

2 Wapeningsberekening

$$h = 250 \text{ mm} \quad d_t = 51 \text{ mm} \quad d_b = 51 \text{ mm} \quad d_v = 199 \text{ mm}$$

$$n_{xx} = 75,32 \text{ kN/m} \quad n_{yy} = -3,50 \text{ kN/m} \quad n_{xy} = 2,95 \text{ kN/m}$$

$$m_{xx} = -0,517 \text{ kNm/m} \quad m_{yy} = -0,02 \text{ kNm/m} \quad m_{xy} = 7,23 \text{ kNm/m}$$

$$v_x = -0,24 \text{ kN/m} \quad v_y = -1,84 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_o = \sqrt{v_x^2 + v_y^2} = \sqrt{-0,24^2 + -1,84^2} = 1,85 \text{ kN/m}$$

$$\tan \varphi_o = \frac{v_y}{v_x} = \frac{-1,84}{-0,24} = 7,775 \quad \varphi_o = 82,7$$

$$\sin \varphi_o = 0,992 \quad \cos \varphi_o = 0,128$$

Opneembare dwarskracht

$$\rho_{lx} = A_{s1x} / (b_w d) = 265 / (1000 \times 217) = 0,00122$$

$$\rho_{ly} = A_{s1y} / (b_w d) = 126 / (1000 \times 217) = 0,000581$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_o + \rho_{ly} \sin^2 \varphi_o = 0,000591 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_o + n_{yy} \sin^2 \varphi_o + n_{xy} \sin 2 \varphi_o = -1,47 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{217}} = 1,96 \leq 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 1471 / 250000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 1,96 \times (100 \times 0,000591 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 217 \times 10^{-3} = 54,17 \text{ kN}$$

$$v_{min} = 0,035 k^{3/2} f_{ck}^{1/2} = 0,035 \times 1,96^{3/2} \times 20^{1/2} = 0,43 \text{ MPa} \dots(6.3N)$$

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,43 + 0,15 \times 0) \times 1000 \times 217 \times 10^{-3} = 93,396 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(54,17; 93,4) = 93,4 \text{ kN}$$

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

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,52}{0,199} + (1 - 0,50) \times 75,32 = 40,26 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,02}{0,199} + (1 - 0,50) \times -3,50 = -1,67 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-7,23}{0,199} + (1 - 0,50) \times 2,95 = -34,89 \text{ kN/m}$$

$$n_{ot} = |n_{xyt}| = 34,89 \text{ kN/m}$$

1: $n_{xxt} > -n_{ot}$ $n_{yyt} > -n_{ot}$ ja \rightarrow Geval 1 wapening in x- en y-richting

2: $n_{xxt} n_{yyt} < n_{ot}^2$ $n_{xyt} < -n_{ot}$ nee

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{nee}$$

$$4: n_{xxt} n_{yyt} > n_{0t}^2 \quad n_{xxt} < 0 \quad n_{yyt} < 0 \quad \text{nee}$$

Toetsing betondrukkkracht

$$n_{ct} = 2 n_{0t} = 2 \times 34,89 = 69,77 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 51 \times 10^{-3} = 681,33 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 40,26 + 34,89 = 75,15 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = -1,67 + 34,89 = 33,21 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{75,15 \times 10^3}{435} = 173 \text{ mm}^2/\text{m}$$

$$A_{syt,ULS} = \frac{n_{syt}}{f_{yd}} = \frac{33,21 \times 10^3}{435} = 76 \text{ mm}^2/\text{m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,52}{0,199} + 0,50 \times 75,32 = 35,06 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,02}{0,199} + 0,50 \times -3,50 = -1,83 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{7,23}{0,199} + 0,50 \times 2,95 = 37,84 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 37,84 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

$$2: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{yyb} < -n_{0b} \quad \text{nee}$$

$$3: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{xxb} < -n_{0b} \quad \text{nee}$$

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

Toetsing betondrukkkracht

$$n_{cb} = 2 n_{0b} = 2 \times 37,84 = 75,68 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 51 \times 10^{-3} = 681,33 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 35,06 + 37,84 = 72,90 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = -1,83 + 37,84 = 36,01 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{72,90 \times 10^3}{435} = 168 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{36,01 \times 10^3}{435} = 83 \text{ mm}^2/\text{m}$$