$2: n_{xxt} n_{yyt} < n_{ot}^2 \quad n_{yyt} < -n_{ot} \quad \text{nee}$$

$$3: n_{xxt} n_{yyt} < n_{ot}^2 \quad n_{xxt} < -n_{ot} \quad \text{nee}$$

$$4: n_{xxt} n_{yyt} > n_{ot}^2 \quad n_{xxt} < 0 \quad n_{yyt} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

Toetsing betondrukkracht

$$n_{ct} = \left| \frac{1}{2} (n_{xxt} + n_{yyt}) - \sqrt{\frac{1}{4} (n_{xxt} - n_{yyt})^2 + n_{xyt}^2} \right| =$$

$$= \left| \frac{1}{2} (-23,29 + -134,84) - \sqrt{\frac{1}{4} (-23,29 - -134,84)^2 + 0,00^2} \right| = 134,84 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 44 \times 10^{-3} = 588,00 \text{ kN/m}$$

Onderschiil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{3,16}{0,136} + 0,50 \times 0,00 = 23,29 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{18,33}{0,136} + 0,50 \times 0,00 = 134,84 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,136} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

$$n_{ob} = |n_{xyb}| = 0,00 \text{ kN/m}$$

$$1: n_{xxb} > -n_{ob} \quad n_{yyb} > -n_{ob} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

$$2: n_{xxb} n_{yyb} < n_{ob}^2 \quad n_{yyb} < -n_{ob} \quad \text{nee}$$

$$3: n_{xxb} n_{yyb} < n_{ob}^2 \quad n_{xxb} < -n_{ob} \quad \text{nee}$$

$$4: n_{xxb} n_{yyb} > n_{ob}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{nee}$$

Toetsing betondrukkracht

$$n_{cb} = 2 n_{ob} = 2 \times 0,00 = 0,00 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 44 \times 10^{-3} = 588,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{ob} = 23,29 + 0,00 = 23,29 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{ob} = 134,84 + 0,00 = 134,84 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{23,29 \times 10^3}{435} = 54 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{134,84 \times 10^3}{435} = 310 \text{ mm}^2/\text{m}$$