2 Wapeningsberekening

$h = 200$ mm $\quad d_t = 114$ mm $\quad d_b = 114$ mm $\quad d_v = 86$ mm

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

$m_{xx} = 8{,}867$ kNm/m $\quad m_{yy} = 0{,}10$ kNm/m $\quad m_{xy} = 7{,}87$ kNm/m

$v_x = -1{,}07$ kN/m $\quad v_y = 4{,}38$ kN/m $\quad \theta = 22^0$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-1{,}07^2 + 4{,}38^2} = 4{,}50 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{4{,}38}{-1{,}07} = -4{,}108 \qquad \varphi_0 = -76{,}3$$

$\sin \varphi_0 = -0{,}972 \quad \cos \varphi_0 = 0{,}237$

Opneembare dwarskracht

$\rho_{lx} = A_{slx} / (b_w\ d) = 0 /(1000 \times 92) = 0$

$\rho_{ly} = A_{sly} / (b_w\ d) = 183 /(1000 \times 92) = 0{,}001993$

$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0{,}001882 \le 0{,}02$

$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\ \varphi_0 = 0{,}00$ kN/m

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{92}} = 2{,}474 > 2{,}0 \rightarrow k = 2{,}0$$

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

$= [0{,}12 \times 2 \times (100 \times 0{,}001882 \times 20)^{1/3} + 0{,}15 \times 0] \times 1000 \times 92 \times 10^{-3} = 34{,}35$ kN

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

$V_{Rd,c} = (v_{min} + k_1\ \sigma_{cp})\ b_w\ d = (0{,}443 + 0{,}15 \times 0) \times 1000 \times 92 \times 10^{-3} = 40{,}73$ kN ...(6.2.b)

$V_{Rd,c} = \max(V_{Rd,c\,(6.2.a)}; V_{Rd,c\,(6.2.b)}) = \max(34{,}35; 40{,}73) = 40{,}73$ kN

$v_o < V_{Rdc} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-8{,}87}{0{,}086} + (1 - 0{,}50) \times 0{,}00 = -102{,}62 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0{,}10}{0{,}086} + (1 - 0{,}50) \times 0{,}00 = -1{,}13 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-7{,}87}{0{,}086} + (1 - 0{,}50) \times 0{,}00 = -91{,}10 \text{ kN/m}$$

$n_{0t} = |\ n_{xyt}\ | = 91{,}10$ kN/m

1: $n_{xxt} > -n_{0t}$	$n_{yyt} > -n_{0t}$	nee
2: $n_{xxt}\ n_{yyt} < n_{0t}^2$	$n_{yyt} < -n_{0t}$	nee
3: $n_{xxt}\ n_{yyt} < n_{0t}^2$	$n_{xxt} < -n_{0t}$	ja → Geval 3 wapening in alleen y-richting

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

Toetsing betondrukkracht

$$n_{ct} = (-n_{xxt}) + \frac{n_{0t}^2}{(-n_{xxt})} = 102,62 + \frac{91,10^2}{102,62} = 183,49 \text{ kN/m}$$

$$n_{ct} < 1,0\ f_{cd}\ b_w\ d_t = 1,0 \times 13,33 \times 1000 \times 114 \times 10^{-3} = 1514,67 \text{ kN/m}$$

Berekening wapening

$$n_{syt} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = -1,13 + \frac{91,10^2}{102,62} = 79,73 \text{ kN/m}$$

$$A_{syt,ULS} = \frac{n_{syt}}{f_{yd}} = \frac{79,73 \times 10^3}{435} = 183 \text{ mm}^2/\text{m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma\ n_{xx} = \frac{8,87}{0,086} + 0,50 \times 0,00 = 102,62 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma\ n_{yy} = \frac{0,10}{0,086} + 0,50 \times 0,00 = 1,13 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma\ n_{xy} = \frac{7,87}{0,086} + 0,50 \times 0,00 = 91,10 \text{ kN/m}$$

$$n_{0b} = \left| n_{xyb} \right| = 91,10 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkracht

$$n_{cb} = 2\ n_{0b} = 2 \times 91,10 = 182,19 \text{ kN/m}$$

$$n_{cb} < 1,0\ f_{cd}\ b_w\ d_b = 1,0 \times 13,33 \times 1000 \times 114 \times 10^{-3} = 1514,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 102,62 + 91,10 = 193,72 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 1,13 + 91,10 = 92,23 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{193,72 \times 10^3}{435} = 446 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{92,23 \times 10^3}{435} = 212 \text{ mm}^2/\text{m}$$