



projectnr	part	date	page
1264	Bijlage A	29-7-2024	A1

Bijlage A

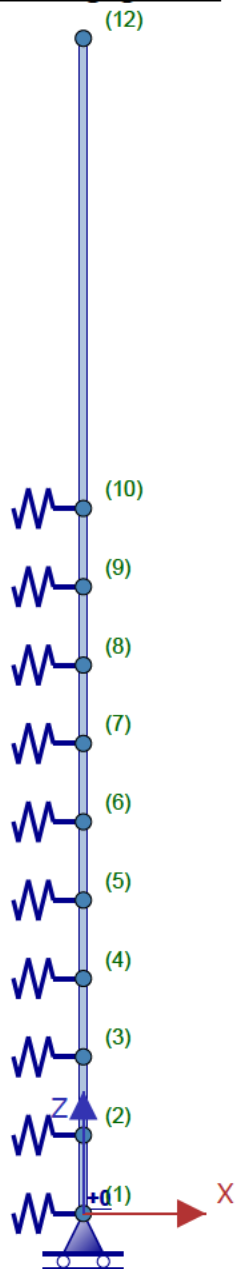
Uitgebreide computeruitdraai constructieberekeningen

Bestand :.....1264-5.1 Aanmeerpalen.xfr2**Inhoudsopgave**

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Gehanteerde normen: : NEN-EN 1993-1-1+C2+A1/NB:2016 nl

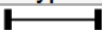
Gevolgklasse : CC1

Zwaartekrachtversnelling g : $9,81 \text{ m/s}^2$ **1 Invoergegevens****1.1 KNOPEN**

Knoop-nummer	Coördinaten		Opleggingen			Veerwaarden		
	X [mm]	Z [mm]	Tx	Tz	Ry	Kx [kN/m]	Kz [kN/m]	Cy [kNm/rad]
1	0	0	S	A		3000		
2	0	1000	S			3000		
3	0	2000	S			3000		
4	0	3000	S			2000		

Knoop- nummer	Coördinaten		Opleggingsen			Veerwaarden		
	X [mm]	Z [mm]	Tx	Tz	Ry	Kx [kN/m]	Kz [kN/m]	Cy [kNm/rad]
5	0	4000	S			500		
6	0	5000	S			1500		
7	0	6000	S			1500		
8	0	7000	S			1000		
9	0	8000	S			500		
10	0	9000	S			500		
12	0	15000						

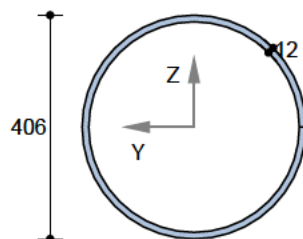
1.2 STAVEN

Staaf- nummer	Knoop		Staaf- type	Profiel	Lengte [mm]
	van	naar			
1	1	12		HFCHS4064X12	15000

1.3 PROFIELEN

Profiel- nummer	Naam	Gewicht [kg/m]	E [N/mm ²]	A [mm ²]	I _y [mm ⁴]	Wy;el_1 [mm ³]	Wy;el_2 [mm ³]
1	HFCHS4064X12	116,1	210000	1,4792E	2,8613E8	1,4095E6	1,4095E6

HFCHS4064X12



Materiaalgegevens

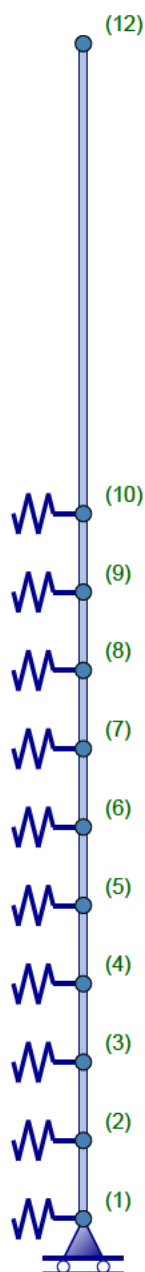
Staalsoort	S 235 (Warmgewalst)
Elasticiteitsmodulus	E = 210000 N/mm ²

Doorsnedegegevens

Maximale coördinaat	y _{max} =	203,0 mm	z _{max} =	203,0 mm
Minimale coördinaat	y _{min} =	-203,0 mm	z _{min} =	-203,0 mm
Zwaartelij	z _s =	0,0 mm	y _s =	0,0 mm
Oppervlak / Gewicht	A =	14792,4 mm ²	G =	116,1 kg/m
Statisch moment	S _y =	925969 mm ³	S _z =	925965 mm ³
Traagheidsmoment	I _y =	286127165 mm ⁴	I _z =	286125576 mm ⁴
Traagheidsstraal	i _y =	139,1 mm	i _z =	139,1 mm
Elastisch weerstandsmoment	W _{y,el} =	1409493 mm ³	W _{z,el} =	1409482 mm ³
Centrifugaalmoment	C _{yz} =	0 mm ³	hoek =	0,00 graden
Traagheidsmoment	I _{max} =	286127165 mm ⁴	I _{min} =	286125576 mm ⁴
Traagheidsstraal	i _{max} =	139,1 mm	i _{min} =	139,1 mm
Halveringslijn	z _h =	0,0 mm	y _h =	0,0 mm
Plastisch weerstandsmoment	W _{y,pl} =	1851937 mm ³	W _{z,pl} =	1851929 mm ³

1.4 BELASTINGSGEVALLEN

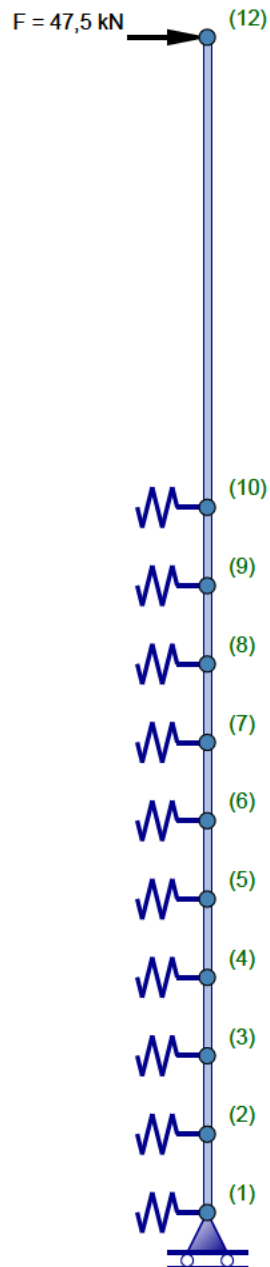
Nr.	Omschrijving	Type	ψ_0	ψ_1	ψ_2
1	Permanent	Permanent incl. eigen gewicht	1,00	1,00	1,00
2	Veranderlijk	Wind	0,00	0,20	0,00

1.5 BELASTINGSGEVAL 1 Permanent INCL. eigen gewicht

*) Belastingen a.g.v. eigen gewicht worden niet getekend!
 Totaal eigen gewicht: : 1709 kg.

1.5.1 Staafbelastingen

Staaf- nummer	Belasting				Afstand van		
	Type	q1	q2	Hoek	Knoop	a [mm]	L [mm]
1	 q	-1,139 kN/m	-1,139 kN/m	-90,0	1	0	15000

1.6 BELASTINGSGEVAL 2 Veranderlijk

1.6.1 Knoopbelastingen

Knoop- nummer	Fx [kN]	Fz [kN]	My [kNm]
12	47,500		

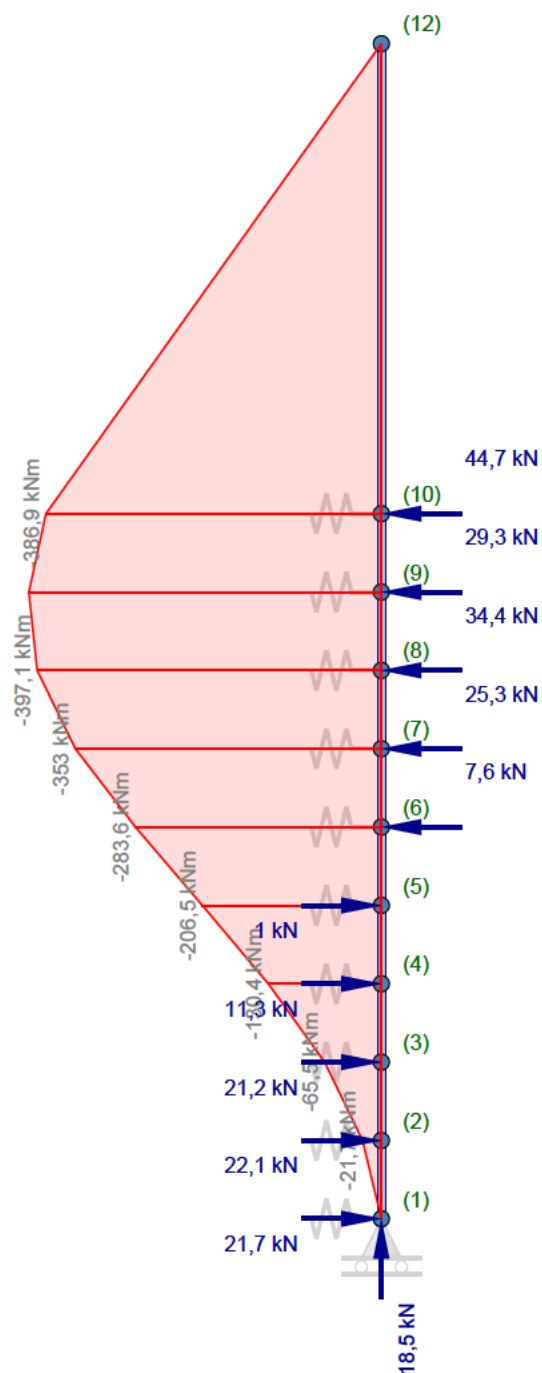
2 Berekeningsresultaten**2.1 KNOPEN - Imperfectie scheefstand**

Knoop- nummer	1/300 in +X		1/300 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
1	0	0	0	0
2	3	1000	-3	1000
3	7	2000	-7	2000
4	10	3000	-10	3000
5	13	4000	-13	4000
6	17	5000	-17	5000
7	20	6000	-20	6000
8	23	7000	-23	7000
9	27	8000	-27	8000
10	30	9000	-30	9000
12	50	15000	-50	15000

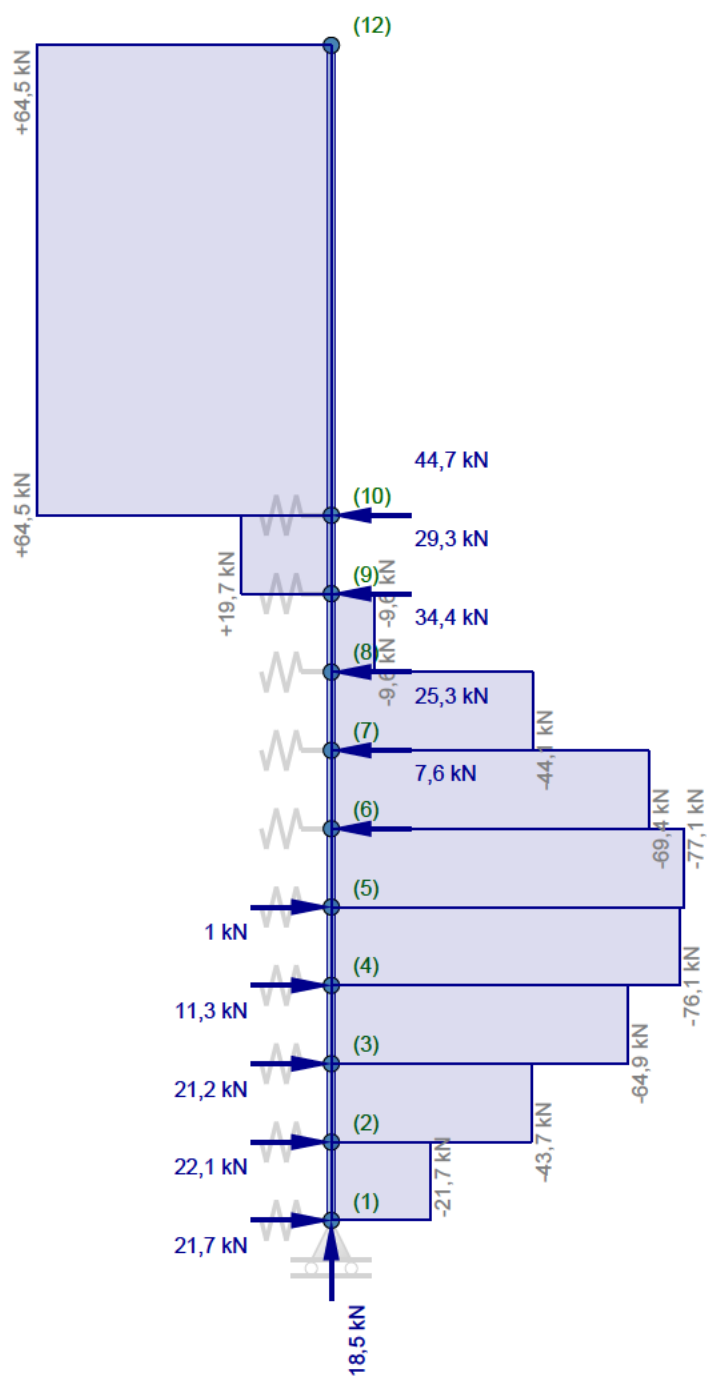
2.2 UITERSTE GRENSTOESTANDEN (UGT)**2.2.1 Belastingscombinaties****(GNL) Geometrisch niet-lineaire krachtsverdeling**

Combinatie nummer	Omschrijving	Type
1.1	Veranderlijk + Scheefstand 1/300 -X + Scheefstand 1/300 -X + Scheefstand 1/300 -X + Scheefstand 1/300 +X	UGT
1.2	Veranderlijk + Scheefstand 1/300 -X + Scheefstand 1/300 -X + Scheefstand 1/300 -X + Scheefstand 1/300 -X	UGT

Combinatie nummer	Belasting ($\psi \times \gamma$)				
	1	2			
1.1	1,00x1,08	1,00x1,35			
1.2	1,00x1,08	1,00x1,35			



Omhullende M-lijn



Omhullende D-lijn

2.2.2 Omhullende reactiekrachten

Knoop-nummer	Combinatie nummer	Fx [kN]	Fz [kN]	My [kNm]
1	1.1	21,705	18,454	
	1.2	21,645	18,454	
2	1.1	22,087		
	1.2	22,048		

Knoop-nummer	Combinatie nummer	Fx [kN]	Fz [kN]	My [kNm]
3	1.1	21,204		
	1.2	21,183		
4	1.1	11,254		
	1.2	11,249		
5	1.1	0,993		
	1.2	0,994		
6	1.1	-7,638		
	1.2	-7,635		
7	1.1	-25,301		
	1.2	-25,298		
8	1.1	-34,446		
	1.2	-34,446		
9	1.1	-29,268		
	1.2	-29,269		
10	1.1	-44,654		
	1.2	-44,659		
Minimale / maximale waarden				
10	1.2	-44,659		
2	1.1	22,087		
1	1.1		18,454	
1	1.2		18,454	

2.2.3 Omhullende staafkrachten

Staaf-nummer	Combinatie nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vz-lokaal [kN]	My-lokaal [kNm]
1	1.1	1		18,526	-21,646	0,000
	1.1	2		-17,296	-21,646	-21,646
	1.1	2		-17,370	-43,725	-21,647
	1.2	5		-13,276	-77,086	-206,510
	1.2	6		-12,045	-77,086	-283,595
	1.2	9		-8,579	-9,566	-406,622
	1.2	10		-7,595	64,481	-386,888
	1.1	12		0,214	-64,461	0,000

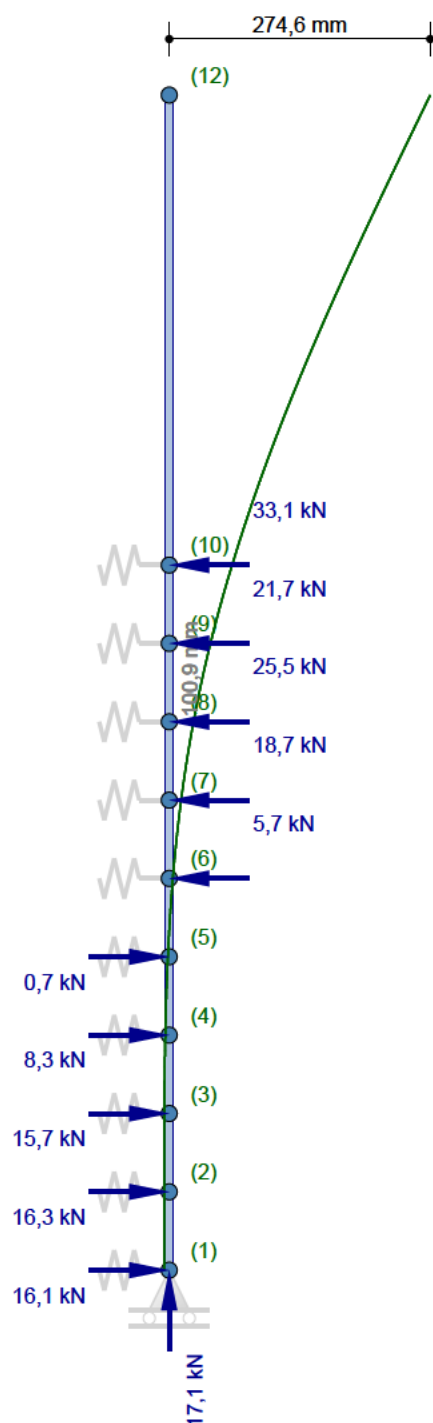
2.3 BRUIKBAARHEIDSGRENSTOESTANDEN (BGT)

2.3.1 Belastingscombinaties

(GNL) Geometrisch niet-lineaire krachtsverdeling

Combinatie nummer	Omschrijving	Type
2	Veranderlijk	BGT

Combinatie nummer	Belasting ($\psi \times \gamma$)				
	1	2			
2	1,00x1,00	1,00x1,00			



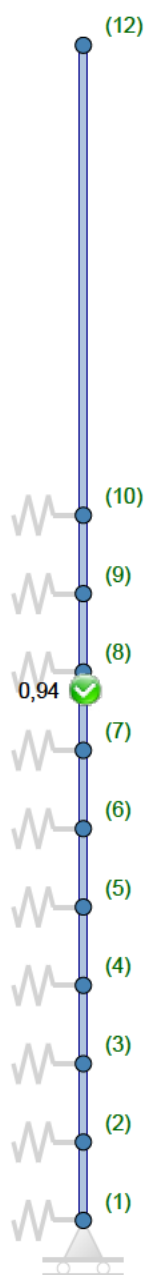
Omhullende verplaatsing

2.3.2 Omhullende knoopverplaatsingen

Knoop-nummer	Combinatie nummer	dx [mm]	dz [mm]	dr [mrad]
1	2	-5,4	0,0	0,1
2	2	-5,4	0,0	0,0
3	2	-5,2	0,0	-0,5
4	2	-4,2	0,0	-1,7
5	2	-1,5	0,0	-3,8
6	2	3,8	0,0	-6,8
7	2	12,5	0,0	-10,8
8	2	25,5	0,0	-15,4
9	2	43,3	0,0	-20,3
10	2	66,1	0,0	-25,2
12	2	274,6	0,0	-39,5
Minimale / maximale waarden				
2	2	-5,4		
12	2	274,6		
12	2		0,0	
1	2		0,0	
12	2			-39,5
1	2			0,1

2.4 EN1993 TOETSINGEN

De toetsing van de staalprofielen in de uiterste grenstoestand volgens EN 1993-1-1 is gebaseerd op een geometrische niet-lineaire krachtsverdeling (tweede orde analyse) inclusief de gegeven imperfecties volgens art.5.3.2. (a) algemene initiële scheefstanden, volgens figuur 5.2)



Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
1	HFCHS4064X12	1.1	1	6.2.4	0,01
		1.2	1	6.2.5	0,93
		1.2	1	6.2.6	0,06
		1.2	1	6.2.8	0,93
		1.2	1	6.3.3	0,94

2.5 BEREKENING VAN UNITY CHECKS**2.5.1 Staaf 1 - HFC4064X12 (S 235)****Axiale druk****art. 6.2.4**

Combinatie: 1.1 x = 0 mm Nx = -18,526 kN Vz = -21,646 kN My = 0 kNm

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{14792,4 \times 235}{1,00} \times 10^{-3} = 3476,215 \text{ kN} \quad (6.10)$$

$$\frac{N_{Ed}}{N_{c,Rd}} = \frac{18,5}{3476,2} = 0,01 < 1,0 \quad (6.9)$$

Buigend moment**art. 6.2.5**

Combinatie: 1.2 x = 8000 mm Nx = -8,677 kN Vz = 19,733 kN My = -406,622 kNm

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{1851937 \times 235}{1,00} \times 10^{-6} = 435,205 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{406,622}{435,205} = 0,93 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)**art. 6.2.6**

Combinatie: 1.2 x = 4000 mm Nx = -13,276 kN Vz = -77,086 kN My = -206,509 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{9417 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 1277,7 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{77,1}{1277,7} = 0,06 < 1,0 \quad (6.17)$$

Buiging en dwarskracht**art. 6.2.8**

Combinatie: 1.2 x = 8000 mm Nx = -8,677 kN Vz = 19,733 kN My = -406,622 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{9417 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 1277,7 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 19,733 \text{ kN} < V_{z,pl,Rd} / 2 = 1277,657 / 2 = 638,828 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Prismatische, op buiging en druk belaste staven (maatgevend)**art. 6.3.3**

Combinatie: 1.2 x = 8000 mm Nx = -18,382 kN Vz = -9,566 kN My = -406,622 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{15000}{139,1} \frac{1}{93,9} = 1,148 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{15000}{139,1} \frac{1}{93,9} = 1,148 \quad (6.50)$$

Knikkromme $y-y$ a $\alpha = 0,21$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,21 \times (1,148 - 0,2) + 1,148^2] = 1,259$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{1,259 + \sqrt{1,259^2 - 1,148^2}} = 0,563 \quad (6.49)$$

Knikkromme $z-z$ a $\alpha = 0,21$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,21 \times (1,148 - 0,2) + 1,148^2] = 1,259$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{1,259 + \sqrt{1,259^2 - 1,148^2}} = 0,563 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 14792 \times 10^{-3} = 3476,2 \text{ kN}$$

$$M_{y,Rk} = f_y W_{pl,y} = 235 \times 1851937 \times 10^{-6} = 435,2 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{pl,z} = 235 \times 1851929 \times 10^{-6} = 435,2 \text{ kNm}$$

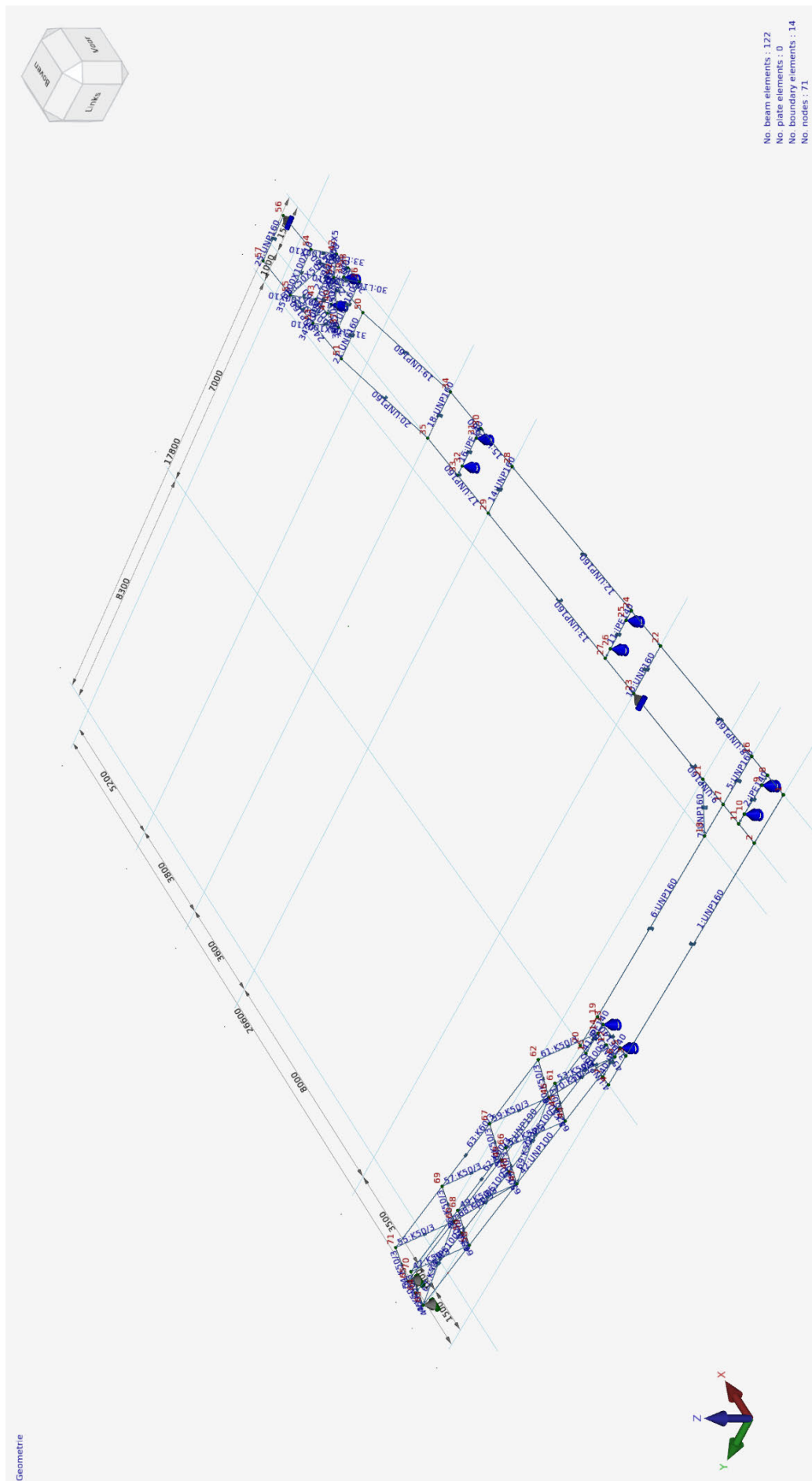
$$\frac{N_{Ed}}{\chi_y N_{Rk}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} = \frac{18,382}{0,563 \times 3476,215} + 1 \times \frac{406,622}{1 \times \frac{435,205}{1,00}} = 0,94 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} = \frac{18,382}{0,563 \times 3476,215} + 1 \times \frac{406,622}{1 \times \frac{435,205}{1,00}} = 0,94 < 1 \quad (6.62)$$

Bestand : 1264-5.2 Steiger.xfem

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1. Invoergegevens

Gehanteerde normen: : NEN-EN 1993-1-1+C2+A1/NB:2016 nl

Gevolgklasse : CC1

Zwaartekrachtversnelling g : 9,81 m/s²**1.1 KNOPEN**

Knoop- nummer	Coördinaten			Opleggingen					
	X [mm]	Y [mm]	Z [mm]	Tx	Ty	Tz	Rx	Ry	Rz
1	0	0	0						
2	0	1500	0						
3	0	8500	0						
4	0	9500	0						
5	300	8500	0			S			
6	300	8800	0						
7	300	9500	0						
8	750	0	0						
9	750	300	0			S			
10	750	1200	0			S			
11	750	1500	0						
12	750	8800	0						
13	1200	8500	0			S			
14	1200	8800	0						
15	1200	9500	0						
16	1500	0	0						
17	1500	1500	0						
18	1500	2500	0						
19	1500	8500	0						
20	1500	9500	0						
21	2500	1500	0						
22	6000	0	0						
23	6000	1500	0	A	A				
24	7500	0	0						
25	7500	300	0			S			
26	7500	1200	0			S			
27	7500	1500	0						
28	14000	0	0						
29	14000	1500	0						
30	15800	0	0						
31	15800	300	0			S			
32	15800	1200	0			S			
33	15800	1500	0						
34	17600	0	0						
35	17600	1500	0						
36	23250	0	0						
37	23250	1500	0						
38	24000	0	0						
39	24000	300	0			S			
40	24000	1200	0			S			
41	24000	1500	0						
42	24750	0	0						
43	24750	1500	0						
44	300	11050	375						
45	750	11050	375						
46	1200	11050	375						
47	300	13300	750						
48	750	13300	750						

Knoop- nummer	Coördinaten			Opleggingen					
	X [mm]	Y [mm]	Z [mm]	Tx	Ty	Tz	Rx	Ry	Rz
49	1200	13300	750						
50	21400	0	900						
51	21400	1500	900						
52	23250	0	900						
53	23250	1500	900						
54	24750	0	900						
55	24750	1500	900						
56	26600	0	900	A	A				
57	26600	1500	900						
58	300	15550	1125						
59	750	15550	1125						
60	1200	15550	1125						
61	300	9725	1475						
62	1200	9725	1475						
63	300	17800	1500	A		A			
64	750	17800	1500						
65	1200	17800	1500	A		A			
66	300	11975	1850						
67	1200	11975	1850						
68	300	14225	2225						
69	1200	14225	2225						
70	300	16475	2600						
71	1200	16475	2600						

1.2 VEREN

Knoop- nummer	Veerwaarden					
	Kx [kN/m]	Ky [kN/m]	Kz [kN/m]	Cx [kNm/rad]	Cy [kNm/rad]	Cz [kNm/rad]
1						
2						
3						
4						
5			10			
6						
7						
8						
9			7,5			
10			7,5			
11						
12						
13			10			
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18						
19						
20						
21						
22						
23						
24						
25			10			
26			10			
27						
28						

Knoop- nummer	Veerwaarden					
	Kx [kN/m]	Ky [kN/m]	Kz [kN/m]	Cx [kNm/rad]	Cy [kNm/rad]	Cz [kNm/rad]
29						
30						
31			10			
32			10			
33						
34						
35						
36						
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38						
39			10			
40			10			
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70						
71						

1.3 STAVEN

Staaf- nummer	Knoop		Staafaansluitingen		Profiel	Lengte [mm]
	van	naar	begin	begin		
1	1	4	aaaaaa	aaaaaa	UNP160	9500
2	8	11	aaa__	aaa__	IPE140	1500
3	3	19	aaa__	aaa__	IPE140	1500
4	4	20	aaaaaa	aaaaaa	UNP160	1500
5	16	17	aaaaaa	aaaaaa	UNP160	1500
6	17	20	aaaaaa	aaaaaa	UNP160	8000
7	18	21	aaa__	aaa__	UNP160	1414
8	1	22	aaaaaa	aaaaaa	UNP160	6000

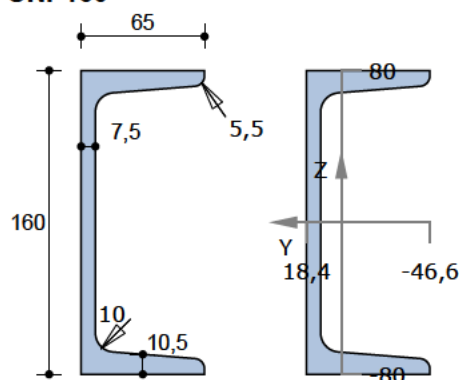
Staaf- nummer	Knoop		Staafaansluitingen		Profiel	Lengte [mm]
	van	naar	begin	begin		
9	2	23	aaaaaa	aaaaaa	UNP160	6000
10	23	22	aaaaaa	aaaaaa	UNP160	1500
11	24	27	aaaaaa	aaa	IPE140	1500
12	22	28	aaa	aaa	UNP160	8000
13	23	29	aaa	aaa	UNP160	8000
14	28	29	aaaaaa	aaaaaa	UNP160	1500
15	28	34	aaaaaa	aaaaaa	UNP160	3600
16	30	33	aaa	aaa	IPE140	1500
17	29	35	aaaaaa	aaaaaa	UNP160	3600
18	34	35	aaaaaa	aaaaaa	UNP160	1500
19	34	50	aaaaaa	aaaaaa	UNP160	3905
20	35	51	aaaaaa	aaaaaa	UNP160	3905
21	51	50	aaaaaa	aaaaaa	UNP160	1500
22	50	56	aaaaaa	aaaaaa	UNP160	5200
23	38	41	aaa	aaa	IPE140	1500
24	51	57	aaaaaa	aaaaaa	UNP160	5200
25	57	56	aaaaaa	aaaaaa	UNP160	1500
26	36	42	aaaaaa	aaaaaa	UNP160	1500
27	42	43	aaaaaa	aaaaaa	UNP160	1500
28	43	37	aaaaaa	aaaaaa	UNP160	1500
29	37	36	aaaaaa	aaaaaa	UNP160	1500
30	36	52	aaaaaa	aaaaaa	L100X100X10	900
31	37	53	aaaaaa	aaaaaa	L100X100X10	900
32	43	55	aaaaaa	aaaaaa	L100X100X10	900
33	42	54	aaaaaa	aaaaaa	L100X100X10	900
34	53	52	aaaaaa	aaaaaa	L100X100X10	1500
35	55	54	aaaaaa	aaaaaa	L100X100X10	1500
36	37	52	aaaaaa	aaaaaa	L50X50X5	1749
37	37	55	aaaaaa	aaaaaa	L50X50X5	1749
38	55	42	aaaaaa	aaaaaa	L50X50X5	1749
39	42	52	aaaaaa	aaaaaa	L50X50X5	1749
40	5	7	aaa	aaa	IPE140	1000
41	13	15	aaa	aaa	IPE140	1000
42	6	63	aaa	aaaaaa	UNP100	9124
43	14	65	aaa	aaaaaa	UNP100	9124
44	63	65	aaa	aaaaaa	K50/3	900
45	6	14	aaa	aaa	UNP100	900
46	63	70	aaaaaa	aaaaaa	K50/3	1722
47	70	58	aaaaaa	aaaaaa	K50/3	1741
48	58	68	aaaaaa	aaaaaa	K50/3	1722
49	68	47	aaaaaa	aaaaaa	K50/3	1741
50	47	66	aaaaaa	aaaaaa	K50/3	1722
51	66	44	aaaaaa	aaaaaa	K50/3	1741
52	44	61	aaaaaa	aaaaaa	K50/3	1722
53	61	6	aaaaaa	aaa	K50/3	1741
54	65	71	aaaaaa	aaaaaa	K50/3	1722
55	71	60	aaaaaa	aaaaaa	K50/3	1741
56	60	69	aaaaaa	aaaaaa	K50/3	1722
57	69	49	aaaaaa	aaaaaa	K50/3	1741
58	49	67	aaaaaa	aaaaaa	K50/3	1722
59	67	46	aaaaaa	aaaaaa	K50/3	1741
60	46	62	aaaaaa	aaaaaa	K50/3	1722
61	62	14	aaaaaa	aaa	K50/3	1741
62	61	70	aaaaaa	aaaaaa	K60/3	6843
63	62	71	aaaaaa	aaaaaa	K60/3	6843
64	44	46	aaaaaa	aaaaaa	K50/3	900
65	47	49	aaaaaa	aaaaaa	K50/3	900

Staafternummer	Knoop		Staaftaansluitingen		Profiel	Lengte [mm]
	van	naar	begin	begin		
66	58	60	aaaaaa	aaaaaa	K50/3	900
67	63	60	aaa	aaa	K50/3	2452
68	60	47	aaa	aaa	K50/3	2452
69	47	46	aaa	aaa	K50/3	2452
70	46	6	aaa	aaa	K50/3	2452
71	12	45	aaa	aaa	IPE100	2281
72	45	48	aaa	aaa	IPE100	2281
73	48	59	aaa	aaa	IPE100	2281
74	59	64	aaa	aaa	IPE100	2281

1.4 PROFIELEN

Profielnummer	Naam	Gewicht [kg/m]	E [N/mm ²]	A [mm ²]	I _x [mm ⁴]	I _y [mm ⁴]	I _z [mm ⁴]
1	UNP160	18,8	210000	2,398E3	7,1948E4	9,2339E6	8,4989E5
2	IPE140	12,9	210000	1,643E3	2,4571E4	5,4151E6	4,492E5
3	L100X100X10	15,0	210000	1,916E3	7,0315E4	1,7661E6	1,7661E6
4	L50X50X5	3,8	210000	4,8E2	4,583E3	1,0959E5	1,0959E5
5	UNP100	10,5	210000	1,343E3	2,728E4	2,0496E6	2,912E5
6	K50/3	4,4	210000	5,58E2	3,1147E5	2,0394E5	2,0394E5
7	IPE100	8,1	210000	1,033E3	1,2088E4	1,7115E6	1,5921E5
8	K60/3	5,2	210000	6,67E2	5,5558E5	3,5508E5	3,5508E5

UNP160



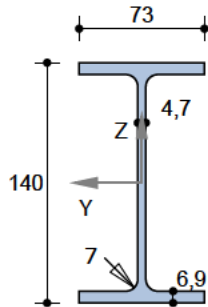
Materiaalgegevens

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f _y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

Maximale coördinaat	y _{max}	= 18,4 mm	z _{max}	= 80,0 mm
Minimale coördinaat	y _{min}	= -46,6 mm	z _{min}	= -80,0 mm
Zwaartelij	z _s	= 0,0 mm	y _s	= 0,0 mm
Oppervlak / Gewicht	A	= 2398,3 mm ²	G	= 18,8 kg/m
Statisch moment	S _y	= 68666 mm ³	S _z	= 19354 mm ³
Traagheidsmoment	I _x	= 71948 mm ⁴		
Traagheidsmoment	I _y	= 9233934 mm ⁴	I _z	= 849890 mm ⁴
Traagheidsstraal	i _y	= 62,1 mm	i _z	= 18,8 mm
Elastisch weerstandsmoment	W _{y,el}	= 115424 mm ³	W _{z,el}	= 18239 mm ³
Centrifugalmoment	C _{yz}	= 0 mm ³	hoek	= 0,00 graden

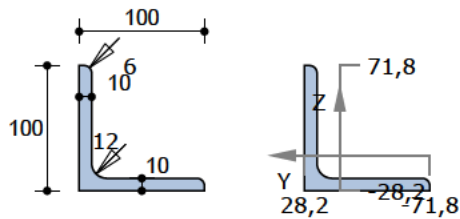
Traagheidsmoment	$I_{\max}$	=	9233934 mm ⁴	$I_{\min}$	=	849890 mm ⁴
Traagheidsstraal	$i_{\max}$	=	62,1 mm	$i_{\min}$	=	18,8 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	10,9 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	137331 mm ³	$W_{z,pl}$	=	35146 mm ³

IPE140**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f_y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

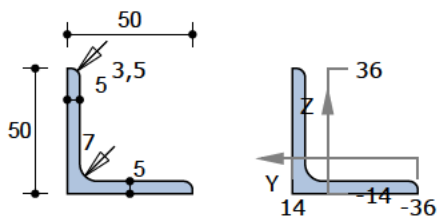
Maximale coördinaat	$y_{\max}$	=	36,5 mm	$z_{\max}$	=	70,0 mm
Minimale coördinaat	$y_{\min}$	=	-36,5 mm	$z_{\min}$	=	-70,0 mm
Zwaartelij	z_s	=	0,0 mm	y_s	=	0,0 mm
Oppervlak / Gewicht	A	=	1643,4 mm ²	G	=	12,9 kg/m
Statisch moment	S_y	=	44196 mm ³	S_z	=	9625 mm ³
Traagheidsmoment	I_x	=	24571 mm ⁴			
Traagheidsmoment	I_y	=	5415105 mm ⁴	I_z	=	449200 mm ⁴
Traagheidsstraal	i_y	=	57,4 mm	i_z	=	16,5 mm
Elastisch weerstandsmoment	$W_{y,el}$	=	77359 mm ³	$W_{z,el}$	=	12307 mm ³
Centrifugaalmoment	C_{yz}	=	0 mm ³	hoek	=	0,00 graden
Traagheidsmoment	$I_{\max}$	=	5415105 mm ⁴	$I_{\min}$	=	449200 mm ⁴
Traagheidsstraal	$i_{\max}$	=	57,4 mm	$i_{\min}$	=	16,5 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	0,0 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	88392 mm ³	$W_{z,pl}$	=	19250 mm ³

L100X100X10**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f_y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

Maximale coördinaat	y_{max}	= 28,2 mm	z_{max}	= 28,2 mm
Minimale coördinaat	y_{min}	= -71,8 mm	z_{min}	= -71,8 mm
Zwaartelij	z_s	= 0,0 mm	y_s	= 0,0 mm
Oppervlak / Gewicht	A	= 1915,7 mm ²	G	= 15,0 kg/m
Statisch moment	S_y	= 25210 mm ³	S_z	= 25210 mm ³
Traagheidsmoment	I_x	= 70315 mm ⁴		
Traagheidsmoment	I_y	= 1766127 mm ⁴	I_z	= 1766127 mm ⁴
Traagheidsstraal	i_y	= 30,4 mm	i_z	= 30,4 mm
Elastisch weerstandsmoment	$W_{y,el}$	= 24604 mm ³	$W_{z,el}$	= 24604 mm ³
Centrifugaalmoment	C_{yz}	= -1036198 mm ³	hoek	= 45,00 graden
Traagheidsmoment	I_{max}	= 2802325 mm ⁴	I_{min}	= 729928 mm ⁴
Traagheidsstraal	i_{max}	= 38,2 mm	i_{min}	= 19,5 mm
Halveringslijn	z_h	= 18,6 mm	y_h	= 18,6 mm
Plastisch weerstandsmoment	$W_{y,pl}$	= 44865 mm ³	$W_{z,pl}$	= 44865 mm ³

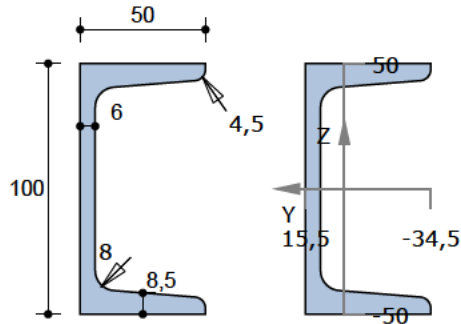
L50X50X5**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f_y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

Maximale coördinaat	y_{max}	= 14,0 mm	z_{max}	= 14,0 mm
Minimale coördinaat	y_{min}	= -36,0 mm	z_{min}	= -36,0 mm
Zwaartelij	z_s	= 0,0 mm	y_s	= 0,0 mm
Oppervlak / Gewicht	A	= 480,4 mm ²	G	= 3,8 kg/m
Statisch moment	S_y	= 3140 mm ³	S_z	= 3140 mm ³
Traagheidsmoment	I_x	= 4583 mm ⁴		
Traagheidsmoment	I_y	= 109588 mm ⁴	I_z	= 109588 mm ⁴
Traagheidsstraal	i_y	= 15,1 mm	i_z	= 15,1 mm
Elastisch weerstandsmoment	$W_{y,el}$	= 3047 mm ³	$W_{z,el}$	= 3047 mm ³
Centrifugaalmoment	C_{yz}	= -64131 mm ³	hoek	= 45,00 graden

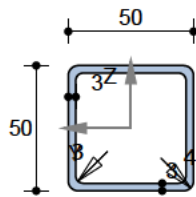
Traagheidsmoment	$I_{\max}$	=	173719 mm ⁴	$I_{\min}$	=	45457 mm ⁴
Traagheidsstraal	$i_{\max}$	=	19,0 mm	$i_{\min}$	=	9,7 mm
Halveringslijn	z_h	=	9,2 mm	y_h	=	9,2 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	5583 mm ³	$W_{z,pl}$	=	5583 mm ³

UNP100**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)		
Vloegrens	f_y	=	235 MPa
Elasticiteitsmodulus	E	=	210000 MPa

Doorsnedegegevens

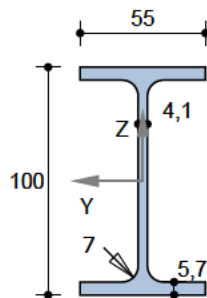
Maximale coördinaat	$y_{\max}$	=	15,5 mm	$z_{\max}$	=	50,0 mm
Minimale coördinaat	$y_{\min}$	=	-34,5 mm	$z_{\min}$	=	-50,0 mm
Zwaartelij	z_s	=	0,0 mm	y_s	=	0,0 mm
Oppervlak / Gewicht	A	=	1342,7 mm ²	G	=	10,5 kg/m
Statisch moment	S_y	=	24431 mm ³	S_z	=	8577 mm ³
Traagheidsmoment	I_x	=	27280 mm ⁴			
Traagheidsmoment	I_y	=	2049645 mm ⁴	I_z	=	291203 mm ⁴
Traagheidsstraal	i_y	=	39,1 mm	i_z	=	14,7 mm
Elastisch weerstandsmoment	$W_{y,el}$	=	40993 mm ³	$W_{z,el}$	=	8445 mm ³
Centrifugaalmoment	C_{yz}	=	0 mm ³	hoek	=	0,00 graden
Traagheidsmoment	$I_{\max}$	=	2049645 mm ⁴	$I_{\min}$	=	291203 mm ⁴
Traagheidsstraal	$i_{\max}$	=	39,1 mm	$i_{\min}$	=	14,7 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	6,8 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	48863 mm ³	$W_{z,pl}$	=	16198 mm ³

K50/3**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f_y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

Maximale coördinaat	y_{max}	=	25,0 mm	z_{max}	=	25,0 mm
Minimale coördinaat	y_{min}	=	-25,0 mm	z_{min}	=	-25,0 mm
Zwaartelij	z_s	=	0,0 mm	y_s	=	0,0 mm
Oppervlak / Gewicht	A	=	557,9 mm ²	G	=	4,4 kg/m
Statisch moment	S_y	=	4892 mm ³	S_z	=	4892 mm ³
Traagheidsmoment	I_x	=	311469 mm ⁴			
Traagheidsmoment	I_y	=	203941 mm ⁴	I_z	=	203941 mm ⁴
Traagheidsstraal	i_y	=	19,1 mm	i_z	=	19,1 mm
Elastisch weerstandsmoment	$W_{y,el}$	=	8158 mm ³	$W_{z,el}$	=	8158 mm ³
Centrifugaalmoment	C_{yz}	=	0 mm ³	hoek	=	45,00 graden
Traagheidsmoment	I_{max}	=	203941 mm ⁴	I_{min}	=	203941 mm ⁴
Traagheidsstraal	i_{max}	=	19,1 mm	i_{min}	=	19,1 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	0,0 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	9785 mm ³	$W_{z,pl}$	=	9785 mm ³

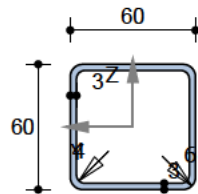
IPE100**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)	
Vloeigrens	f_y	= 235 MPa
Elasticiteitsmodulus	E	= 210000 MPa

Doorsnedegegevens

Maximale coördinaat	y_{max}	=	27,5 mm	z_{max}	=	50,0 mm
Minimale coördinaat	y_{min}	=	-27,5 mm	z_{min}	=	-50,0 mm
Zwaartelij	z_s	=	0,0 mm	y_s	=	0,0 mm
Oppervlak / Gewicht	A	=	1033,1 mm ²	G	=	8,1 kg/m
Statisch moment	S_y	=	19720 mm ³	S_z	=	4575 mm ³
Traagheidsmoment	I_x	=	12088 mm ⁴			
Traagheidsmoment	I_y	=	1711485 mm ⁴	I_z	=	159207 mm ⁴

Traagheidsstraal	i_y	=	40,7 mm	i_z	=	12,4 mm
Elastisch weerstandsmoment	$W_{y,el}$	=	34230 mm ³	$W_{z,el}$	=	5789 mm ³
Centrifugaalmoment	C_{yz}	=	0 mm ³	hoek	=	0,00 graden
Traagheidsmoment	I_{max}	=	1711485 mm ⁴	I_{min}	=	159207 mm ⁴
Traagheidsstraal	i_{max}	=	40,7 mm	i_{min}	=	12,4 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	0,0 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	39439 mm ³	$W_{z,pl}$	=	9149 mm ³

K60/3**Materiaalgegevens**

Staalsoort	S 235 (Warmgewalst)
Vloeigrens	f_y = 235 MPa
Elasticiteitsmodulus	E = 210000 MPa

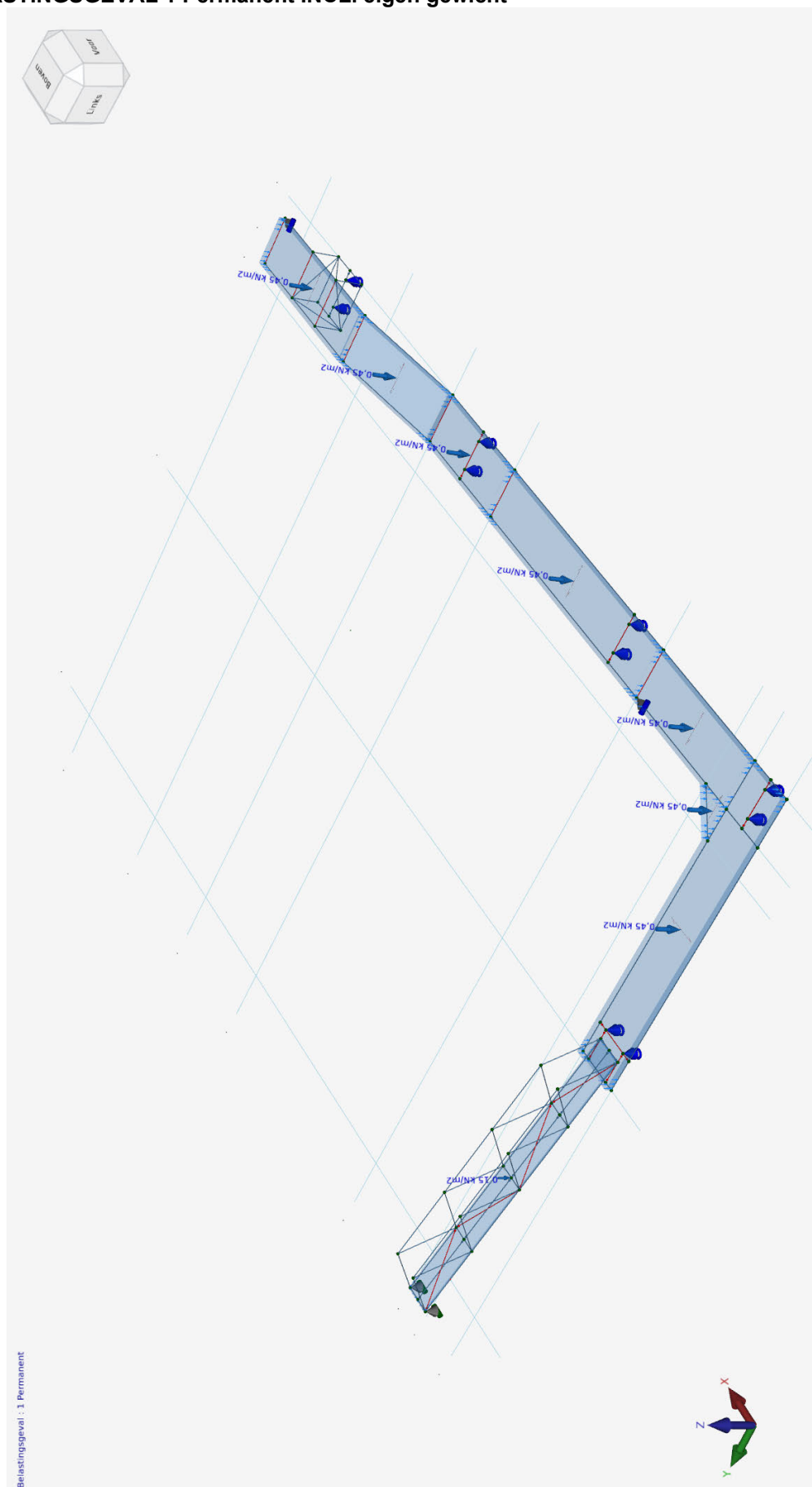
Doorsnedegegevens

Maximale coördinaat	y_{max}	=	30,0 mm	z_{max}	=	30,0 mm
Minimale coördinaat	y_{min}	=	-30,0 mm	z_{min}	=	-30,0 mm
Zwaartelijn	z_s	=	0,0 mm	y_s	=	0,0 mm
Oppervlak / Gewicht	A	=	666,5 mm ²	G	=	5,2 kg/m
Statisch moment	S_y	=	7049 mm ³	S_z	=	7049 mm ³
Traagheidsmoment	I_x	=	555579 mm ⁴			
Traagheidsmoment	I_y	=	355080 mm ⁴	I_z	=	355080 mm ⁴
Traagheidsstraal	i_y	=	23,1 mm	i_z	=	23,1 mm
Elastisch weerstandsmoment	$W_{y,el}$	=	11836 mm ³	$W_{z,el}$	=	11836 mm ³
Centrifugaalmoment	C_{yz}	=	0 mm ³	hoek	=	45,00 graden
Traagheidsmoment	I_{max}	=	355080 mm ⁴	I_{min}	=	355080 mm ⁴
Traagheidsstraal	i_{max}	=	23,1 mm	i_{min}	=	23,1 mm
Halveringslijn	z_h	=	0,0 mm	y_h	=	0,0 mm
Plastisch weerstandsmoment	$W_{y,pl}$	=	14097 mm ³	$W_{z,pl}$	=	14097 mm ³

1.5 BELASTINGSGEVALLEN

Nr.	Omschrijving	Type	ψ_0	ψ_1	ψ_2
1	Permanent	Permanent incl. eigen gewicht	1,00	1,00	1,00
2	Veranderlijk	A:Woonfunctie en logiesfunctie	0,40	0,50	0,30
3	Veranderlijk plaatselijk	A:Woonfunctie en logiesfunctie	0,40	0,50	0,30

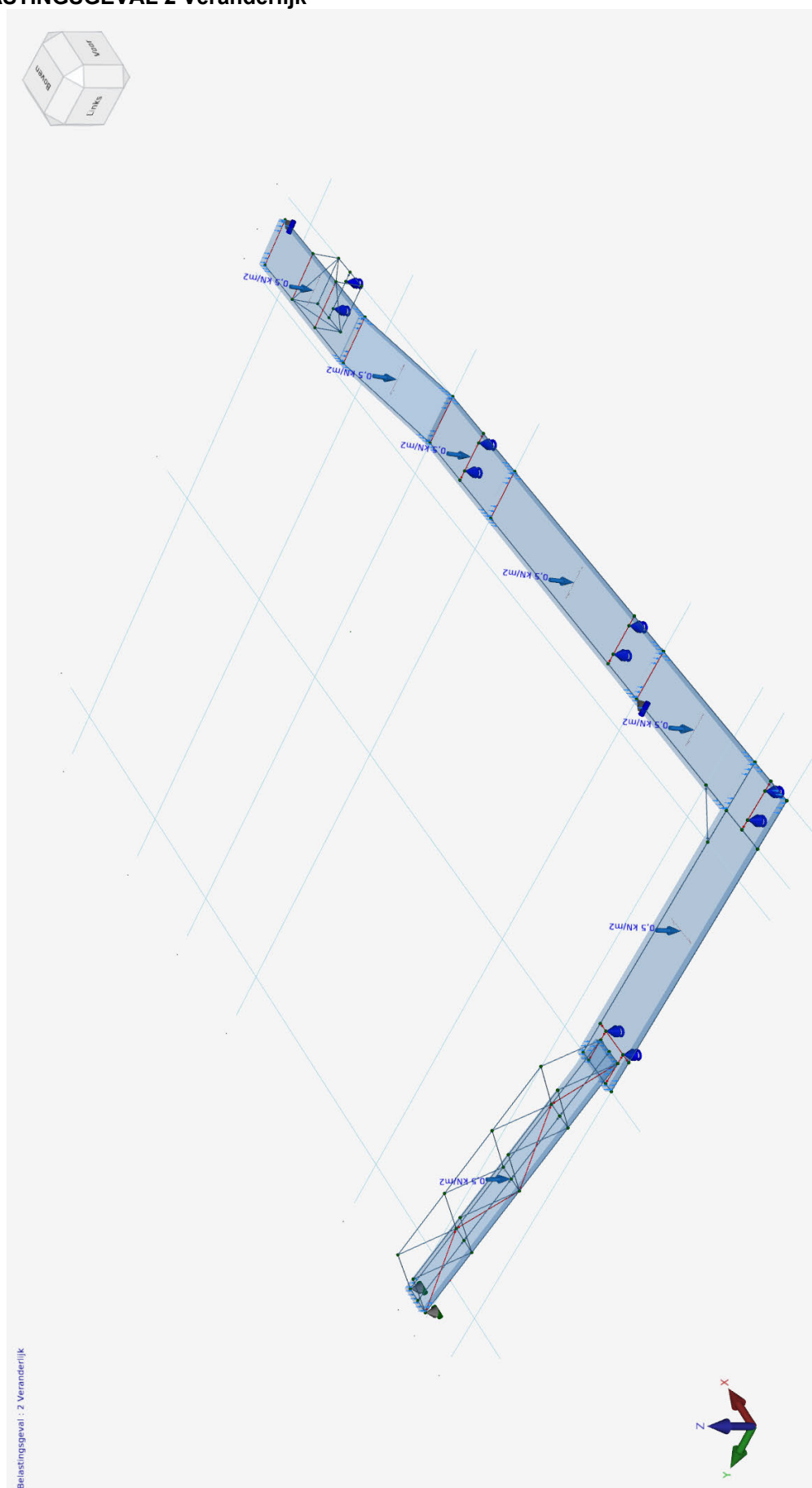
Totaal eigen gewicht: : 2401 kg.

1.6 BELASTINGSGEVAL 1 Permanent INCL. eigen gewicht

1.6.1 Staafbelastingen

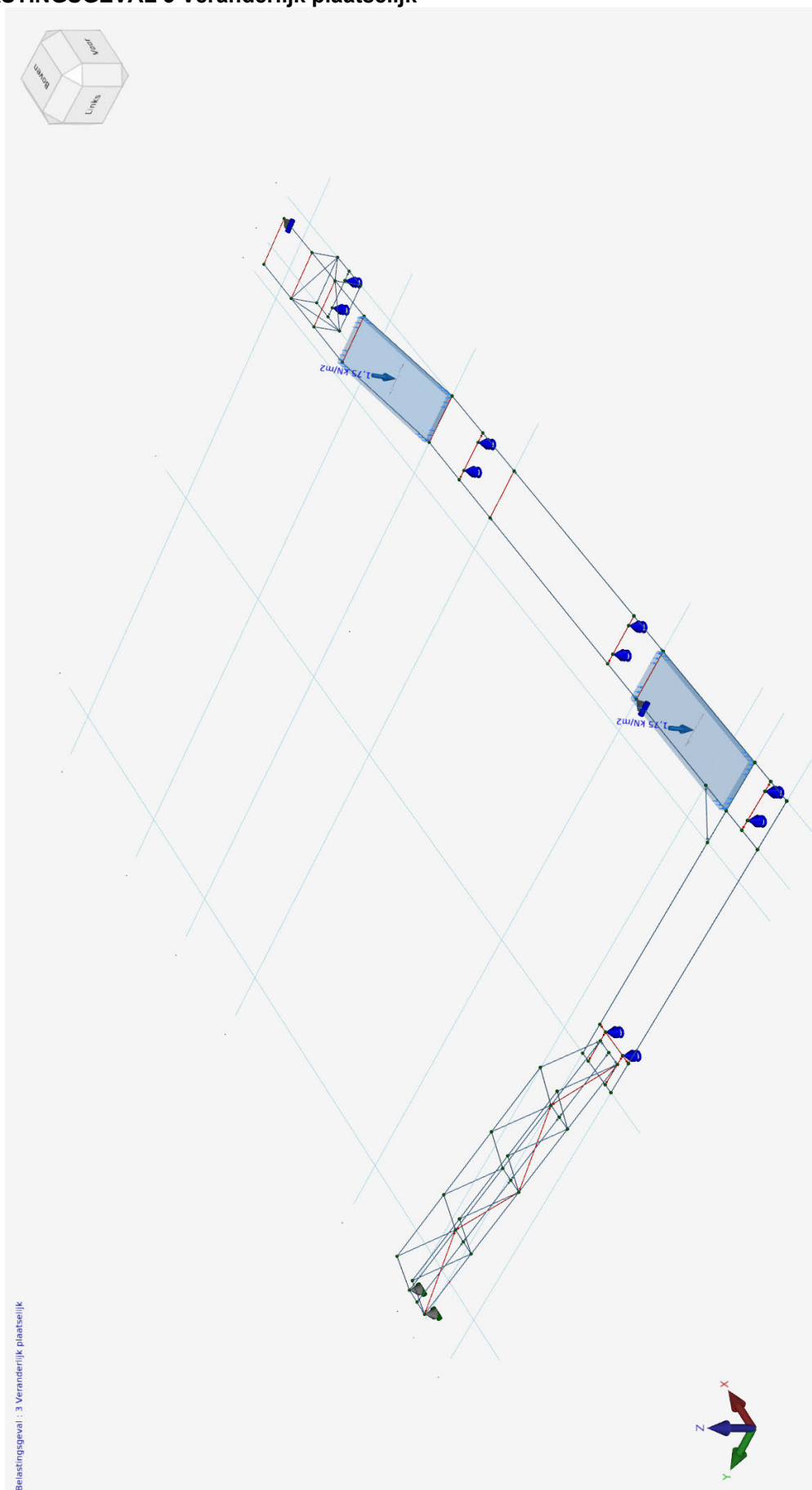
Staaf-nummer	Richting	Type	Belasting				Afstand van		
			q1	q2	Hoek	Exc.	Knoop	a [mm]	L [mm]
1	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	1	0	9500
1	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	1	0	1500
1	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	1	1500	8000
2	G-Z		-0,127 kN/m	-0,127 kN/m	0,0	0,0	8	0	1500
3	G-Z		-0,127 kN/m	-0,127 kN/m	0,0	0,0	3	0	1500
4	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	4	0	1500
5	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	16	0	1500
5	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	16	0	1500
6	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	17	0	8000
6	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	17	0	1000
6	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	17	1000	7000
7	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	18	0	1414
7	L-Z		-0,159 kN/m	0,000 kN/m	0,0	0,0	18	0	1414
8	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	1	0	6000
8	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	1	1500	4500
9	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	2	0	6000
9	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	2	2500	3500
9	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	2	1500	1000
9	L-Z		-0,225 kN/m	0,000 kN/m	0,0	0,0	2	1500	1000
10	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	23	0	1500
11	G-Z		-0,127 kN/m	-0,127 kN/m	0,0	0,0	24	0	1500
12	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	22	0	8000
12	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	22	0	8000
13	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	23	0	8000
13	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	23	0	8000
14	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	28	0	1500
15	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	28	0	3600
15	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	28	0	3600
16	G-Z		-0,127 kN/m	-0,127 kN/m	0,0	0,0	30	0	1500
17	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	29	0	3600
17	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	29	0	3600
18	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	34	0	1500
19	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	34	0	3905
19	G-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	34	0	3905
20	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	35	0	3905
20	G-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	35	0	3905
21	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	51	0	1500
22	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	50	0	5200
22	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	50	0	5200
23	G-Z		-0,127 kN/m	-0,127 kN/m	0,0	0,0	38	0	1500
24	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	51	0	5200
24	L-Z		-0,338 kN/m	-0,338 kN/m	0,0	0,0	51	0	5200
25	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	57	0	1500
26	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	36	0	1500
27	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	42	0	1500
28	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	43	0	1500
29	G-Z		-0,185 kN/m	-0,185 kN/m	0,0	0,0	37	0	1500
30	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	36	0	900
31	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	37	0	900
32	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	43	0	900
33	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	42	0	900
34	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	53	0	1500
35	G-Z		-0,148 kN/m	-0,148 kN/m	0,0	0,0	55	0	1500
36	G-Z		-0,037 kN/m	-0,037 kN/m	0,0	0,0	37	0	1749

Staaf-nummer	Richting	Type	Belasting				Afstand van		
			q1	q2	Hoek	Exc.	Knoop	a [mm]	L [mm]
37	G-Z	 q	-0,037 kN/m	-0,037 kN/m	0,0	0,0	37	0	1749
38	G-Z	 q	-0,037 kN/m	-0,037 kN/m	0,0	0,0	55	0	1749
39	G-Z	 q	-0,037 kN/m	-0,037 kN/m	0,0	0,0	42	0	1749
40	G-Z	 q	-0,127 kN/m	-0,127 kN/m	0,0	0,0	5	0	1000
41	G-Z	 q	-0,127 kN/m	-0,127 kN/m	0,0	0,0	13	0	1000
42	G-Z	 q	-0,103 kN/m	-0,103 kN/m	0,0	0,0	6	0	9124
42	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	6	0	2281
42	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	6	2281	2281
42	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	6	4562	2281
42	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	6	6843	2281
43	G-Z	 q	-0,103 kN/m	-0,103 kN/m	0,0	0,0	14	0	9124
43	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	14	0	2281
43	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	14	2281	2281
43	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	14	4562	2281
43	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	14	6843	2281
44	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	63	0	900
45	G-Z	 q	-0,103 kN/m	-0,103 kN/m	0,0	0,0	6	0	900
46	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	63	0	1722
47	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	70	0	1741
48	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	58	0	1722
49	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	68	0	1741
50	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	47	0	1722
51	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	66	0	1741
52	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	44	0	1722
53	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	61	0	1741
54	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	65	0	1722
55	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	71	0	1741
56	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	60	0	1722
57	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	69	0	1741
58	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	49	0	1722
59	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	67	0	1741
60	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	46	0	1722
61	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	62	0	1741
62	G-Z	 q	-0,051 kN/m	-0,051 kN/m	0,0	0,0	61	0	6843
63	G-Z	 q	-0,051 kN/m	-0,051 kN/m	0,0	0,0	62	0	6843
64	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	44	0	900
65	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	47	0	900
66	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	58	0	900
67	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	63	0	2452
68	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	60	0	2452
69	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	47	0	2452
70	G-Z	 q	-0,043 kN/m	-0,043 kN/m	0,0	0,0	46	0	2452
71	G-Z	 q	-0,080 kN/m	-0,080 kN/m	0,0	0,0	12	0	2281
71	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	12	0	2281
71	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	12	0	2281
72	G-Z	 q	-0,080 kN/m	-0,080 kN/m	0,0	0,0	45	0	2281
72	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	45	0	2281
72	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	45	0	2281
73	G-Z	 q	-0,080 kN/m	-0,080 kN/m	0,0	0,0	48	0	2281
73	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	48	0	2281
73	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	48	0	2281
74	G-Z	 q	-0,080 kN/m	-0,080 kN/m	0,0	0,0	59	0	2281
74	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	59	0	2281
74	G-Z	 q	-0,034 kN/m	-0,034 kN/m	0,0	0,0	59	0	2281

1.7 BELASTINGSGEVAL 2 Veranderlijk

1.7.1 Staaftbelastingen

Staaft- nummer	Richting	Type	Belasting				Afstand van		
			q1	q2	Hoek	Exc.	Knoop	a [mm]	L [mm]
1	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	1	0	1500
1	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	1	1500	8000
5	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	16	0	1500
6	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	17	0	1000
6	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	17	1000	7000
8	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	1	1500	4500
9	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	2	2500	3500
9	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	2	1500	1000
12	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	22	0	8000
13	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	23	0	8000
15	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	28	0	3600
17	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	29	0	3600
19	G-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	34	0	3905
20	G-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	35	0	3905
22	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	50	0	5200
24	L-Z	 q	-0,375 kN/m	-0,375 kN/m	0,0	0,0	51	0	5200
42	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	6	6843	2281
42	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	6	0	2281
42	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	6	2281	2281
42	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	6	4562	2281
43	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	14	4562	2281
43	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	14	2281	2281
43	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	14	0	2281
43	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	14	6843	2281
71	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	12	0	2281
71	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	12	0	2281
72	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	45	0	2281
72	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	45	0	2281
73	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	48	0	2281
73	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	48	0	2281
74	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	59	0	2281
74	G-Z	 q	-0,113 kN/m	-0,113 kN/m	0,0	0,0	59	0	2281

1.8 BELASTINGSGEVAL 3 Veranderlijk plaatselijk

1.8.1 Staafbelastingen

Staaf- nummer	Belasting						Afstand van		
	Richting	Type	q1	q2	Hoek	Exc.	Knoop	a [mm]	L [mm]
8	L-Z	 q	-1,313 kN/m	-1,313 kN/m	0,0	0,0	1	1500	4500
9	L-Z	 q	-1,313 kN/m	-1,313 kN/m	0,0	0,0	2	2500	3500
9	L-Z	 q	-1,313 kN/m	-1,313 kN/m	0,0	0,0	2	1500	1000
19	G-Z	 q	-1,313 kN/m	-1,313 kN/m	0,0	0,0	34	0	3905
20	G-Z	 q	-1,313 kN/m	-1,313 kN/m	0,0	0,0	35	0	3905

2.Berekeningsresultaten**2.1 KNOPEN - Imperfectie scheefstand**

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	300	0	300	0
6	300	0	300	0
7	300	0	300	0
8	750	0	750	0
9	750	0	750	0
10	750	0	750	0
11	750	0	750	0
12	750	0	750	0
13	1200	0	1200	0
14	1200	0	1200	0
15	1200	0	1200	0
16	1500	0	1500	0
17	1500	0	1500	0
18	1500	0	1500	0
19	1500	0	1500	0
20	1500	0	1500	0
21	2500	0	2500	0
22	6000	0	6000	0
23	6000	0	6000	0
24	7500	0	7500	0
25	7500	0	7500	0
26	7500	0	7500	0
27	7500	0	7500	0
28	14000	0	14000	0
29	14000	0	14000	0
30	15800	0	15800	0
31	15800	0	15800	0
32	15800	0	15800	0
33	15800	0	15800	0
34	17600	0	17600	0
35	17600	0	17600	0
36	23250	0	23250	0
37	23250	0	23250	0
38	24000	0	24000	0
39	24000	0	24000	0
40	24000	0	24000	0
41	24000	0	24000	0
42	24750	0	24750	0
43	24750	0	24750	0
44	302	375	298	375
45	752	375	748	375
46	1202	375	1198	375
47	304	750	296	750
48	754	750	746	750
49	1204	750	1196	750
50	21405	900	21396	900
51	21405	900	21396	900
52	23255	900	23246	900
53	23255	900	23246	900

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
54	24755	900	24746	900
55	24755	900	24746	900
56	26605	900	26596	900
57	26605	900	26596	900
58	306	1125	294	1125
59	756	1125	744	1125
60	1206	1125	1194	1125
61	307	1475	293	1475
62	1207	1475	1193	1475
63	308	1500	293	1500
64	758	1500	743	1500
65	1208	1500	1193	1500
66	309	1850	291	1850
67	1209	1850	1191	1850
68	311	2225	289	2225
69	1211	2225	1189	2225
70	313	2600	287	2600
71	1213	2600	1187	2600

2.2 UITERSTE GRENSTOESTANDEN (UGT)

2.2.1 Belastingscombinaties

(GL) Geometrisch lineaire krachtsverdeling

Combinatie nummer	Omschrijving	Type
1.1	Permanent + Scheefstand 1/200 +X	UGT
2.2	Permanent + Scheefstand 1/200 -X	UGT
3.1	Veranderlijk + Scheefstand 1/200 +X	UGT
4.2	Veranderlijk + Scheefstand 1/200 -X	UGT
5.1	Veranderlijk plaatselijk + Scheefstand 1/200 +X	UGT
6.2	Veranderlijk plaatselijk + Scheefstand 1/200 -X	UGT

Combinatie nummer	Belasting ($\psi \times y$)				
	1	2	3		
1.1	1,00 x 1,22	0,40 x 1,35			
2.2	1,00 x 1,22	0,40 x 1,35			
3.1	1,00 x 1,08	1,00 x 1,35			
4.2	1,00 x 1,08	1,00 x 1,35			
5.1	1,00 x 1,08		1,00 x 1,35		
6.2	1,00 x 1,08		1,00 x 1,35		

2.2.2 Omhullende reactiekrachten

Knoop- nummer	Comb. nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
5	4.2	0,000	0,000	8,908			
	5.1	0,000	0,000	5,078			
9	1.1	0,000	0,000	5,995			
	6.2	0,000	0,000	7,770			
10	1.1	0,000	0,000	5,984			
	4.2	0,000	0,000	7,392			
13	3.1	0,000	0,000	9,031			
	6.2	0,000	0,000	5,067			
23	4.2	-3,656	0,117	0,001			
	5.1	3,762	-0,097	0,001			
	6.2	3,731	-0,097	0,001			
25	1.1	0,000	0,000	7,150			
	6.2	0,000	0,000	10,738			
26	2.2	0,000	0,000	7,240			
	5.1	0,000	0,000	10,254			
31	1.1	0,000	0,000	7,696			
	4.2	0,000	0,000	9,572			
32	1.1	0,000	0,000	7,669			
	4.2	0,000	0,000	9,513			
39	2.2	0,000	0,000	7,384			
	3.1	0,000	0,000	8,832			
40	2.2	0,000	0,000	7,309			
	3.1	0,000	0,000	8,638			
56	4.2	3,483	-0,117	0,001			
	5.1	-3,558	0,097	0,001			
63	4.2	0,165	0,000	2,913			
	5.1	-0,226	0,000	1,727			
65	3.1	0,032	0,000	3,270	0,000		
	4.2	0,007	0,000	3,257	0,000		
	6.2	0,009	0,000	1,657			
Minimale / maximale waarden							
23	4.2	-3,656					
23	5.1	3,762					
56	4.2		-0,117				
23	4.2		0,117				
23	6.2			0,001			
25	6.2			10,738			

2.2.3 Omhullende staafkrachten

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
1	3.1	2		0,844	-0,884	0,890	0,023	2,562	-0,702
	3.1	2		1,358	0,074	3,130	0,022	2,585	-0,310
	4.2	2		0,860	-0,901	0,889	0,023	2,560	-0,715
	4.2	2		1,383	0,076	3,130	0,022	2,583	-0,316
	5.1	2		-1,018	1,067	0,040	-0,014	0,682	0,846
	5.1	2		-1,638	-0,090	1,733	-0,025	0,667	0,374
	3.1		4424	1,358	0,074	0,000	0,022	7,160	-0,093
	4.2		4425	1,383	0,076	0,000	0,022	7,159	-0,095
	5.1		4573	-1,638	-0,090	0,000	-0,025	3,329	0,099
	6.2		4573	-1,621	-0,089	0,000	-0,025	3,328	0,098
	3.1	3		1,358	0,074	-4,362	0,022	-1,729	0,210
	3.1	3		1,228	0,051	2,242	0,022	-1,729	0,210
	4.2	3		1,383	0,076	-4,362	0,022	-1,729	0,214
	5.1	3		-1,638	-0,090	-2,215	-0,025	-1,020	-0,253
	6.2	3		-1,466	-0,061	1,331	-0,025	-1,020	-0,250
	6.2	4		-1,466	0,061	-0,768	-0,025	-0,029	-0,311
2	5.1	8		-0,070	0,000	-7,587	0,000	0,000	0,000
	6.2	9		0,069	0,000	-7,628	0,000	-2,282	0,000
	6.2	9		0,069	0,000	0,142	0,000	-2,282	0,000
	1.1		764	-0,020	0,000	0,000	0,000	-1,753	0,000
	4.2		768	-0,059	0,000	0,000	0,000	-2,181	0,000
	5.1	10		0,070	0,000	7,387	0,000	-2,210	0,000
	6.2	10		0,069	0,000	7,387	0,000	-2,210	0,000
	4.2	11		-0,059	0,000	-7,292	0,000	0,000	0,000
3	5.1	11		0,070	0,000	-7,346	0,000	0,000	0,000
	3.1	5		0,024	-0,129	-6,645	0,000	-1,987	-0,039
	3.1	5		-0,036	0,090	0,067	0,000	-1,987	-0,039
	5.1	5		0,044	-0,108	-0,021	0,000	-1,070	0,047
	1.1		728	-0,012	0,031	0,000	0,000	-1,581	0,000
	4.2		788	-0,037	0,091	0,000	0,000	-1,971	0,005
	4.2	13		-0,097	-0,142	6,630	0,000	-1,983	0,043
	5.1	13		0,044	-0,108	-0,144	0,000	-1,144	-0,051
	5.1	13		0,115	0,168	3,835	0,000	-1,144	-0,051
	4.2	19		-0,097	0,142	-6,589	0,000	0,000	0,000
4	5.1	19		0,115	-0,168	-3,794	0,000	0,000	0,000
	3.1	4		-0,051	-1,228	1,172	0,022	-0,022	-0,260
	4.2	4		-0,052	-1,252	1,172	0,021	-0,022	-0,265
	5.1	4		0,061	1,482	0,767	-0,029	0,025	0,314
	6.2	4		0,061	1,466	0,768	-0,029	0,025	0,311
	5.1	7		-0,061	1,482	0,708	0,029	0,246	0,131
	6.2	7		-0,061	1,466	0,708	0,029	0,246	0,129
	5.1		403	-0,030	-0,297	0,000	0,029	0,247	0,100
	3.1		963	0,025	0,246	0,000	-0,022	0,364	0,055
	3.1	15		0,025	0,246	-0,047	-0,022	0,358	0,113
	3.1	15		0,000	-1,218	-1,092	-0,022	0,358	0,113
	3.1	20		0,000	1,218	1,151	-0,022	-0,022	-0,252
5	4.2	20		0,000	1,241	1,151	-0,021	-0,022	-0,257
	5.1	20		0,000	-1,470	0,725	0,029	0,025	0,304
	1.1	16		0,261	-0,303	2,018	-0,017	-0,002	-0,217
	3.1	16		0,760	-0,881	2,446	-0,022	-0,002	-0,630
	4.2	16		0,775	-0,898	2,447	-0,022	-0,002	-0,642
	5.1	16		-0,917	1,063	2,059	0,012	0,004	0,760
	6.2	16		-0,908	1,052	2,060	0,012	0,004	0,752

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
5	1.1	17		-0,261	0,303	-0,758	0,017	-2,080	-0,238
	3.1	17		-0,760	0,881	-0,840	0,022	-2,462	-0,692
	4.2	17		-0,775	0,898	-0,842	0,022	-2,464	-0,705
	5.1	17		0,917	-1,063	-1,213	-0,012	-2,457	0,834
	6.2	17		0,908	-1,052	-1,214	-0,012	-2,460	0,825
6	3.1	17		0,968	-0,294	3,347	-0,022	2,461	0,025
	4.2	17		0,987	-0,299	3,346	-0,022	2,463	0,025
	5.1	17		-1,168	0,355	1,664	0,025	2,465	-0,029
	6.2	17		-1,156	0,351	1,664	0,025	2,468	-0,029
	4.2	18		-1,383	0,097	2,054	0,022	5,274	-0,325
	5.1	18		1,638	-0,115	0,878	-0,025	3,847	0,384
	5.1		2557	1,638	-0,115	0,000	-0,025	4,531	0,206
	4.2		2919	-1,383	0,097	0,000	0,022	7,245	-0,139
	4.2	19		-1,383	0,097	-4,367	0,022	-1,665	0,257
	4.2	19		-1,241	0,000	2,221	0,022	-1,665	0,257
	5.1	19		1,638	-0,115	-2,506	-0,025	-1,035	-0,304
	6.2	19		1,454	0,000	1,288	-0,025	-1,036	-0,301
	6.2	20		1,454	0,000	-0,724	-0,025	0,029	-0,301
7	2.2	18		0,199	0,000	0,251	0,000	0,000	0,000
	3.1	18		0,550	0,000	0,222	0,000	0,000	0,000
	4.2	18		0,561	0,000	0,222	0,000	0,000	0,000
	5.1	18		-0,665	0,000	0,222	0,000	0,000	0,000
	1.1		672	-0,189	0,000	0,000	0,000	0,081	0,000
	6.2		672	0,658	0,000	0,000	0,000	0,072	0,000
	1.1	21		-0,189	0,000	0,205	0,000	0,000	0,000
	4.2	21		-0,561	0,000	0,182	0,000	0,000	0,000
	5.1	21		0,665	0,000	0,182	0,000	0,000	0,000
	6.2	21		0,658	0,000	0,182	0,000	0,000	0,000
8	3.1	1		-0,884	0,844	-2,496	0,022	0,023	0,625
	4.2	1		-0,901	0,860	-2,495	0,022	0,023	0,637
	5.1	1		1,067	-1,018	-0,886	-0,012	-0,014	-0,754
	3.1	8		0,884	0,844	-2,645	-0,022	-1,905	0,008
	3.1	8		0,884	0,786	4,654	-0,022	-1,905	0,008
	6.2	8		-1,056	-0,938	6,553	0,013	-0,734	-0,010
	3.1	16		0,884	0,786	4,504	-0,022	1,529	0,597
	4.2	16		1,799	0,026	2,059	-0,020	1,553	-0,034
	5.1	16		-2,130	-0,031	4,343	0,009	4,111	0,039
	6.2	16		-1,056	-0,938	6,404	0,013	4,125	-0,713
	6.2		3359	-2,107	-0,030	0,000	0,009	8,151	-0,018
	5.1		3360	-2,130	-0,031	0,000	0,009	8,149	-0,018
	1.1		3402	0,607	0,009	0,000	-0,015	2,819	0,005
	4.2		3424	1,799	0,026	0,000	-0,020	3,533	0,017
	4.2	22		1,799	-0,026	2,757	-0,020	0,020	0,084
	5.1	22		-2,130	0,031	6,168	0,009	-0,007	-0,099
9	3.1	2		0,959	0,513	-2,239	0,023	0,000	0,391
	3.1	11		-0,959	0,513	-2,389	-0,023	-1,736	-0,006
	4.2	11		-0,977	0,523	-2,390	-0,023	-1,737	-0,006
	4.2	11		-0,977	0,583	4,902	-0,023	-1,737	-0,006
	5.1	11		1,157	-0,690	5,504	0,015	-1,336	0,008
	4.2	17		-0,977	0,583	4,752	-0,023	1,884	0,430
	5.1	17		1,157	-0,690	5,354	0,015	2,735	-0,510
	4.2	21		-1,972	-0,026	0,874	-0,021	3,515	0,121
	5.1	21		2,334	0,031	2,264	0,007	6,377	-0,144
	2.2		3299	-0,700	-0,009	0,000	-0,016	3,078	0,036
	4.2		3317	-1,972	-0,026	0,000	-0,021	3,872	0,100

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
9	5.1		3469	2,334	0,031	0,000	0,007	7,474	-0,114
	4.2	23		-1,972	0,026	2,872	-0,021	-0,020	0,031
	5.1	23		2,334	-0,031	5,911	0,007	0,007	-0,036
10	3.1	23		-0,284	-0,075	0,122	-0,020	0,022	-0,030
	4.2	23		-0,286	-0,077	0,122	-0,020	0,021	-0,031
	5.1	23		0,229	0,090	0,160	0,007	-0,007	0,036
	6.2	23		0,228	0,089	0,161	0,007	-0,008	0,035
	1.1		656	0,104	-0,026	0,000	0,015	0,065	-0,007
	5.1		805	-0,229	0,090	0,000	-0,007	0,057	0,037
	1.1	22		0,104	0,026	0,190	0,015	0,015	-0,029
	3.1	22		0,284	0,075	0,177	0,020	0,020	-0,083
	4.2	22		0,286	0,077	0,177	0,020	0,020	-0,084
	5.1	22		-0,229	-0,090	0,139	-0,007	-0,009	0,099
	6.2	22		-0,228	-0,089	0,139	-0,007	-0,009	0,098
11	4.2	24		0,240	-0,624	-8,881	0,000	0,000	-0,936
	5.1	24		-0,200	0,519	-10,538	0,000	0,000	0,779
	6.2	25		0,199	0,517	-10,579	0,000	-3,168	-0,621
	6.2	25		0,199	0,517	0,158	0,000	-3,168	-0,621
	3.1		575	-0,238	-0,619	0,000	0,000	-2,665	0,572
	2.2		635	-0,089	-0,231	0,000	0,000	-2,114	0,200
	4.2	26		-0,240	-0,624	8,993	0,000	-2,692	0,187
	5.1	26		0,200	0,519	10,289	0,000	-3,081	-0,156
	4.2	27		-0,240	0,624	-8,952	0,000	0,000	0,000
	5.1	27		0,200	-0,519	-10,248	0,000	0,000	0,000
12	4.2	22		-1,876	0,312	-2,935	0,000	0,000	0,000
	5.1	22		2,220	-0,260	-6,306	0,000	0,000	0,000
	4.2	24		1,876	0,312	-4,540	0,000	-5,606	0,468
	4.2	24		2,500	0,072	4,341	0,000	-5,606	-0,468
	5.1	24		-2,220	-0,260	-7,152	0,000	-10,094	-0,390
	5.1	24		-2,739	-0,060	3,386	0,000	-10,094	0,390
	6.2	24		-2,197	-0,259	-7,153	0,000	-10,094	-0,388
	6.2	24		-2,714	-0,060	3,386	0,000	-10,094	0,388
	3.1		5556	2,460	0,071	0,000	0,000	3,197	-0,174
	4.2		5556	2,500	0,072	0,000	0,000	3,197	-0,176
	5.1		7504	-2,739	-0,060	0,000	0,000	0,069	0,030
	6.2		7504	-2,714	-0,060	0,000	0,000	0,069	0,030
	4.2	28		2,500	-0,072	2,616	0,000	0,000	0,000
	5.1	28		-2,739	0,060	0,280	0,000	0,000	0,000
13	4.2	23		-1,607	-0,195	-2,993	0,000	0,000	0,000
	3.1	27		0,975	0,045	4,354	0,000	-5,693	-0,290
	4.2	27		1,607	-0,195	-4,598	0,000	-5,693	-0,292
	4.2	27		0,983	0,045	4,354	0,000	-5,693	-0,292
	5.1	27		-1,338	0,162	-6,917	0,000	-9,741	0,243
	5.1	27		-0,819	-0,037	3,331	0,000	-9,741	0,243
	4.2		5568	0,983	0,045	0,000	0,000	3,164	-0,109
	5.1		7407	-0,819	-0,037	0,000	0,000	0,099	0,022
14	2.2	28		0,005	-0,055	0,175	0,005	-0,005	-0,041
	4.2	28		0,013	-0,148	0,169	0,014	-0,014	-0,111
	5.1	28		-0,011	0,123	0,131	-0,013	0,014	0,093
	6.2		660	0,011	0,123	0,000	0,013	0,057	-0,011
	2.2		779	-0,005	-0,055	0,000	-0,005	0,063	-0,002
	4.2	29		-0,013	0,148	0,131	-0,014	-0,014	-0,111
	5.1	29		0,011	-0,123	0,168	0,013	0,014	0,093
15	4.2	28		-2,649	0,059	-2,784	-0,014	-0,014	0,111
	5.1	28		2,863	-0,049	-0,411	0,014	0,013	-0,093

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
15	4.2	30		2,649	0,059	-4,711	0,014	-6,759	-0,006
	5.1	30		-2,863	-0,049	6,454	-0,014	-1,641	0,005
	6.2	30		-2,837	-0,049	6,456	-0,013	-1,641	0,005
	3.1	34		2,607	-0,058	-2,816	0,014	-0,045	0,098
	4.2	34		2,649	-0,058	-2,820	0,014	-0,051	0,099
	5.1	34		-2,863	0,049	-5,439	-0,014	-9,062	-0,083
	6.2	34		-2,837	0,049	-5,441	-0,013	-9,066	-0,083
16	4.2	31		0,000	0,000	-9,498	0,000	-2,843	0,000
	4.2	31		0,000	0,000	0,073	0,000	-2,843	0,000
	1.1		786	0,000	0,000	0,000	0,000	-2,261	0,000
	4.2		837	0,000	0,000	0,000	0,000	-2,824	0,000
	4.2	32		0,000	0,000	9,463	0,000	-2,833	0,000
17	4.2	29		-0,835	0,058	-2,733	-0,014	0,014	0,111
	5.1	29		0,695	-0,049	-0,502	0,014	-0,013	-0,093
	3.1	33		0,828	0,058	-4,660	0,014	-6,640	-0,006
	4.2	33		0,835	0,059	4,763	0,014	-6,639	-0,006
	5.1	33		-0,695	-0,049	-1,517	-0,014	-1,831	0,005
	6.2	33		-0,692	-0,048	6,412	-0,013	-1,830	0,005
	3.1	35		0,828	-0,058	-2,832	0,014	-0,191	0,099
	4.2	35		0,835	-0,059	-2,836	0,014	-0,200	0,100
	5.1	35		-0,695	0,048	-5,393	-0,014	-8,791	-0,082
	6.2	35		-0,692	0,048	-5,396	-0,013	-8,797	-0,082
18	2.2	34		-0,001	-0,101	0,181	0,005	-0,009	-0,076
	4.2	34		-0,001	-0,273	0,182	0,015	-0,024	-0,205
	5.1	34		-0,001	0,227	0,122	-0,014	0,020	0,170
	6.2		615	0,001	0,226	0,000	0,014	0,058	-0,030
	2.2		803	0,001	-0,101	0,000	-0,005	0,064	-0,005
	2.2	35		0,001	0,101	0,157	-0,005	-0,009	-0,075
	4.2	35		0,001	0,273	0,118	-0,015	-0,024	-0,204
	5.1	35		0,001	-0,227	0,177	0,014	0,020	0,170
19	1.1	34		-0,488	0,022	2,336	-0,004	0,225	0,041
	3.1	34		-2,194	0,058	3,227	-0,013	0,030	0,111
	4.2	34		-2,234	0,059	3,242	-0,013	0,037	0,112
	5.1	34		4,230	-0,048	4,462	0,013	9,077	-0,092
	6.2	34		4,207	-0,048	4,468	0,013	9,081	-0,091
	6.2		1968	-4,207	-0,048	0,000	-0,013	13,483	-0,003
	1.1		2858	0,488	0,022	0,000	0,004	3,562	0,021
	1.1	50		1,243	-0,022	0,855	0,004	-3,114	0,043
	4.2	50		3,198	-0,059	0,825	0,013	-4,759	0,118
	5.1	50		-2,130	0,048	4,414	-0,013	-9,151	-0,097
20	6.2	50		-2,102	0,048	4,407	-0,013	-9,220	-0,097
	1.1	35		0,306	0,021	2,178	-0,004	0,295	0,040
	3.1	35		0,082	0,058	2,769	-0,013	0,205	0,110
	4.2	35		0,080	0,058	2,775	-0,013	0,214	0,110
	5.1	35		1,657	-0,049	4,969	0,013	8,777	-0,093
	6.2	35		1,658	-0,049	4,971	0,013	8,783	-0,093
	6.2		2189	-1,658	-0,049	0,000	-0,013	14,230	-0,014
	1.1		2665	-0,306	0,021	0,000	0,004	3,196	0,016
	1.1	51		0,449	-0,021	1,012	0,004	-2,568	0,042
	2.2	51		0,452	-0,021	1,007	0,005	-2,603	0,043
	4.2	51		0,884	-0,058	1,291	0,013	-3,117	0,117
	5.1	51		0,443	0,049	3,908	-0,013	-10,831	-0,098
21	6.2	51		0,446	0,049	3,904	-0,013	-10,883	-0,098
	4.2	51		0,000	-0,218	0,122	0,009	0,020	-0,163
	5.1	51		0,000	0,184	0,171	-0,009	-0,016	0,138

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
21	2.2		704	0,000	-0,080	0,000	-0,003	0,063	0,003
	6.2		857	0,000	0,183	0,000	0,009	0,057	0,019
	2.2	50		0,000	0,080	0,179	-0,003	0,008	-0,060
	4.2	50		0,000	0,218	0,177	-0,009	0,021	-0,164
	5.1	50		0,000	-0,184	0,128	0,009	-0,016	0,138
22	4.2	50		-3,139	0,059	-1,718	-0,006	4,750	0,046
	6.2	50		3,246	-0,048	-3,931	0,006	9,228	-0,040
	3.1	52		4,690	0,220	-0,183	0,002	0,075	-0,164
	4.2	52		3,139	0,059	-3,697	0,006	-0,259	0,062
	4.2	52		4,687	0,224	-0,223	0,002	0,130	-0,167
	5.1	52		-3,273	-0,048	-4,977	-0,006	0,917	-0,050
	5.1	52		-2,108	-0,221	-0,811	-0,002	0,969	0,164
	2.2		1872	2,512	0,078	0,000	0,001	-0,205	-0,057
	1.1		1911	2,509	0,074	0,000	0,001	-0,249	-0,051
	3.1	54		4,690	0,220	-1,788	0,002	-1,403	0,166
	3.1	54		3,355	0,057	2,126	0,002	-2,099	-0,046
	4.2	54		4,687	0,224	-1,828	0,002	-1,408	0,169
	5.1	54		-2,108	-0,221	-1,656	-0,002	-0,881	-0,168
	5.1	54		-3,488	-0,049	1,195	-0,002	-1,247	0,039
	5.1	56		-3,488	0,049	-0,151	-0,002	0,002	-0,053
23	5.1	38		-0,016	0,000	-8,287	0,000	0,000	0,000
	3.1	39		0,012	0,000	-8,732	0,000	-2,613	0,000
	3.1	39		0,012	0,000	0,100	0,000	-2,613	0,000
	5.1	39		0,016	0,000	-8,328	0,000	-2,492	0,000
	2.2		847	0,012	0,000	0,000	0,000	-2,160	0,000
	3.1		1034	0,012	0,000	0,000	0,000	-2,577	0,000
	3.1	40		0,012	0,000	8,616	0,000	-2,578	0,000
24	4.2	51		-0,344	0,059	-1,583	-0,006	3,126	0,047
	6.2	51		0,284	-0,049	-4,073	0,006	10,874	-0,040
	4.2	53		0,344	0,059	-3,563	0,006	-1,634	0,062
	4.2	53		1,787	0,225	0,511	0,002	-0,852	-0,167
	5.1	53		-0,285	-0,049	-5,119	-0,006	2,316	-0,051
	5.1	53		0,060	-0,220	-1,589	-0,002	2,000	0,165
	2.2		2176	1,378	0,078	0,000	0,001	-0,499	-0,032
	4.2		2327	1,787	0,225	0,000	0,002	-0,730	-0,059
	3.1		2352	1,775	0,222	0,000	0,002	-0,754	-0,053
	4.2	55		1,787	0,225	-1,095	0,002	-1,290	0,171
	4.2	55		0,081	0,059	2,132	0,002	-2,115	-0,049
	5.1	55		0,060	-0,220	-2,435	-0,002	-1,018	-0,166
25	2.2	57		-0,022	-0,029	0,170	0,001	-0,001	-0,022
	4.2	57		-0,059	-0,081	0,152	0,002	-0,002	-0,061
	5.1	57		0,048	0,070	0,147	-0,002	0,002	0,052
	6.2		737	-0,048	0,069	0,000	0,002	0,056	-0,001
	2.2		754	0,022	-0,029	0,000	-0,001	0,063	0,000
	1.1	56		0,022	0,029	0,168	-0,001	-0,001	-0,021
	4.2	56		0,059	0,081	0,147	-0,002	-0,002	-0,061
	5.1	56		-0,048	-0,070	0,152	0,002	0,002	0,053
	3.1	36		1,315	-0,171	-4,099	-0,002	0,632	-0,127
26	4.2	36		1,318	-0,173	-4,089	-0,002	0,622	-0,129
	5.1	36		0,437	0,166	-3,905	0,002	0,509	0,127
	3.1	38		-1,315	-0,171	-4,248	0,002	-2,498	-0,001
	4.2	38		-1,318	-0,173	-4,239	0,002	-2,501	-0,001
	4.2	38		-1,318	-0,161	4,448	0,002	-2,501	-0,001
	5.1	38		-0,437	0,182	4,233	-0,002	-2,476	-0,002
	4.2	42		-1,318	0,161	-4,299	0,002	-0,779	-0,122

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
26	5.1	42		-0,437	-0,182	-4,083	-0,002	-0,643	0,134
27	4.2	42		0,080	0,175	0,111	0,003	0,012	0,132
	5.1	42		-0,215	-0,169	0,154	-0,003	-0,022	-0,126
	6.2	42		-0,212	-0,167	0,156	-0,003	-0,024	-0,124
	2.2		650	0,021	0,062	0,000	-0,001	0,044	-0,007
	5.1		771	0,215	-0,169	0,000	0,003	0,037	-0,004
	2.2	43		0,021	-0,062	0,192	-0,001	0,037	0,046
	4.2	43		-0,080	-0,175	0,188	-0,003	0,046	0,130
	5.1	43		0,215	0,169	0,145	0,003	0,016	-0,127
	6.2	43		0,212	0,167	0,144	0,003	0,015	-0,126
	3.1	43		1,930	-0,172	-4,103	-0,002	0,756	-0,127
28	4.2	43		1,893	-0,175	-4,107	-0,002	0,757	-0,130
	5.1	43		0,722	0,167	-4,164	0,002	0,572	0,127
	3.1	41		-1,930	-0,160	4,322	0,002	-2,378	-0,002
	4.2	41		-1,893	-0,175	-4,257	0,002	-2,380	-0,002
	5.1	41		-0,722	0,182	4,101	-0,002	-2,607	-0,002
	6.2	41		-0,683	0,165	-4,318	-0,002	-2,609	-0,002
	6.2	41		-0,683	0,180	4,093	-0,002	-2,609	-0,002
	3.1	37		-1,930	0,160	-4,172	0,002	-0,808	-0,122
	4.2	37		-1,893	0,163	-4,163	0,002	-0,799	-0,124
	5.1	37		-0,722	-0,182	-3,951	-0,002	-0,413	0,135
	6.2	37		-0,683	-0,180	-3,943	-0,002	-0,404	0,133
	3.1	37		0,073	0,170	0,111	0,002	0,012	0,128
	4.2	37		0,076	0,173	0,113	0,002	0,011	0,130
	5.1	37		-0,211	-0,168	0,157	-0,002	-0,025	-0,125
29	1.1		650	0,025	0,059	0,000	-0,001	0,044	-0,007
	6.2		776	0,211	-0,166	0,000	0,002	0,037	-0,005
	1.1	36		0,025	-0,059	0,191	-0,001	0,037	0,043
	3.1	36		-0,073	-0,170	0,188	-0,002	0,046	0,127
	4.2	36		-0,076	-0,173	0,187	-0,002	0,045	0,129
	5.1	36		0,211	0,168	0,142	0,002	0,014	-0,127
	1.1	36		3,202	-1,149	0,085	0,000	-0,036	-0,570
	3.1	36		3,905	-1,164	0,098	0,000	-0,044	-0,635
	4.2	36		3,908	-1,125	0,097	0,000	-0,042	-0,624
	5.1	36		3,760	-0,624	0,045	0,000	-0,016	-0,507
30	6.2	36		3,756	-0,589	0,046	0,000	-0,018	-0,497
	1.1	52		-3,040	1,148	-0,085	0,000	-0,040	-0,463
	3.1	52		-3,761	1,164	-0,098	0,000	-0,044	-0,413
	4.2	52		-3,765	1,126	-0,097	0,000	-0,045	-0,389
	5.1	52		-3,616	0,624	-0,045	0,000	-0,024	-0,055
	6.2	52		-3,612	0,590	-0,046	0,000	-0,024	-0,033
	2.2	37		3,368	-1,338	-0,040	0,000	0,015	-0,619
	3.1	37		4,346	-1,755	-0,013	0,000	0,002	-0,783
	5.1	37		3,798	-0,074	-0,066	0,000	0,029	-0,380
	6.2	37		3,767	-0,043	-0,065	0,000	0,027	-0,371
31	2.2	53		-3,206	1,339	0,040	0,000	0,021	-0,586
	3.1	53		-4,202	1,754	0,013	0,000	0,010	-0,796
	4.2	53		-4,187	1,726	0,014	0,000	0,009	-0,779
	5.1	53		-3,655	0,073	0,066	0,000	0,031	0,313
	6.2	53		-3,624	0,044	0,065	0,000	0,031	0,332
	2.2	43		3,230	1,428	-0,085	0,000	0,036	0,632
	3.1	43		3,927	1,739	-0,094	0,000	0,041	0,758
	4.2	43		3,911	1,738	-0,096	0,000	0,043	0,759
32	5.1	43		4,023	0,871	-0,048	0,000	0,018	0,570
	6.2	43		4,021	0,870	-0,047	0,000	0,017	0,571

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
32	2.2	55		-3,068	-1,427	0,085	0,000	0,040	0,653
	3.1	55		-3,783	-1,740	0,094	0,000	0,043	0,807
	4.2	55		-3,767	-1,738	0,096	0,000	0,043	0,805
	5.1	55		-3,879	-0,872	0,048	0,000	0,025	0,215
	6.2	55		-3,877	-0,869	0,047	0,000	0,026	0,212
33	3.1	42		4,168	1,596	0,017	0,000	-0,004	0,742
	4.2	42		4,193	1,591	0,016	0,000	-0,003	0,743
	5.1	42		3,129	1,087	0,063	0,000	-0,026	0,611
	6.2	42		3,155	1,082	0,063	0,000	-0,028	0,611
	3.1	54		-4,025	-1,597	-0,017	0,000	-0,011	0,694
	4.2	54		-4,049	-1,590	-0,016	0,000	-0,012	0,689
	5.1	54		-2,986	-1,088	-0,063	0,000	-0,030	0,368
	6.2	54		-3,011	-1,081	-0,063	0,000	-0,029	0,363
34	1.1	53		0,094	-0,101	0,129	0,001	-0,022	-0,077
	4.2	53		0,181	-0,304	0,105	0,003	-0,013	-0,229
	5.1	53		-0,105	0,290	0,125	-0,003	-0,027	0,216
	6.2	53		-0,105	0,287	0,126	-0,003	-0,028	0,214
	2.2		717	-0,097	-0,105	0,000	-0,001	0,024	0,005
	5.1		783	0,105	0,290	0,000	0,003	0,022	0,011
	2.2	52		-0,097	0,105	0,141	-0,001	0,031	-0,077
	4.2	52		-0,181	0,304	0,134	-0,003	0,035	-0,227
	5.1	52		0,105	-0,290	0,114	0,003	0,019	0,218
	6.2	52		0,105	-0,287	0,113	0,003	0,019	0,216
	2.2	55		0,097	-0,098	0,142	0,001	-0,031	-0,072
35	3.1	55		0,180	-0,282	0,136	0,002	-0,036	-0,210
	4.2	55		0,182	-0,286	0,136	0,002	-0,036	-0,213
	5.1	55		-0,109	0,278	0,110	-0,002	-0,016	0,210
	6.2		695	0,106	0,275	0,000	0,002	0,022	-0,016
	1.1		786	-0,095	-0,094	0,000	-0,001	0,024	-0,005
	3.1	54		-0,180	0,282	0,103	-0,002	0,011	-0,213
	4.2	54		-0,182	0,286	0,103	-0,002	0,011	-0,216
	5.1	54		0,109	-0,278	0,129	0,002	0,031	0,207
	1.1	37		-0,052	-0,009	0,034	0,000	-0,010	-0,010
	3.1	37		-0,266	-0,008	0,030	0,000	-0,009	-0,013
	4.2	37		-0,275	-0,007	0,030	0,000	-0,009	-0,013
36	5.1	37		0,397	-0,007	0,031	0,000	-0,009	-0,006
	6.2	37		0,396	-0,007	0,031	0,000	-0,009	-0,006
	2.2		887	0,058	-0,009	0,000	0,000	0,005	0,002
	3.1		889	0,266	-0,008	0,000	0,000	0,005	0,006
	1.1	52		0,092	0,009	0,033	0,000	0,009	-0,005
	2.2	52		0,099	0,009	0,033	0,000	0,009	-0,005
	4.2	52		0,311	0,007	0,030	0,000	0,008	0,000
	5.1	52		-0,361	0,007	0,029	0,000	0,008	-0,007
	6.2	52		-0,360	0,007	0,029	0,000	0,008	-0,007
	2.2	37		-0,181	0,001	0,033	0,000	-0,016	0,002
	3.1	37		-0,402	0,002	0,028	0,000	-0,016	0,006
37	4.2	37		-0,348	0,002	0,028	0,000	-0,016	0,006
	5.1	37		-0,543	-0,002	0,051	0,000	-0,032	-0,005
	6.2	37		-0,490	-0,002	0,051	0,000	-0,032	-0,005
	3.1		809	0,402	0,002	0,000	0,000	-0,004	-0,004
	6.2		1502	0,490	-0,002	0,000	0,000	0,006	0,002
	1.1	55		0,265	-0,001	0,035	0,000	0,018	-0,001
	2.2	55		0,222	-0,001	0,035	0,000	0,018	-0,001
	3.1	55		0,438	-0,002	0,032	0,000	0,020	-0,002
	4.2	55		0,384	-0,002	0,032	0,000	0,019	-0,002

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
37	5.1	55		0,579	0,002	0,009	0,000	-0,005	0,001
	6.2	55		0,526	0,002	0,008	0,000	-0,005	0,001
38	1.1	55		-0,096	-0,012	0,033	0,000	-0,009	-0,009
	3.1	55		-0,312	-0,014	0,030	0,000	-0,008	-0,007
	4.2	55		-0,315	-0,014	0,029	0,000	-0,008	-0,007
	5.1	55		0,370	-0,008	0,029	0,000	-0,008	-0,009
	6.2	55		0,363	-0,008	0,029	0,000	-0,008	-0,009
	4.2		861	0,315	-0,014	0,000	0,000	0,005	-0,004
	1.1		863	0,096	-0,012	0,000	0,000	0,005	-0,001
	2.2	42		0,060	0,011	0,034	0,000	0,010	-0,012
	3.1	42		0,276	0,014	0,030	0,000	0,009	-0,017
	4.2	42		0,279	0,014	0,030	0,000	0,009	-0,017
	5.1	42		-0,406	0,008	0,031	0,000	0,009	-0,005
	6.2	42		-0,399	0,008	0,031	0,000	0,009	-0,005
39	1.1	42		0,229	0,000	0,039	0,000	-0,020	0,002
	4.2	42		0,133	0,002	0,042	0,000	-0,025	0,006
	5.1	42		1,017	-0,002	0,054	0,000	-0,032	-0,005
	6.2	42		0,963	-0,002	0,055	0,000	-0,032	-0,005
	3.1		1217	-0,192	0,002	0,000	0,000	0,001	-0,003
	6.2		1590	-0,963	-0,002	0,000	0,000	0,011	0,002
	1.1	52		-0,188	0,000	0,028	0,000	0,010	-0,001
	4.2	52		-0,097	-0,002	0,018	0,000	0,003	-0,002
	5.1	52		-0,981	0,002	0,006	0,000	-0,010	0,002
	6.2	52		-0,927	0,002	0,005	0,000	-0,010	0,002
40	4.2	5		-0,223	0,061	2,197	0,000	0,000	0,000
	5.1	5		0,264	-0,072	1,512	0,000	0,000	0,000
	4.2	6		-1,502	-0,026	-0,885	0,000	0,653	0,018
	5.1	6		1,779	0,031	-0,591	0,000	0,447	-0,022
	4.2	7		-1,502	0,026	0,980	0,000	0,000	0,000
41	5.1	7		1,779	-0,031	0,687	0,000	0,000	0,000
	3.1	13		0,229	0,059	2,346	0,000	0,000	0,000
	3.1	14		1,464	-0,025	-0,949	0,000	0,698	0,018
	4.2	14		-0,234	0,060	2,303	0,000	0,697	0,018
	4.2	14		1,492	-0,026	-0,948	0,000	0,697	0,018
	5.1	14		0,277	-0,071	1,048	0,000	0,321	-0,021
	5.1	14		-1,767	0,030	-0,410	0,000	0,321	-0,021
	4.2	15		1,492	0,026	1,044	0,000	0,000	0,000
	5.1	15		-1,767	-0,030	0,506	0,000	0,000	0,000
42	4.2	6		-3,264	0,002	0,284	0,000	0,000	0,000
	4.2		961	3,264	0,002	0,000	0,000	0,137	0,002
	3.1	44		3,113	0,002	-0,391	0,000	-0,122	0,004
	3.1	44		6,054	0,019	0,380	-0,003	-0,160	-0,022
	4.2	44		6,214	0,019	0,379	-0,003	-0,159	-0,022
	6.2	44		0,973	0,000	0,178	0,001	-0,069	0,000
	6.2		3501	0,973	0,000	0,000	0,001	0,039	0,000
	5.1		3504	0,877	0,000	0,000	0,001	0,039	0,000
	4.2		3563	6,214	0,019	0,000	-0,003	0,084	0,002
	3.1		3565	6,054	0,019	0,000	-0,003	0,084	0,002
	3.1	47		6,054	0,019	-0,295	-0,003	-0,063	0,021
	4.2	47		6,214	0,019	-0,296	-0,003	-0,064	0,021
	6.2	47		0,973	0,000	-0,155	0,001	-0,043	0,000
	6.2	47		2,203	-0,011	0,153	0,001	-0,038	0,012
	6.2		5608	2,203	-0,011	0,000	0,001	0,041	0,001
	3.1	58		2,512	-0,002	0,399	0,000	-0,154	0,002
	6.2	58		2,203	-0,011	-0,181	0,001	-0,070	-0,012

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
42	3.1	63		2,624	0,002	0,276	0,000	0,013	-0,003
43	5.1	14		-3,061	-0,001	0,140	0,000	0,000	0,000
	3.1	46		-0,134	0,000	-0,407	0,000	-0,158	0,000
	6.2		3531	3,574	-0,003	0,000	0,001	0,043	0,001
	3.1	49		3,682	0,022	-0,329	-0,003	-0,105	0,029
	3.1	49		4,054	0,024	0,301	-0,003	-0,071	-0,026
	6.2	49		3,652	-0,005	0,160	0,001	-0,045	0,007
	3.1		5581	4,054	0,024	0,000	-0,003	0,082	-0,002
	6.2		5659	3,652	-0,005	0,000	0,001	0,043	0,002
	3.1	60		4,054	0,024	-0,374	-0,003	-0,153	0,028
	3.1	60		2,515	0,037	0,384	-0,003	-0,122	-0,041
	6.2	60		3,652	-0,005	-0,173	0,001	-0,060	-0,004
	3.1		8141	2,515	0,037	0,000	-0,003	0,128	0,007
44	3.1	65		2,628	-0,037	0,291	-0,003	0,015	0,044
	4.2	65		2,612	-0,037	0,291	-0,003	0,016	0,044
	4.2	63		0,000	0,081	0,217	0,000	0,000	0,000
	3.1	64		0,000	-0,060	-0,358	0,000	0,092	0,036
	4.2	64		0,000	0,081	0,196	0,000	0,093	0,037
	4.2	64		0,000	-0,065	-0,356	0,000	0,093	0,037
	6.2	64		0,000	-0,092	-0,080	0,000	0,060	0,016
	3.1	65		0,000	0,060	0,379	0,000	0,074	0,009
	6.2	65		0,000	0,092	0,101	0,000	-0,019	-0,025
	2.2	6		0,013	-0,051	0,220	0,000	0,000	0,000
	3.1	6		0,075	-0,049	0,306	0,000	0,000	0,000
	6.2	6		-0,099	-0,046	0,133	0,000	0,000	0,000
45	2.2	12		-0,013	-0,051	0,163	0,000	0,086	-0,023
	2.2	12		-0,013	0,051	-0,163	0,000	0,086	-0,023
	3.1	12		-0,075	-0,049	0,256	0,000	0,126	-0,022
	3.1	12		-0,075	0,049	-0,256	0,000	0,126	-0,022
	6.2	12		0,099	0,046	-0,083	0,000	0,049	-0,020
	3.1	14		-0,075	-0,049	0,306	0,000	0,000	0,000
	6.2	14		0,099	-0,046	0,133	0,000	0,000	0,000
	2.2	63		2,543	0,009	0,016	0,001	0,009	0,001
	3.1	63		3,072	0,021	0,010	0,002	0,013	0,002
	4.2	63		3,085	0,021	0,010	0,002	0,013	0,002
	5.1	63		1,804	-0,004	0,016	0,000	0,005	0,000
	6.2	63		1,818	-0,004	0,016	0,000	0,005	0,000
46	4.2		290	-3,085	0,021	0,000	-0,002	0,015	0,005
	5.1		456	-1,804	-0,004	0,000	0,000	0,009	-0,002
	1.1	70		-2,470	-0,009	0,053	-0,001	0,023	0,015
	3.1	70		-3,021	-0,021	0,051	-0,002	0,023	0,035
	4.2	70		-3,034	-0,021	0,051	-0,002	0,022	0,035
	5.1	70		-1,753	0,004	0,045	0,000	0,020	-0,007
	6.2	70		-1,767	0,004	0,045	0,000	0,020	-0,007
	2.2	70		-2,355	0,012	0,021	-0,005	-0,002	0,006
	3.1	70		-2,908	0,031	0,018	-0,012	-0,002	0,015
	4.2	70		-2,921	0,030	0,019	-0,012	-0,002	0,014
	5.1	70		-1,635	-0,006	0,019	0,001	-0,002	-0,002
	6.2	70		-1,649	-0,008	0,019	0,002	-0,002	-0,003
47	3.1		749	2,908	0,031	0,000	0,012	0,005	0,009
	2.2		753	2,355	0,012	0,000	0,005	0,006	0,003
	1.1	58		2,262	-0,014	0,028	0,006	0,008	0,017
	3.1	58		2,840	-0,031	0,024	0,012	0,007	0,040
	4.2	58		2,853	-0,030	0,024	0,012	0,006	0,037
	5.1	58		1,567	0,006	0,024	-0,001	0,006	-0,008

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
47	6.2	58		1,581	0,008	0,024	-0,002	0,006	-0,010
48	1.1	58		1,090	-0,024	0,034	0,003	-0,009	-0,049
	3.1	58		1,354	-0,049	0,029	0,008	-0,006	-0,104
	4.2	58		1,356	-0,047	0,029	0,007	-0,005	-0,101
	5.1	58		0,715	0,002	0,031	-0,002	-0,009	0,011
	6.2	58		0,715	0,005	0,031	-0,003	-0,009	0,015
	4.2		801	-1,356	-0,047	0,000	-0,007	0,006	0,063
	6.2		882	-0,715	0,005	0,000	0,003	0,005	-0,011
	1.1	68		-1,032	0,024	0,035	-0,003	0,009	0,007
	2.2	68		-1,034	0,022	0,035	-0,003	0,009	0,007
	3.1	68		-1,303	0,049	0,032	-0,008	0,009	0,020
	4.2	68		-1,304	0,047	0,033	-0,007	0,009	0,020
	5.1	68		-0,664	-0,002	0,030	0,002	0,008	-0,007
	6.2	68		-0,664	-0,005	0,030	0,003	0,008	-0,007
49	1.1	68		-0,799	-0,012	0,026	-0,002	-0,008	0,005
	2.2	68		-0,800	-0,013	0,026	-0,001	-0,008	0,004
	3.1	68		-1,101	-0,024	0,023	-0,003	-0,006	0,014
	4.2	68		-1,103	-0,025	0,022	-0,003	-0,006	0,013
	5.1	68		-0,454	0,000	0,024	0,000	-0,007	-0,005
	6.2	68		-0,455	0,000	0,024	0,000	-0,007	-0,006
	1.1		936	0,799	-0,012	0,000	0,002	0,005	-0,016
	5.1		955	0,454	0,000	0,000	0,000	0,004	0,006
	2.2	47		0,723	0,013	0,023	0,001	0,005	-0,026
	3.1	47		1,032	0,024	0,020	0,003	0,004	-0,055
	4.2	47		1,034	0,025	0,021	0,003	0,005	-0,056
	5.1	47		0,386	0,000	0,019	0,000	0,004	0,006
	6.2	47		0,387	0,000	0,019	0,000	0,004	0,006
50	1.1	47		-0,617	-0,008	0,033	-0,001	-0,007	-0,023
	3.1	47		-0,733	-0,020	0,028	-0,002	-0,005	-0,054
	4.2	47		-0,739	-0,019	0,028	-0,003	-0,004	-0,052
	5.1	47		-0,479	0,005	0,029	0,001	-0,007	0,010
	6.2	47		-0,486	0,006	0,029	0,000	-0,007	0,013
	4.2		788	0,739	-0,019	0,000	0,003	0,007	0,037
	6.2		822	0,486	0,006	0,000	0,000	0,005	-0,008
	1.1	66		0,675	0,008	0,037	0,001	0,010	0,010
	2.2	66		0,682	0,006	0,037	0,001	0,010	0,010
	3.1	66		0,784	0,020	0,033	0,002	0,009	0,020
	4.2	66		0,790	0,019	0,033	0,003	0,009	0,020
	5.1	66		0,530	-0,005	0,032	-0,001	0,010	-0,002
	6.2	66		0,537	-0,006	0,032	0,000	0,010	-0,002
51	1.1	66		0,929	-0,016	0,023	0,005	-0,006	0,012
	3.1	66		1,010	-0,039	0,020	0,010	-0,004	0,026
	4.2	66		1,015	-0,040	0,019	0,010	-0,005	0,025
	5.1	66		0,756	0,009	0,022	-0,002	-0,006	-0,003
	6.2	66		0,763	0,009	0,022	-0,002	-0,006	-0,004
	4.2		773	-1,015	-0,040	0,000	-0,010	0,003	-0,056
	1.1		837	-0,929	-0,016	0,000	-0,005	0,004	-0,025
	2.2	44		-1,014	0,016	0,025	-0,005	0,008	-0,039
	4.2	44		-1,084	0,040	0,024	-0,010	0,009	-0,094
	5.1	44		-0,824	-0,009	0,021	0,002	0,006	0,019
	6.2	44		-0,831	-0,009	0,021	0,002	0,005	0,019
52	2.2	44		-2,465	0,015	0,039	-0,005	-0,010	0,020
	3.1	44		-3,212	0,033	0,032	-0,012	-0,006	0,043
	4.2	44		-3,221	0,034	0,033	-0,012	-0,006	0,045
	5.1	44		-1,555	-0,006	0,036	0,002	-0,011	-0,008

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
52	1.1		970	2,456	0,014	0,000	0,005	0,009	-0,005
	5.1		1008	1,555	-0,006	0,000	-0,002	0,007	0,002
	1.1	61		2,513	-0,014	0,030	0,005	0,002	0,006
	3.1	61		3,263	-0,033	0,029	0,012	0,003	0,013
	4.2	61		3,272	-0,034	0,029	0,012	0,002	0,013
	5.1	61		1,606	0,006	0,025	-0,002	0,002	-0,003
53	6.2	61		1,614	0,006	0,026	-0,002	0,002	-0,002
	2.2	61		2,695	0,009	0,034	0,000	-0,017	0,015
	3.1	61		3,429	0,021	0,030	0,000	-0,015	0,036
	4.2	61		3,438	0,020	0,030	0,000	-0,016	0,035
	5.1	61		1,750	-0,003	0,031	0,000	-0,016	-0,006
	6.2	61		1,757	-0,004	0,030	0,000	-0,016	-0,007
	1.1		1225	-2,685	0,009	0,000	0,000	0,004	-0,005
	5.1		1239	-1,750	-0,003	0,000	0,000	0,003	0,002
	1.1	6		-2,762	-0,009	0,014	0,000	0,000	0,000
	3.1	6		-3,497	-0,021	0,013	0,000	0,000	0,000
	4.2	6		-3,507	-0,020	0,012	0,000	0,000	0,000
	5.1	6		-1,818	0,003	0,012	0,000	0,000	0,000
54	6.2	6		-1,826	0,004	0,012	0,000	0,000	0,000
	3.1	65		3,391	-0,019	0,008	0,016	0,015	-0,081
	4.2	65		3,377	-0,017	0,008	0,016	0,016	-0,078
	6.2	65		1,851	0,011	0,017	-0,003	0,005	0,027
	4.2		214	-3,377	-0,017	0,000	-0,016	0,017	0,074
	6.2		468	-1,851	0,011	0,000	0,003	0,009	-0,022
	2.2	71		-2,661	0,003	0,054	-0,007	0,024	0,022
	3.1	71		-3,340	0,019	0,053	-0,016	0,024	0,049
	5.1	71		-1,814	-0,010	0,045	0,002	0,019	-0,007
	6.2	71		-1,800	-0,011	0,045	0,003	0,020	-0,008
55	3.1	71		-3,226	0,005	0,023	-0,010	-0,004	0,019
	4.2	71		-3,212	0,005	0,023	-0,010	-0,005	0,018
	5.1	71		-1,697	0,007	0,018	0,002	-0,001	0,000
	6.2	71		-1,683	0,006	0,018	0,003	-0,001	-0,001
	5.1		734	1,697	0,007	0,000	-0,002	0,005	0,005
	1.1		818	2,546	0,006	0,000	0,004	0,006	-0,005
	1.1	60		2,469	-0,006	0,026	0,004	0,005	0,001
	3.1	60		3,158	-0,005	0,020	0,010	0,002	-0,009
	4.2	60		3,144	-0,005	0,020	0,010	0,002	-0,010
	5.1	60		1,629	-0,007	0,025	-0,002	0,007	0,012
56	6.2	60		1,615	-0,006	0,025	-0,003	0,007	0,011
	1.1	60		0,851	-0,013	0,036	0,003	-0,010	-0,038
	3.1	60		0,928	-0,028	0,032	0,006	-0,010	-0,085
	5.1	60		0,694	0,003	0,031	0,000	-0,008	0,014
	6.2	60		0,694	0,005	0,031	0,000	-0,008	0,017
	2.2		876	-0,850	-0,011	0,000	-0,003	0,006	0,024
	3.1		894	-0,928	-0,028	0,000	-0,006	0,004	0,060
	1.1	69		-0,793	0,013	0,034	-0,003	0,009	0,015
	2.2	69		-0,793	0,011	0,034	-0,003	0,009	0,015
	3.1	69		-0,877	0,028	0,030	-0,006	0,008	0,037
	5.1	69		-0,643	-0,003	0,030	0,000	0,007	-0,008
	6.2	69		-0,643	-0,005	0,030	0,000	0,008	-0,009
57	1.1	69		-0,558	-0,007	0,027	0,000	-0,008	0,015
	2.2	69		-0,557	-0,008	0,027	0,000	-0,008	0,014
	3.1	69		-0,672	-0,015	0,025	0,000	-0,007	0,036
	4.2	69		-0,671	-0,016	0,025	0,000	-0,008	0,035
	5.1	69		-0,434	0,002	0,023	0,000	-0,007	-0,008

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
57	6.2	69		-0,434	0,002	0,023	0,000	-0,007	-0,009
	5.1		916	0,434	0,002	0,000	0,000	0,004	0,010
	3.1		1022	0,672	-0,015	0,000	0,000	0,006	-0,051
	2.2	49		0,480	0,008	0,022	0,000	0,004	-0,027
	3.1	49		0,604	0,015	0,018	0,000	0,001	-0,062
	4.2	49		0,603	0,016	0,018	0,000	0,002	-0,063
	5.1	49		0,365	-0,002	0,020	0,000	0,005	0,011
	6.2	49		0,365	-0,002	0,020	0,000	0,005	0,012
58	1.1	49		-0,675	-0,006	0,034	-0,001	-0,008	-0,020
	3.1	49		-0,975	-0,015	0,030	-0,004	-0,008	-0,047
	4.2	49		-0,970	-0,014	0,030	-0,004	-0,007	-0,045
	5.1	49		-0,356	0,004	0,030	0,001	-0,007	0,010
	6.2	49		-0,349	0,005	0,030	0,001	-0,007	0,012
	2.2		833	0,668	-0,005	0,000	0,001	0,006	0,014
	3.1		849	0,975	-0,015	0,000	0,004	0,005	0,035
	1.1	67		0,733	0,006	0,036	0,001	0,010	0,010
	2.2	67		0,726	0,005	0,036	0,001	0,010	0,009
	3.1	67		1,026	0,015	0,031	0,004	0,009	0,021
	4.2	67		1,021	0,014	0,032	0,004	0,008	0,021
	5.1	67		0,407	-0,004	0,032	-0,001	0,009	-0,003
	6.2	67		0,401	-0,005	0,032	-0,001	0,009	-0,003
	1.1	67		0,988	-0,016	0,025	0,005	-0,007	0,015
	3.1	67		1,257	-0,038	0,023	0,011	-0,006	0,033
	4.2	67		1,251	-0,038	0,023	0,011	-0,007	0,032
59	5.1	67		0,630	0,007	0,021	-0,002	-0,005	-0,005
	6.2	67		0,624	0,007	0,021	-0,002	-0,005	-0,006
	5.1		838	-0,630	0,007	0,000	0,002	0,003	0,011
	3.1		947	-1,257	-0,038	0,000	-0,011	0,005	-0,069
	2.2	46		-1,059	0,017	0,024	-0,005	0,006	-0,043
	3.1	46		-1,325	0,038	0,020	-0,011	0,003	-0,099
	4.2	46		-1,320	0,038	0,020	-0,011	0,005	-0,099
	5.1	46		-0,698	-0,007	0,022	0,002	0,007	0,018
	6.2	46		-0,692	-0,007	0,022	0,002	0,006	0,018
	2.2	46		-2,351	0,013	0,041	-0,006	-0,012	0,018
	3.1	46		-2,853	0,032	0,036	-0,014	-0,010	0,043
	4.2	46		-2,844	0,033	0,036	-0,014	-0,010	0,045
60	5.1	46		-1,721	-0,008	0,036	0,002	-0,010	-0,011
	6.2	46		-1,713	-0,008	0,036	0,002	-0,010	-0,010
	1.1		1003	2,360	0,013	0,000	0,006	0,009	-0,005
	4.2		1008	2,844	0,033	0,000	0,014	0,008	-0,012
	1.1	62		2,418	-0,013	0,029	0,006	0,002	0,004
	3.1	62		2,904	-0,032	0,026	0,014	0,001	0,012
	4.2	62		2,895	-0,033	0,025	0,014	0,001	0,012
	5.1	62		1,772	0,008	0,026	-0,002	0,001	-0,003
	6.2	62		1,764	0,008	0,026	-0,002	0,001	-0,003
	2.2	62		2,578	0,008	0,034	0,000	-0,018	0,015
	3.1	62		3,064	0,022	0,030	0,000	-0,016	0,038
	6.2	62		1,909	-0,005	0,030	0,000	-0,015	-0,009
61	1.1		1228	-2,588	0,009	0,000	0,000	0,004	-0,005
	4.2		1249	-3,055	0,021	0,000	0,000	0,003	-0,010
	1.1	14		-2,665	-0,009	0,014	0,000	0,000	0,000
	3.1	14		-3,133	-0,022	0,013	0,000	0,000	0,000
	4.2	14		-3,123	-0,021	0,012	0,000	0,000	0,000
	6.2	14		-1,978	0,005	0,013	0,000	0,000	0,000
	3.1	61		4,409	-0,013	0,058	0,025	-0,013	-0,042

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
62	4.2	61		4,421	-0,012	0,058	0,025	-0,013	-0,042
	1.1		1055	-3,427	-0,006	0,000	-0,011	0,019	0,012
	1.1	66		-3,427	-0,006	-0,076	-0,011	-0,027	0,005
	2.2	66		-3,440	-0,005	-0,076	-0,011	-0,027	0,005
	3.1	66		-5,561	-0,033	0,061	-0,038	-0,018	0,038
	4.2	66		-5,580	-0,033	0,061	-0,037	-0,018	0,037
	6.2	66		-3,052	0,006	0,062	0,007	-0,022	-0,006
	3.1		3391	-5,561	-0,033	0,000	-0,038	0,016	0,001
	4.2		3397	-5,580	-0,033	0,000	-0,037	0,016	0,001
	6.2		3417	-3,052	0,006	0,000	0,007	0,013	0,002
	5.1		3418	-3,033	0,006	0,000	0,007	0,013	0,002
	2.2	68		-3,236	-0,003	0,071	-0,011	-0,023	-0,009
	3.1	68		-5,561	-0,033	-0,064	-0,038	-0,022	-0,038
	4.2	68		-5,580	-0,033	-0,064	-0,037	-0,021	-0,037
	6.2	68		-3,052	0,006	-0,063	0,007	-0,022	0,009
	1.1	70		-3,192	0,004	0,069	-0,011	0,021	-0,018
	3.1	70		-3,929	0,009	0,063	-0,025	0,020	-0,040
63	3.1	62		3,935	-0,011	0,059	0,028	-0,014	-0,043
	6.2	62		2,423	0,003	0,057	-0,006	-0,013	0,010
	1.1		1062	-3,302	-0,004	0,000	-0,012	0,019	0,013
	2.2	67		-3,289	-0,004	-0,075	-0,012	-0,027	0,008
	3.1	67		-5,412	-0,035	0,063	-0,046	-0,020	0,048
	6.2	67		-3,069	0,006	0,062	0,010	-0,021	-0,008
	6.2		3408	-3,069	0,006	0,000	0,010	0,014	0,000
	3.1		3425	-5,412	-0,035	0,000	-0,046	0,016	0,008
	2.2	69		-3,466	-0,010	0,072	-0,016	-0,024	0,004
	3.1	69		-5,412	-0,035	-0,062	-0,046	-0,020	-0,031
	6.2	69		-3,069	0,006	-0,063	0,010	-0,023	0,007
	1.1	71		-3,463	0,010	0,069	-0,017	0,021	-0,018
	3.1	71		-4,348	0,023	0,062	-0,041	0,019	-0,040
	6.2	71		-2,314	-0,004	0,061	0,009	0,018	0,006
64	3.1	44		-0,047	-0,128	0,806	-0,041	-0,121	-0,010
	4.2	44		-0,065	-0,129	0,809	-0,040	-0,123	-0,011
	5.1	44		0,019	-0,065	0,136	0,007	0,025	-0,005
	3.1	45		0,047	-0,128	0,785	0,041	0,237	-0,048
	3.1	45		0,046	0,096	-0,233	0,041	0,237	-0,048
	4.2	45		0,065	0,095	-0,230	0,040	0,237	-0,048
	4.2	46		0,065	-0,095	0,251	0,040	-0,128	-0,005
	5.1	46		-0,019	-0,069	0,246	-0,007	0,025	0,007
65	3.1	47		-0,007	0,080	0,576	-0,040	-0,008	0,052
	4.2	47		0,007	0,077	0,581	-0,040	-0,011	0,051
	6.2	47		0,008	-0,025	0,203	0,008	-0,005	-0,002
	3.1	48		0,007	0,074	-0,501	0,040	0,246	-0,016
	4.2	48		-0,007	0,077	0,560	0,040	0,246	-0,016
	6.2	48		-0,008	-0,025	0,182	-0,008	0,082	-0,009
	3.1	49		0,007	-0,074	0,522	0,040	-0,016	0,018
	4.2	49		-0,007	-0,073	0,517	0,040	-0,018	0,017
	6.2	49		-0,008	-0,003	0,196	-0,008	0,002	-0,008
66	3.1	58		0,085	0,176	0,359	-0,040	0,115	0,072
	4.2	58		0,069	0,173	0,367	-0,039	0,110	0,071
	6.2	58		-0,007	0,050	0,243	0,008	-0,025	0,011
	3.1	59		-0,085	0,176	0,338	0,040	0,272	0,007
	3.1	59		-0,085	0,000	-0,747	0,040	0,272	0,007
	4.2	59		-0,069	0,173	0,347	0,039	0,271	0,007
	6.2	59		0,007	-0,075	-0,161	-0,008	0,080	0,012

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
66	3.1	60		-0,085	0,000	0,768	0,040	0,069	0,008
	6.2	60		0,007	0,075	0,182	-0,008	-0,003	-0,022
67	2.2	63		0,141	0,000	0,064	0,000	0,000	0,000
	3.1	63		0,282	0,000	0,056	0,000	0,000	0,000
	4.2	63		0,422	0,000	0,056	0,000	0,000	0,000
	5.1	63		-0,626	0,000	0,056	0,000	0,000	0,000
	2.2		1226	-0,141	0,000	0,000	0,000	0,039	0,000
	5.1		1226	0,626	0,000	0,000	0,000	0,034	0,000
	1.1	60		-0,047	0,000	0,064	0,000	0,000	0,000
	4.2	60		-0,439	0,000	0,056	0,000	0,000	0,000
	5.1	60		0,609	0,000	0,056	0,000	0,000	0,000
	6.2	60		0,531	0,000	0,056	0,000	0,000	0,000
68	1.1	60		-0,273	0,000	0,064	0,000	0,000	0,000
	4.2	60		-0,727	0,000	0,056	0,000	0,000	0,000
	5.1	60		0,555	0,000	0,056	0,000	0,000	0,000
	6.2	60		0,531	0,000	0,056	0,000	0,000	0,000
	1.1		1226	0,273	0,000	0,000	0,000	0,039	0,000
	3.1		1226	0,682	0,000	0,000	0,000	0,034	0,000
	2.2	47		0,289	0,000	0,064	0,000	0,000	0,000
	3.1	47		0,665	0,000	0,056	0,000	0,000	0,000
	4.2	47		0,710	0,000	0,056	0,000	0,000	0,000
	5.1	47		-0,572	0,000	0,056	0,000	0,000	0,000
69	2.2	47		0,195	0,000	0,064	0,000	0,000	0,000
	3.1	47		0,638	0,000	0,056	0,000	0,000	0,000
	5.1	47		-0,605	0,000	0,056	0,000	0,000	0,000
	6.2	47		-0,627	0,000	0,056	0,000	0,000	0,000
	2.2		1226	-0,195	0,000	0,000	0,000	0,039	0,000
	4.2		1226	-0,603	0,000	0,000	0,000	0,034	0,000
	1.1	46		-0,243	0,000	0,064	0,000	0,000	0,000
	3.1	46		-0,656	0,000	0,056	0,000	0,000	0,000
	4.2	46		-0,621	0,000	0,056	0,000	0,000	0,000
	6.2	46		0,610	0,000	0,056	0,000	0,000	0,000
70	1.1	46		-0,173	0,000	0,064	0,000	0,000	0,000
	3.1	46		-0,416	0,000	0,056	0,000	0,000	0,000
	6.2	46		0,552	0,000	0,056	0,000	0,000	0,000
	1.1		1226	0,173	0,000	0,000	0,000	0,039	0,000
	5.1		1226	-0,485	0,000	0,000	0,000	0,034	0,000
	2.2	6		0,055	0,000	0,064	0,000	0,000	0,000
	3.1	6		0,399	0,000	0,056	0,000	0,000	0,000
	6.2	6		-0,569	0,000	0,056	0,000	0,000	0,000
71	3.1	12		-0,014	0,000	0,520	0,000	0,000	0,000
	4.2	12		-0,016	0,000	0,520	0,000	0,000	0,000
	6.2	12		-0,063	0,000	0,179	0,000	0,000	0,000
	3.1		1141	0,014	0,000	0,000	0,000	0,297	0,000
	5.1		1141	0,061	0,000	0,000	0,000	0,102	0,000
	3.1	45		0,187	0,000	0,520	0,000	0,000	0,000
	4.2	45		0,189	0,000	0,520	0,000	0,000	0,000
72	5.1	45		0,120	0,000	0,179	0,000	0,000	0,000
	3.1	45		-0,241	0,000	0,520	0,000	0,000	0,000
	4.2	45		-0,244	0,000	0,520	0,000	0,000	0,000
	5.1	45		-0,197	0,000	0,179	0,000	0,000	0,000
	6.2	45		-0,199	0,000	0,179	0,000	0,000	0,000
	4.2		1141	0,244	0,000	0,000	0,000	0,297	0,000
	6.2		1141	0,199	0,000	0,000	0,000	0,102	0,000
	4.2	48		0,417	0,000	0,520	0,000	0,000	0,000

Staaf-nummer	Comb.-nummer	Knoop-nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
72	5.1	48		0,256	0,000	0,179	0,000	0,000	0,000
73	2.2	48		-0,247	0,000	0,339	0,000	0,000	0,000
	3.1	48		-0,235	0,000	0,520	0,000	0,000	0,000
	5.1	48		-0,223	0,000	0,179	0,000	0,000	0,000
	6.2	48		-0,228	0,000	0,179	0,000	0,000	0,000
	4.2		1141	0,240	0,000	0,000	0,000	0,297	0,000
	5.1		1141	0,223	0,000	0,000	0,000	0,102	0,000
	4.2	59		0,413	0,000	0,520	0,000	0,000	0,000
	5.1	59		0,283	0,000	0,179	0,000	0,000	0,000
74	3.1	59		-0,056	0,000	0,520	0,000	0,000	0,000
	6.2	59		-0,101	0,000	0,179	0,000	0,000	0,000
	4.2		1141	0,062	0,000	0,000	0,000	0,297	0,000
	6.2		1141	0,101	0,000	0,000	0,000	0,102	0,000
	4.2	64		0,235	0,000	0,520	0,000	0,000	0,000
	5.1	64		0,156	0,000	0,179	0,000	0,000	0,000

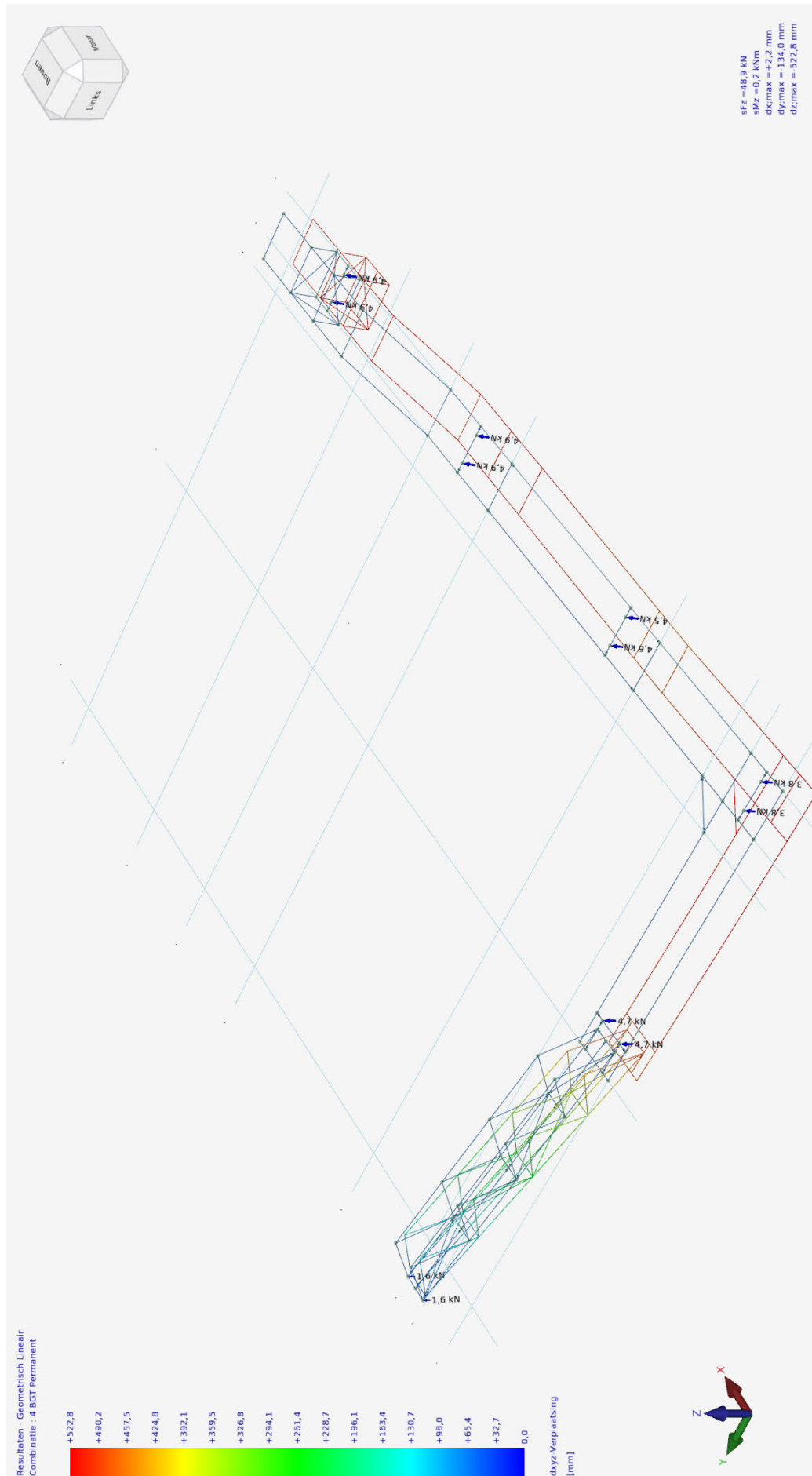
2.3 BRUIKBAARHEIDSGRENSTOESTANDEN (BGT)

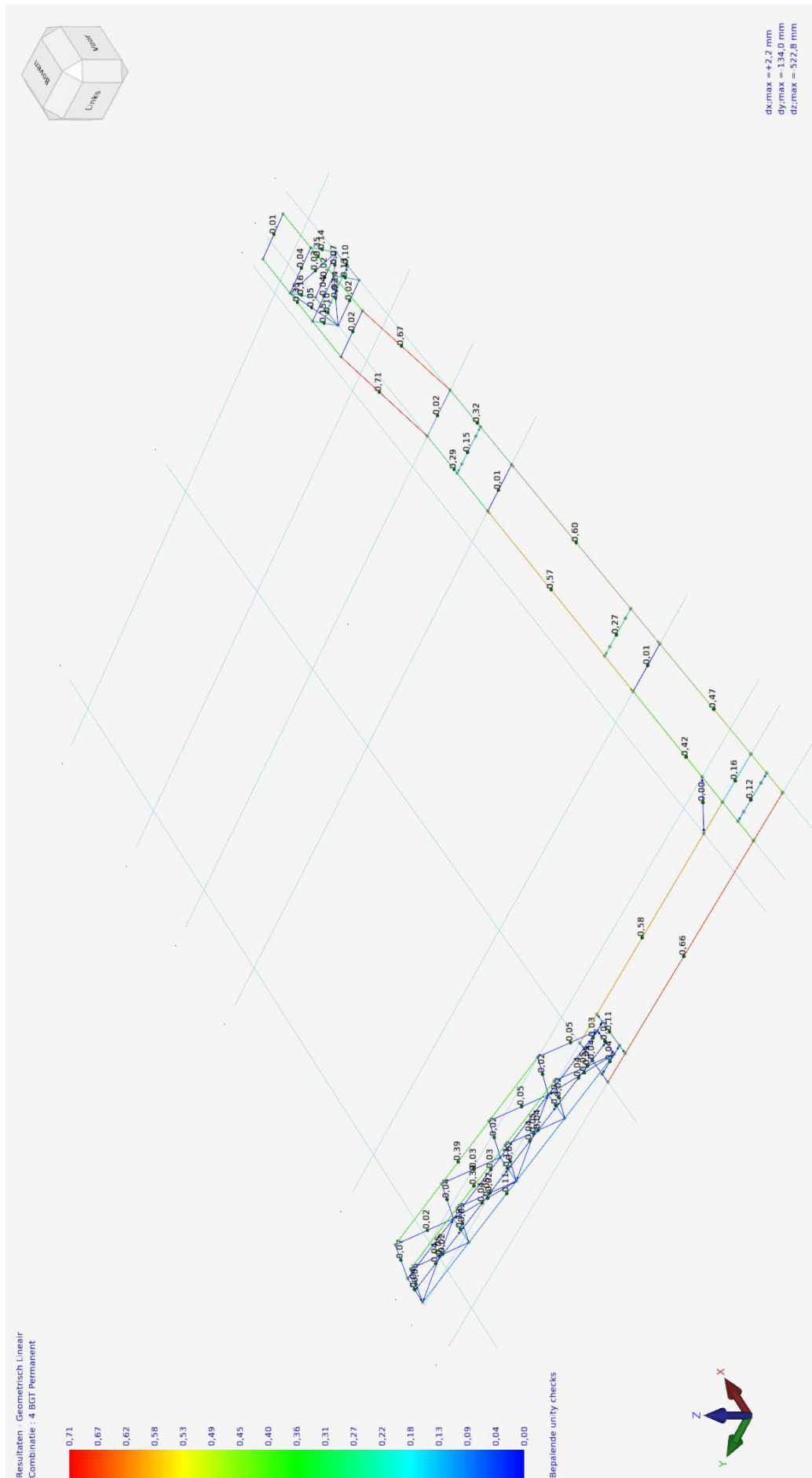
2.3 1 Belastingscombinaties

(GL) Geometrisch lineaire krachtsverdeling

Combinatie nummer	Omschrijving	Type
7	Permanent	BGT
8	Veranderlijk	BGT
9	Veranderlijk plaatselijk	BGT
10	BGT Blijvend	BGT Blijvend
11	BGT Quasi-blijvend	BGT Quasi-blijvend

Combinatie nummer	Belasting ($\psi \times \gamma$)				
	1	2	3		
7	1,00 x 1,00				
8	1,00 x 1,00	1,00 x 1,00			
9	1,00 x 1,00		1,00 x 1,00		
10	1,00 x 1,00				
11	1,00 x 1,00	0,30 x 1,00	0,30 x 1,00		





2.3.2 Omhullende knoopverplaatsingen

Knoop-nummer	Comb. nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
1	7	-0,2	0,3	-522,8	2,2	-12,3	-0,1
	8	4,5	-13,6	-847,1	3,7	-16,6	2,4
	9	-3,9	10,2	-867,8	43,0	21,0	-1,9
2	7	0,0	0,3	-519,3	2,7	-9,7	0,0
	8	0,0	-13,6	-841,1	4,6	-11,8	2,2
	9	0,0	10,2	-803,0	43,4	18,8	-1,6
3	7	-0,9	0,3	-467,5	10,8	0,1	0,1
	8	-1,3	-13,6	-750,5	19,1	10,1	0,7
	9	-5,9	10,2	-470,1	50,7	-1,4	0,2
4	7	-0,9	0,3	-456,8	10,6	1,5	0,0
	8	-2,5	-13,6	-731,7	18,7	13,3	1,7
	9	-5,6	10,2	-419,5	50,5	-4,3	-1,0
5	7	-0,9	0,3	-467,4	3,6	-0,2	0,0
	8	-1,3	-13,0	-753,3	6,2	9,5	1,7
	9	-5,9	9,9	-469,7	19,9	-1,3	-1,1
6	7	-0,9	0,3	-464,4	10,1	0,6	0,0
	8	-1,7	-13,0	-748,0	17,6	9,2	1,2
	9	-5,8	9,9	-454,3	51,4	-1,5	-0,3
7	7	-0,9	0,3	-457,3	10,2	1,5	0,0
	8	-2,5	-13,0	-735,6	17,8	13,2	1,8
	9	-5,6	9,9	-418,3	51,5	-4,3	-1,1
8	7	-0,2	0,3	-513,7	0,9	-12,1	0,0
	8	4,5	-12,3	-834,7	1,3	-16,3	1,4
	9	-3,9	9,4	-883,6	44,0	21,1	-0,7
9	7	-0,1	0,3	-513,2	1,5	-2,5	-0,1
	8	3,6	-12,3	-833,9	2,3	-3,2	3,0
	9	-3,1	9,4	-870,0	45,0	4,6	-2,6
10	7	0,0	0,3	-512,3	0,6	-2,5	-0,1
	8	0,9	-12,3	-832,5	0,9	-3,2	3,0
	9	-0,8	9,4	-830,2	43,5	4,6	-2,6
11	7	0,0	0,3	-512,1	1,4	-9,5	0,0
	8	0,0	-12,3	-832,3	2,2	-11,5	1,5
	9	0,0	9,4	-817,2	44,6	19,0	-0,8
12	7	-0,9	0,4	-464,7	39,5	0,6	0,0
	8	-1,7	-12,2	-753,0	64,3	11,1	1,7
	9	-5,8	9,4	-453,4	50,9	-1,9	-1,0
13	7	-0,9	0,3	-467,6	3,6	0,6	0,0
	8	-1,3	-11,5	-762,5	6,2	10,8	1,8
	9	-5,9	8,9	-468,9	19,9	-0,5	-1,1
14	7	-0,9	0,3	-464,9	9,0	0,3	0,0
	8	-1,7	-11,5	-758,0	14,9	8,2	1,2
	9	-5,8	8,9	-452,6	54,5	-2,0	-0,3
15	7	-0,9	0,3	-458,6	9,1	1,4	0,0
	8	-2,5	-11,5	-747,5	15,1	13,1	1,8
	9	-5,6	8,9	-414,3	54,6	-4,4	-1,1
16	7	-0,2	0,3	-504,7	-0,5	-12,1	-0,1
	8	4,5	-10,9	-822,5	-1,1	-16,3	2,4
	9	-3,9	8,6	-899,4	44,9	20,6	-1,8
17	7	0,0	0,3	-505,0	0,2	-9,5	0,0
	8	0,0	-10,9	-823,7	-0,2	-11,5	2,2
	9	0,0	8,6	-831,5	45,8	18,8	-1,6
18	7	0,0	0,3	-504,4	1,3	-8,1	0,0

Knoop- nummer	Comb. nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
18	8	-1,9	-10,9	-823,2	1,5	-8,5	1,5
	9	1,3	8,6	-785,0	47,3	15,9	-0,7
19	7	-0,9	0,3	-467,8	9,0	0,0	0,1
	8	-1,3	-11,0	-765,8	14,6	10,0	0,7
	9	-5,9	8,6	-468,8	55,9	-1,5	0,3
20	7	-0,9	0,3	-459,0	8,8	1,4	0,0
	8	-2,5	-11,0	-751,4	14,2	13,1	1,7
	9	-5,6	8,6	-413,0	55,7	-4,4	-1,0
21	7	0,0	0,3	-495,2	-1,6	-10,2	0,0
	8	0,0	-9,0	-811,7	-3,3	-12,7	1,9
	9	0,0	7,3	-849,5	46,4	16,9	-1,3
22	7	-0,2	0,0	-442,6	-7,5	-15,1	-0,1
	8	4,5	0,0	-736,8	-14,1	-21,3	2,8
	9	-3,9	0,0	-964,9	48,6	9,7	-2,4
23	7	0,0	0,0	-453,9	-7,5	-12,8	-0,1
	8	0,0	0,0	-757,9	-14,1	-17,1	3,0
	9	0,0	0,0	-892,0	48,6	8,9	-2,6
24	7	-0,2	0,2	-451,0	-5,2	6,3	0,1
	8	4,5	-2,4	-751,2	-9,8	10,7	-0,6
	9	-3,9	2,0	-897,9	40,0	-42,7	0,5
25	7	-0,2	0,2	-452,6	-5,4	6,3	0,0
	8	4,4	-2,4	-754,2	-10,1	10,7	1,3
	9	-3,8	2,0	-885,9	39,7	-42,7	-1,2
26	7	-0,1	0,2	-457,9	-6,4	6,3	-0,2
	8	1,4	-2,4	-764,1	-11,9	10,7	4,6
	9	-1,2	2,0	-851,1	37,6	-42,7	-3,9
27	7	0,0	0,2	-459,9	-0,9	4,7	0,2
	8	0,0	-2,4	-767,7	-1,5	7,7	-2,2
	9	0,0	2,0	-839,9	7,8	-32,8	1,8
28	7	-0,2	2,2	-492,8	0,9	-1,2	-0,1
	8	4,5	-33,5	-820,9	1,9	-7,4	2,9
	9	-3,9	28,3	-659,1	-3,1	15,3	-2,5
29	7	0,0	2,2	-491,4	0,9	-0,9	-0,1
	8	0,0	-33,5	-818,1	1,9	-10,0	2,9
	9	0,0	28,3	-663,6	-3,0	17,8	-2,5
30	7	-0,2	2,0	-491,5	0,5	0,3	-0,1
	8	4,5	-28,8	-808,9	5,0	-5,0	2,4
	9	-3,9	24,3	-687,0	-6,2	16,0	-2,1
31	7	-0,1	2,0	-491,1	1,1	0,1	-0,1
	8	3,6	-28,8	-807,1	5,9	-1,5	3,0
	9	-3,1	24,3	-688,5	-5,3	4,0	-2,6
32	7	0,0	2,0	-490,7	0,0	0,1	-0,1
	8	0,9	-28,8	-802,6	4,0	-1,5	3,0
	9	-0,8	24,3	-694,1	-7,0	4,0	-2,6
33	7	0,0	2,0	-490,7	0,6	0,6	-0,1
	8	0,0	-28,8	-801,5	5,0	-7,6	2,4
	9	0,0	24,3	-696,2	-6,2	18,7	-2,1
34	7	-0,2	1,9	-493,7	0,2	1,6	-0,1
	8	4,5	-24,2	-802,9	8,2	-2,6	2,8
	9	-3,9	20,3	-714,9	-9,4	13,6	-2,4
35	7	0,0	1,9	-493,4	0,2	1,9	-0,1
	8	0,0	-24,2	-790,6	8,2	-5,3	2,8
	9	0,0	20,3	-729,0	-9,4	16,4	-2,4
36	7	1,8	0,3	-490,6	-0,6	-2,2	-0,3
	8	9,5	-0,1	-765,1	15,7	-10,9	4,3

Knoop- nummer	Comb. nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
36	9	8,0	-2,3	-717,9	-17,2	-9,2	-4,0
37	7	2,2	0,3	-491,5	-0,6	-2,2	-0,3
	8	3,2	-0,1	-741,6	15,7	-11,3	4,3
	9	13,8	-2,3	-743,8	-17,2	-8,7	-4,0
38	7	1,8	0,1	-489,0	-0,6	-2,0	-0,3
	8	9,5	3,2	-757,0	15,9	-10,6	4,5
	9	8,0	-5,4	-711,1	-17,5	-8,9	-4,2
39	7	1,9	0,1	-489,0	0,0	-0,5	-0,2
	8	8,2	3,2	-751,9	16,8	-2,5	4,2
	9	9,1	-5,4	-716,0	-16,6	-2,0	-3,9
40	7	2,1	0,1	-489,5	-1,1	-0,5	-0,2
	8	4,5	3,2	-737,6	15,0	-2,5	4,2
	9	12,6	-5,4	-731,8	-18,3	-2,0	-3,9
41	7	2,2	0,1	-489,9	-0,6	-2,0	-0,3
	8	3,2	3,2	-733,1	15,9	-11,0	4,5
	9	13,8	-5,4	-737,3	-17,5	-8,4	-4,2
42	7	1,8	-0,1	-487,6	-0,6	-1,9	-0,3
	8	9,5	6,6	-749,2	16,1	-10,3	4,3
	9	8,0	-8,5	-704,7	-17,7	-8,6	-4,0
43	7	2,2	-0,1	-488,5	-0,6	-1,8	-0,3
	8	3,2	6,6	-725,0	16,2	-10,8	4,3
	9	13,8	-8,5	-731,2	-17,7	-8,1	-4,0
44	7	-0,7	-19,0	-348,5	51,6	0,8	0,1
	8	-1,3	-44,1	-561,4	83,1	8,9	1,4
	9	-4,3	-9,0	-340,9	50,4	-0,9	-0,8
45	7	-0,7	-19,0	-348,8	51,6	0,5	0,0
	8	-1,3	-43,5	-565,4	83,6	8,4	1,2
	9	-4,3	-9,4	-340,4	50,3	-1,4	-0,9
46	7	-0,7	-19,0	-348,9	51,6	0,0	-0,1
	8	-1,3	-43,0	-568,8	84,1	6,9	1,0
	9	-4,3	-9,9	-339,6	50,2	-1,7	-1,0
47	7	-0,4	-38,3	-232,5	51,6	0,7	0,0
	8	-0,8	-75,2	-374,5	83,1	6,5	1,0
	9	-2,8	-27,9	-227,4	50,5	-0,5	-0,8
48	7	-0,4	-38,3	-232,7	51,6	0,3	-0,1
	8	-0,8	-74,9	-377,3	83,7	5,5	0,7
	9	-2,8	-28,3	-227,1	50,4	-0,9	-0,8
49	7	-0,4	-38,3	-232,7	51,7	-0,1	-0,1
	8	-0,8	-74,6	-379,4	84,2	4,4	0,7
	9	-2,8	-28,7	-226,6	50,3	-1,3	-0,9
50	7	0,0	1,3	-494,5	-0,4	-1,6	-0,3
	8	0,0	-22,1	-783,7	14,3	-8,8	4,3
	9	0,0	20,5	-731,6	-15,8	-4,9	-4,0
51	7	0,4	1,3	-495,1	-0,4	-1,4	-0,3
	8	-6,7	-22,1	-762,2	14,3	-10,4	4,3
	9	6,2	20,5	-755,2	-15,8	-3,2	-4,0
52	7	0,0	0,8	-490,6	-0,6	-2,2	-0,3
	8	0,0	-14,2	-765,1	15,7	-10,7	4,3
	9	0,0	13,2	-717,9	-17,2	-8,8	-4,0
53	7	0,4	0,8	-491,5	-0,5	-2,1	-0,3
	8	-6,7	-14,2	-741,6	15,7	-11,3	4,3
	9	6,2	13,2	-743,8	-17,2	-8,1	-4,0
54	7	0,0	0,5	-487,6	-0,6	-1,8	-0,3
	8	0,0	-8,0	-749,3	16,1	-10,3	4,4
	9	0,0	7,4	-704,7	-17,7	-8,8	-4,0

Knoop- nummer	Comb. nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
55	7	0,4	0,5	-488,5	-0,6	-1,8	-0,3
	8	-6,7	-8,0	-725,0	16,2	-10,7	4,4
	9	6,2	7,4	-731,2	-17,7	-8,4	-4,0
56	7	0,0	0,0	-484,8	-0,7	-1,4	-0,3
	8	0,0	0,0	-731,0	16,6	-9,7	4,4
	9	0,0	0,0	-689,0	-18,2	-8,4	-4,1
57	7	0,4	0,0	-485,7	-0,6	-1,4	-0,3
	8	-6,7	0,0	-706,0	16,7	-10,1	4,4
	9	6,2	0,0	-716,2	-18,2	-8,0	-4,1
58	7	-0,2	-57,6	-116,3	51,6	0,6	0,0
	8	-0,5	-106,4	-187,3	83,2	4,2	0,5
	9	-1,4	-46,9	-113,8	50,5	-0,1	-0,7
59	7	-0,2	-57,7	-116,5	51,7	0,1	-0,1
	8	-0,5	-106,2	-188,9	83,7	2,6	0,2
	9	-1,4	-47,2	-113,7	50,4	-0,4	-0,7
60	7	-0,2	-57,7	-116,4	51,7	-0,2	-0,1
	8	-0,5	-106,1	-189,8	84,3	1,8	0,3
	9	-1,4	-47,5	-113,4	50,3	-0,8	-0,8
61	8	9,7	-135,4	-671,3	82,9	8,2	1,4
	9	-6,3	-64,5	-407,7	50,3	-0,8	-0,8
62	8	6,9	-135,6	-680,2	84,0	6,1	1,1
	9	-7,4	-65,1	-406,2	50,1	-1,6	-1,0
63	7	0,0	-77,0	0,0	51,8	0,6	0,0
	8	0,0	-137,6	0,0	83,4	4,5	0,5
	9	0,0	-65,8	0,0	50,7	-0,2	-0,6
64	7	0,0	-77,1	-0,1	51,8	0,0	-0,1
	8	0,0	-137,7	-0,1	84,5	0,0	-0,2
	9	0,0	-66,1	-0,1	50,5	0,0	-0,6
65	7	0,0	-77,1	0,0	51,8	-0,2	-0,1
	8	0,0	-137,8	0,0	84,5	-0,2	0,0
	9	0,0	-66,4	0,0	50,5	-0,3	-0,6
66	8	8,7	-166,6	-484,6	83,1	7,1	1,9
	9	-4,6	-83,4	-294,2	50,4	-0,6	-0,9
67	8	5,9	-167,2	-491,0	84,2	4,9	1,6
	9	-5,6	-84,0	-293,2	50,3	-1,4	-1,1
68	8	6,8	-197,9	-297,6	83,2	5,7	1,7
	9	-2,7	-102,4	-180,7	50,5	-0,4	-0,8
69	8	3,6	-198,8	-301,5	84,3	3,1	1,5
	9	-3,7	-102,9	-180,0	50,3	-1,1	-1,0
70	8	5,9	-229,1	-110,3	83,3	4,9	0,8
	9	-1,1	-121,4	-67,0	50,6	-0,2	-0,7
71	8	1,6	-230,5	-111,8	84,4	1,7	0,9
	9	-1,7	-121,8	-66,8	50,4	-0,7	-1,0
Minimale / maximale waarden							
62	9	-7,4					
37	9	13,8					
71	8		-230,5				
29	9		28,3				
22	9			-964,9			
65	9			0,0			
40	9				-18,3		
65	8				84,5		
24	9					-42,7	
8	9					21,1	
41	9						-4,2

Knoop- nummer	Comb. nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
26	8						4,6

2.4 EN1993 TOETSINGEN

Let op! Dit is een ontwerpberekening waarbij de invloed van het geometrische niet-lineaire effect (tweede-orde effect) NIET is meegenomen. Je moet alsnog een definitieve (geometrische niet-lineaire) berekening maken.

Staa- nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
1	UNP160	5.1	1	6.2.5	0,10
		3.1	1	6.2.5	0,22
		3.1	1	6.2.6	0,03
		5.1	1	6.2.6	0,01
		3.1	1	6.2.8	0,20
		5.1	1	6.2.8	0,10
		5.1	1	6.3.1.1	0,01
		5.1	1	6.3.3	0,21
		8		Doorbuiging	0,66
		8		Doorbuiging	0,39
2	IPE140	6.2	1	6.2.5	0,11
		6.2	1	6.2.6	0,07
		6.2	1	6.2.8	0,11
		4.2	1	6.2.8	0,00
		4.2	1	6.3.1.1	0,00
		6.2	1	6.3.2.1	0,12
		9		Doorbuiging	0,07
		9		Doorbuiging	0,04
3	IPE140	3.1	1	6.2.5	0,10
		5.1	1	6.2.5	0,01
		3.1	1	6.2.6	0,06
		3.1	1	6.2.8	0,10
		5.1	1	6.2.8	0,01
		3.1	1	6.2.9.1	0,10
		5.1	1	6.2.9.1	0,01
		4.2	1	6.2.9.1	0,02
		5.1	1	6.3.1.1	0,00
		3.1	1	6.3.2.1	0,11
		8		Doorbuiging	0,06
		8		Doorbuiging	0,03
4	UNP160	5.1	1	6.2.5	0,04
		3.1	1	6.2.5	0,01
		4.2	1	6.2.6	0,01
		5.1	1	6.2.6	0,01
		4.2	1	6.2.8	0,01
		5.1	1	6.2.8	0,04
		5.1	1	6.3.1.1	0,00
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
5	UNP160	5.1	1	6.2.5	0,10
		4.2	1	6.2.5	0,08
		4.2	1	6.2.6	0,01
		5.1	1	6.2.6	0,01

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
5	UNP160	4.2	1	6.2.8	0,08
		5.1	1	6.2.8	0,10
		4.2	1	6.3.1.1	0,00
		4.2	1	6.3.3	0,16
		8		Doorbuiging	0,03
		8		Doorbuiging	0,01
6	UNP160	4.2	1	6.2.5	0,22
		5.1	1	6.2.5	0,05
		4.2	1	6.2.6	0,03
		4.2	1	6.2.8	0,19
		5.1	1	6.2.8	0,05
		4.2	1	6.3.1.1	0,01
		4.2	1	6.3.3	0,27
		8		Doorbuiging	0,58
7	UNP160	8		Doorbuiging	0,31
		1.1	1	6.2.8	0,00
		4.2	1	6.3.1.1	0,00
		4.2	1	6.3.3	0,00
		9		Doorbuiging	0,00
8	UNP160	9		Doorbuiging	0,00
		5.1	1	6.2.5	0,09
		6.2	1	6.2.5	0,25
		6.2	1	6.2.6	0,04
		5.1	1	6.2.6	0,01
		6.2	1	6.2.8	0,24
		5.1	1	6.2.8	0,09
		5.1	1	6.3.1.1	0,03
		5.1	1	6.3.3	0,39
		9		Doorbuiging	0,47
9	UNP160	9		Doorbuiging	0,46
		5.1	1	6.2.5	0,06
		5.1	1	6.2.5	0,23
		5.1	1	6.2.6	0,04
		5.1	1	6.2.8	0,20
		5.1	1	6.2.8	0,06
		4.2	1	6.3.1.1	0,02
		4.2	1	6.3.3	0,21
		9		Doorbuiging	0,42
10	UNP160	9		Doorbuiging	0,37
		5.1	1	6.2.5	0,01
		1.1	1	6.2.8	0,00
		5.1	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,00
		8		Doorbuiging	0,00
11	IPE140	8		Doorbuiging	0,00
		4.2	1	6.2.5	0,21
		6.2	1	6.2.5	0,15
		6.2	1	6.2.6	0,10
		6.2	1	6.2.8	0,15
		4.2	1	6.2.8	0,21
		6.2	1	6.2.9.1	0,15
		4.2	1	6.2.9.1	0,17
		4.2	1	6.2.9.1	0,18
		4.2	1	6.3.1.1	0,00
		6.2	1	6.3.2.1	0,17
		4.2	1	6.3.3	0,27

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
11	IPE140	9		Doorbuiging	0,10
		9		Doorbuiging	0,06
12	UNP160	6.2	1	6.2.5	0,31
		4.2	1	6.2.5	0,06
		6.2	1	6.2.6	0,04
		6.2	1	6.2.8	0,31
		4.2	1	6.2.8	0,06
		5.1	1	6.3.1.1	0,09
		5.1	1	6.3.3	0,45
		9		Doorbuiging	0,39
		9		Doorbuiging	0,60
13	UNP160	5.1	1	6.2.5	0,30
		4.2	1	6.2.5	0,04
		5.1	1	6.2.6	0,04
		5.1	1	6.2.8	0,30
		4.2	1	6.2.8	0,04
		5.1	1	6.3.1.1	0,05
		5.1	1	6.3.3	0,37
		9		Doorbuiging	0,37
		9		Doorbuiging	0,57
14	UNP160	4.2	1	6.2.5	0,01
		2.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,01
		4.2	1	6.3.1.1	0,00
		8		Doorbuiging	0,00
		9		Doorbuiging	0,00
15	UNP160	5.1	1	6.2.4	0,01
		4.2	1	6.2.5	0,01
		6.2	1	6.2.5	0,28
		6.2	1	6.2.6	0,04
		6.2	1	6.2.8	0,28
		4.2	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,03
		5.1	1	6.3.3	0,32
		8		Doorbuiging	0,20
		9		Doorbuiging	0,21
16	IPE140	4.2	1	6.2.5	0,14
		4.2	1	6.2.6	0,09
		4.2	1	6.2.8	0,14
		4.2	1	6.2.8	0,00
		2.2	1	6.3.1.1	0,00
		4.2	1	6.3.2.1	0,15
		8		Doorbuiging	0,09
		8		Doorbuiging	0,05
17	UNP160	4.2	1	6.2.5	0,01
		6.2	1	6.2.5	0,27
		6.2	1	6.2.6	0,04
		6.2	1	6.2.8	0,27
		4.2	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,01
		6.2	1	6.3.3	0,29
		8		Doorbuiging	0,20
		9		Doorbuiging	0,21
18	UNP160	4.2	1	6.2.5	0,02
		1.1	1	6.2.8	0,00
		4.2	1	6.2.8	0,02

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
18	UNP160	7		Doorbuiging	0,00
		8		Doorbuiging	0,00
19	UNP160	5.1	1	6.2.4	0,01
		6.2	1	6.2.5	0,42
		4.2	1	6.2.5	0,01
		6.2	1	6.2.6	0,03
		6.2	1	6.2.8	0,42
		4.2	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,05
		6.2	1	6.3.3	0,47
		9		Doorbuiging	0,62
		9		Doorbuiging	0,67
20	UNP160	6.2	1	6.2.5	0,44
		4.2	1	6.2.5	0,01
		6.2	1	6.2.6	0,03
		6.2	1	6.2.8	0,44
		4.2	1	6.2.8	0,01
		6.2	1	6.3.1.1	0,02
		6.2	1	6.3.3	0,47
		9		Doorbuiging	0,65
		9		Doorbuiging	0,71
21	UNP160	4.2	1	6.2.5	0,02
		1.1	1	6.2.8	0,00
		4.2	1	6.2.8	0,02
		4.2	1	6.3.1.1	0,00
		7		Doorbuiging	0,00
		8		Doorbuiging	0,00
22	UNP160	3.1	1	6.2.3	0,01
		5.1	1	6.2.4	0,01
		6.2	1	6.2.5	0,29
		4.2	1	6.2.5	0,02
		5.1	1	6.2.6	0,03
		6.2	1	6.2.8	0,29
		4.2	1	6.2.8	0,02
		5.1	1	6.3.1.1	0,06
		6.2	1	6.3.3	0,35
		9		Doorbuiging	0,08
		9		Doorbuiging	0,15
23	IPE140	3.1	1	6.2.5	0,13
		3.1	1	6.2.6	0,08
		3.1	1	6.2.8	0,13
		6.2	1	6.2.8	0,00
		3.1	1	6.3.2.1	0,14
		8		Doorbuiging	0,09
		8		Doorbuiging	0,04
24	UNP160	6.2	1	6.2.5	0,34
		4.2	1	6.2.5	0,02
		5.1	1	6.2.6	0,03
		6.2	1	6.2.8	0,34
		4.2	1	6.2.8	0,02
		5.1	1	6.3.1.1	0,01
		6.2	1	6.3.3	0,35
		9		Doorbuiging	0,12
		9		Doorbuiging	0,20
25	UNP160	4.2	1	6.2.5	0,01
		2.2	1	6.2.8	0,00

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
25	UNP160	4.2	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,00
		9		Doorbuiging	0,00
		8		Doorbuiging	0,00
26	UNP160	4.2	1	6.2.5	0,08
		5.1	1	6.2.5	0,02
		4.2	1	6.2.6	0,03
		4.2	1	6.2.8	0,08
		5.1	1	6.2.8	0,02
		4.2	1	6.3.1.1	0,00
		4.2	1	6.3.3	0,10
		9		Doorbuiging	0,03
		9		Doorbuiging	0,02
27	UNP160	4.2	1	6.2.5	0,02
		4.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,02
		4.2	1	6.3.1.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
28	UNP160	6.2	1	6.2.5	0,08
		5.1	1	6.2.5	0,02
		6.2	1	6.2.6	0,03
		6.2	1	6.2.8	0,08
		5.1	1	6.2.8	0,02
		3.1	1	6.3.1.1	0,01
		5.1	1	6.3.3	0,10
		9		Doorbuiging	0,03
		9		Doorbuiging	0,02
29	UNP160	4.2	1	6.2.5	0,02
		3.1	1	6.2.8	0,00
		4.2	1	6.2.8	0,02
		4.2	1	6.3.1.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
30	L100X100X10	4.2	1	6.2.4	0,01
		3.1	3	6.2.5	0,11
		4.2	3	6.2.5	0,01
		3.1	1	6.2.6	0,01
		5.1	1	6.2.9.2	0,06
		6.2	1	6.2.9.2	0,01
		4.2	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,13
		9		Doorbuiging	0,00
31	L100X100X10	8		Doorbuiging	0,00
		3.1	1	6.2.4	0,01
		3.1	3	6.2.5	0,14
		6.2	3	6.2.5	0,01
		3.1	1	6.2.6	0,01
		3.1	1	6.2.9.2	0,07
		3.1	1	6.2.9.2	0,01
		3.1	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,15
32	L100X100X10	8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		5.1	1	6.2.4	0,01
		3.1	3	6.2.5	0,14

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
32	L100X100X10	4.2	3	6.2.5	0,01
		3.1	1	6.2.6	0,01
		6.2	1	6.2.9.2	0,05
		6.2	1	6.2.9.2	0,01
		5.1	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,16
		9		Doorbuiging	0,00
		8		Doorbuiging	0,00
33	L100X100X10	4.2	1	6.2.4	0,01
		4.2	3	6.2.5	0,13
		5.1	3	6.2.5	0,01
		3.1	1	6.2.6	0,01
		4.2	1	6.2.9.2	0,07
		4.2	1	6.2.9.2	0,01
		4.2	1	6.3.1.1	0,01
		4.2	1	6.3.3	0,14
34	L100X100X10	8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		4.2	3	6.2.5	0,04
		4.2	3	6.2.5	0,01
		4.2	1	6.3.1.1	0,00
35	L100X100X10	9		Doorbuiging	0,00
		8		Doorbuiging	0,00
		4.2	3	6.2.5	0,04
		3.1	3	6.2.5	0,01
		4.2	1	6.3.1.1	0,00
36	L50X50X5	9		Doorbuiging	0,00
		8		Doorbuiging	0,00
		3.1	3	6.2.5	0,02
		1.1	3	6.2.5	0,01
		5.1	1	6.3.1.1	0,01
37	L50X50X5	5.1	1	6.3.3	0,02
		9		Doorbuiging	0,01
		8		Doorbuiging	0,00
		4.2	3	6.2.5	0,01
		6.2	3	6.2.5	0,05
38	L50X50X5	8		Doorbuiging	0,01
		8		Doorbuiging	0,01
		4.2	3	6.2.5	0,02
		2.2	3	6.2.5	0,01
		5.1	1	6.3.1.1	0,01
39	L50X50X5	5.1	1	6.3.3	0,03
		9		Doorbuiging	0,01
		8		Doorbuiging	0,00
		5.1	1	6.2.5	0,01
		6.2	3	6.2.5	0,05
40	IPE140	4.2	3	6.2.5	0,01
		5.1	1	6.2.9.2	0,01
		5.1	1	6.3.1.1	0,02
		5.1	1	6.3.3	0,07
		8		Doorbuiging	0,01
		9		Doorbuiging	0,00
		4.2	1	6.2.5	0,03
		4.2	1	6.2.6	0,02
		4.2	1	6.2.8	0,03
		5.1	1	6.2.8	0,00

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
40	IPE140	4.2	1	6.2.9.1	0,03
		5.1	1	6.2.9.1	0,00
		5.1	1	6.2.9.1	0,01
		5.1	1	6.3.1.1	0,00
		4.2	1	6.3.2.1	0,03
		4.2	1	6.3.3	0,04
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
41	IPE140	3.1	1	6.2.5	0,03
		3.1	1	6.2.6	0,02
		3.1	1	6.2.8	0,03
		5.1	1	6.2.8	0,00
		3.1	1	6.2.9.1	0,03
		5.1	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,01
		4.2	1	6.3.1.1	0,00
		3.1	1	6.3.2.1	0,03
		5.1	1	6.3.3	0,02
		8		Doorbuiging	0,01
		8		Doorbuiging	0,01
42	UNP100	4.2	1	6.2.3	0,02
		4.2	1	6.2.5	0,01
		3.1	1	6.2.5	0,01
		3.1	1	6.2.8	0,01
		3.1	1	6.2.8	0,01
		5.1	1	6.3.1.1	0,11
		8		Doorbuiging	0,01
		8		Doorbuiging	0,01
43	UNP100	3.1	1	6.2.3	0,01
		3.1	1	6.2.5	0,01
		3.1	1	6.2.5	0,01
		3.1	1	6.2.8	0,01
		3.1	1	6.2.8	0,01
		4.2	1	6.3.1.1	0,03
		8		Doorbuiging	0,01
		8		Doorbuiging	0,01
44	K50/3	4.2	1	6.2.5	0,04
		4.2	1	6.2.5	0,02
		3.1	1	6.2.6	0,01
		4.2	1	6.2.8	0,04
		4.2	1	6.2.8	0,02
		4.2	1	6.2.9.1	0,04
		4.2	1	6.2.9.1	0,02
		4.2	1	6.2.9.1	0,01
		3.1	1	6.3.1.1	0,00
		8		Doorbuiging	0,03
		8		Doorbuiging	0,01
45	UNP100	2.2	1	6.2.5	0,01
		3.1	1	6.2.5	0,01
		3.1	1	6.2.8	0,01
		2.2	1	6.2.8	0,01
		3.1	1	6.3.1.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
46	K50/3	4.2	1	6.2.4	0,02
		1.1	1	6.2.5	0,01

Staafternummer	Profiel	Combinatienummer	Klasse	Artikel	U.C.
46	K50/3	3.1	1	6.2.5	0,02
		1.1	1	6.2.8	0,01
		3.1	1	6.2.8	0,02
		1.1	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		4.2	1	6.3.1.1	0,03
		4.2	1	6.3.3	0,05
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
47	K50/3	4.2	1	6.2.3	0,02
		3.1	1	6.2.5	0,02
		3.1	1	6.2.7	0,00
		1.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,02
		1.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		9		Doorbuiging	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
48	K50/3	4.2	1	6.2.4	0,01
		3.1	1	6.2.5	0,05
		1.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,05
		1.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,05
		3.1	1	6.2.9.1	0,01
		4.2	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,05
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
49	K50/3	4.2	1	6.2.3	0,01
		4.2	1	6.2.5	0,02
		2.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,02
		2.2	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,02
		4.2	1	6.2.9.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
50	K50/3	4.2	1	6.2.3	0,01
		3.1	1	6.2.5	0,02
		1.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,02
		1.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
51	K50/3	4.2	1	6.2.4	0,01
		4.2	1	6.2.5	0,04
		4.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,04
		4.2	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,04
		4.2	1	6.2.9.1	0,04
		4.2	1	6.2.9.1	0,01

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
51	K50/3	4.2	1	6.3.1.1	0,01
		4.2	1	6.3.3	0,04
		9		Doorbuiging	0,00
		8		Doorbuiging	0,00
52	K50/3	4.2	1	6.2.3	0,02
		4.2	1	6.2.5	0,02
		4.2	1	6.2.7	0,00
		5.1	1	6.2.8	0,00
		4.2	1	6.2.8	0,02
		5.1	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,02
		4.2	1	6.2.9.1	0,00
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
53	K50/3	4.2	1	6.2.4	0,03
		2.2	1	6.2.5	0,01
		3.1	1	6.2.5	0,02
		2.2	1	6.2.8	0,01
		3.1	1	6.2.8	0,02
		2.2	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		4.2	1	6.3.1.1	0,04
		3.1	1	6.3.3	0,05
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
54	K50/3	3.1	1	6.2.4	0,03
		3.1	1	6.2.5	0,01
		3.1	1	6.2.5	0,04
		3.1	1	6.2.7	0,01
		3.1	1	6.2.8	0,01
		3.1	1	6.2.8	0,04
		3.1	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,04
		3.1	1	6.2.9.1	0,00
		3.1	1	6.3.1.1	0,04
		3.1	1	6.3.3	0,07
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
55	K50/3	3.1	1	6.2.3	0,02
		3.1	1	6.2.5	0,01
		5.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,01
		5.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
56	K50/3	3.1	1	6.2.4	0,01
		3.1	1	6.2.5	0,04
		1.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,04
		1.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,04
		3.1	1	6.2.9.1	0,00
		3.1	1	6.3.1.1	0,01

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
56	K50/3	3.1	1	6.3.3	0,04
		9		Doorbuiging	0,00
		8		Doorbuiging	0,00
57	K50/3	3.1	1	6.2.3	0,01
		4.2	1	6.2.5	0,03
		2.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,03
		2.2	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,03
		4.2	1	6.2.9.1	0,00
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
58	K50/3	3.1	1	6.2.3	0,01
		3.1	1	6.2.5	0,02
		1.1	1	6.2.8	0,00
		3.1	1	6.2.8	0,02
		1.1	1	6.2.9.1	0,00
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		9		Doorbuiging	0,00
		9		Doorbuiging	0,00
59	K50/3	3.1	1	6.2.4	0,01
		4.2	1	6.2.5	0,04
		4.2	1	6.2.7	0,00
		4.2	1	6.2.8	0,00
		4.2	1	6.2.8	0,04
		4.2	1	6.2.9.1	0,00
		4.2	1	6.2.9.1	0,04
		4.2	1	6.2.9.1	0,01
		3.1	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,05
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00
60	K50/3	3.1	1	6.2.3	0,02
		4.2	1	6.2.5	0,02
		2.2	1	6.2.5	0,01
		4.2	1	6.2.7	0,00
		2.2	1	6.2.8	0,01
		4.2	1	6.2.8	0,02
		2.2	1	6.2.9.1	0,01
		4.2	1	6.2.9.1	0,02
		4.2	1	6.2.9.1	0,00
		9		Doorbuiging	0,01
		9		Doorbuiging	0,00
61	K50/3	3.1	1	6.2.4	0,02
		2.2	1	6.2.5	0,01
		3.1	1	6.2.5	0,02
		2.2	1	6.2.8	0,01
		3.1	1	6.2.8	0,02
		2.2	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,00
		3.1	1	6.3.1.1	0,03
		3.1	1	6.3.3	0,05
		8		Doorbuiging	0,00
		8		Doorbuiging	0,00

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
62	K60/3	4.2	1	6.2.4	0,04
		3.1	1	6.2.5	0,01
		2.2	1	6.2.5	0,01
		3.1	1	6.2.7	0,00
		2.2	1	6.2.8	0,01
		3.1	1	6.2.8	0,01
		2.2	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,00
		4.2	1	6.3.1.1	0,30
		4.2	1	6.3.3	0,39
		8		Doorbuiging	0,01
		8		Doorbuiging	0,01
63	K60/3	3.1	1	6.2.4	0,03
		3.1	1	6.2.5	0,01
		2.2	1	6.2.5	0,01
		3.1	1	6.2.7	0,00
		2.2	1	6.2.8	0,01
		3.1	1	6.2.8	0,01
		2.2	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,01
		3.1	1	6.2.9.1	0,00
		3.1	1	6.3.1.1	0,27
		3.1	1	6.3.3	0,39
		8		Doorbuiging	0,01
		8		Doorbuiging	0,00
64	K50/3	3.1	1	6.2.5	0,10
		4.2	1	6.2.5	0,02
		4.2	1	6.2.6	0,02
		4.2	1	6.2.7	0,02
		3.1	1	6.2.8	0,10
		4.2	1	6.2.8	0,02
		3.1	1	6.2.9.1	0,10
		4.2	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,02
		5.1	1	6.3.1.1	0,00
		8		Doorbuiging	0,09
		8		Doorbuiging	0,07
65	K50/3	3.1	1	6.2.5	0,02
		3.1	1	6.2.5	0,11
		4.2	1	6.2.6	0,02
		3.1	1	6.2.7	0,02
		3.1	1	6.2.8	0,11
		3.1	1	6.2.8	0,02
		3.1	1	6.2.9.1	0,11
		3.1	1	6.2.9.1	0,02
		3.1	1	6.2.9.1	0,02
		6.2	1	6.3.1.1	0,00
		8		Doorbuiging	0,09
		8		Doorbuiging	0,07
66	K50/3	3.1	1	6.2.5	0,12
		3.1	1	6.2.5	0,03
		3.1	1	6.2.6	0,02
		3.1	1	6.2.7	0,02
		3.1	1	6.2.8	0,12
		3.1	1	6.2.8	0,03

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
66	K50/3	3.1	1	6.2.9.1	0,12
		3.1	1	6.2.9.1	0,03
		3.1	1	6.2.9.1	0,03
		3.1	1	6.3.1.1	0,00
		3.1	1	6.3.3	0,12
		8		Doorbuiging	0,10
		8		Doorbuiging	0,08
67	K50/3	2.2	1	6.2.5	0,02
		1.1	1	6.2.8	0,02
		4.2	1	6.3.1.1	0,01
		4.2	1	6.3.3	0,02
		9		Doorbuiging	0,05
		9		Doorbuiging	0,00
68	K50/3	4.2	1	6.2.3	0,01
		2.2	1	6.2.5	0,02
		2.2	1	6.2.8	0,02
		4.2	1	6.2.9.1	0,01
		5.1	1	6.3.1.1	0,01
		5.1	1	6.3.3	0,02
		9		Doorbuiging	0,05
		8		Doorbuiging	0,00
69	K50/3	2.2	1	6.2.5	0,02
		1.1	1	6.2.8	0,02
		3.1	1	6.3.1.1	0,01
		3.1	1	6.3.3	0,03
		9		Doorbuiging	0,05
		8		Doorbuiging	0,00
70	K50/3	1.1	1	6.2.5	0,02
		2.2	1	6.2.8	0,02
		6.2	1	6.3.1.1	0,01
		6.2	1	6.3.3	0,02
		8		Doorbuiging	0,05
		9		Doorbuiging	0,00
71	IPE100	3.1	1	6.2.5	0,03
		4.2	1	6.2.6	0,01
		3.1	1	6.2.8	0,03
		3.1	1	6.3.2.1	0,04
		8		Doorbuiging	0,04
		8		Doorbuiging	0,03
72	IPE100	4.2	1	6.2.5	0,03
		3.1	1	6.2.6	0,01
		4.2	1	6.2.8	0,03
		4.2	1	6.3.2.1	0,04
		8		Doorbuiging	0,04
		8		Doorbuiging	0,03
73	IPE100	4.2	1	6.2.5	0,03
		3.1	1	6.2.6	0,01
		4.2	1	6.2.8	0,03
		4.2	1	6.3.2.1	0,04
		8		Doorbuiging	0,04
		8		Doorbuiging	0,03
74	IPE100	4.2	1	6.2.5	0,03
		3.1	1	6.2.6	0,01
		4.2	1	6.2.8	0,03
		4.2	1	6.3.2.1	0,04
		8		Doorbuiging	0,04
		8		Doorbuiging	0,04

Staaf-nummer	Profiel	Combinatie nummer	Klasse	Artikel	U.C.
74	IPE100	8		Doorbuiging	0,03
Maximale waarden					
11	IPE140	4	1	6.3.3	0,27
20	UNP160	9	1	Doorbuiging	0,71
32	L100X100X10	3	1	6.3.3	0,16
39	L50X50X5	5	1	6.3.3	0,07
42	UNP100	5	1	6.3.1.1	0,11
62	K60/3	4	1	6.3.3	0,39
66	K50/3	3	1	6.3.3	0,12
71	IPE100	3	1	6.3.2.1	0,04

2.5 BEREKENING VAN UNITY CHECKS

2.5.1 Staaf 11 - IPE140 (S 235)

Buigend moment

art. 6.2.5

Combinatie: 4.2 x=0 mm Nx=-0,24 kN Vy=-0,624 kN Vz=-8,881 kN
Mx=0 kNm My=0 kNm Mz=0,936 kNm

$$M_{z,c,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} f_y}{\gamma_{M0}} = \frac{19250 \times 235}{1,00} \times 10^{-6} = 4,524 \text{ kNm} \quad (6.13)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,936}{4,524} = 0,21 < 1,0 \quad (6.12)$$

Buigend moment

art. 6.2.5

Combinatie: 6.2 x=300 mm Nx=0,199 kN Vy=0,517 kN Vz=-10,579 kN
Mx=0 kNm My=-3,168 kNm Mz=-0,621 kNm

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{88392 \times 235}{1,00} \times 10^{-6} = 20,772 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{3,168}{20,772} = 0,15 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)

art. 6.2.6

Combinatie: 6.2 x=300 mm Nx=0,199 kN Vy=0,517 kN Vz=-10,579 kN
Mx=0 kNm My=-3,168 kNm Mz=-0,621 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{765 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 103,7 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{10,6}{103,7} = 0,10 < 1,0 \quad (6.17)$$

Buiging en dwarskracht

art. 6.2.8

Combinatie: 6.2 x=300 mm Nx=0,199 kN Vy=0,517 kN Vz=-10,579 kN
Mx=0 kNm My=-3,168 kNm Mz=-0,621 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{765 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 103,7 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 10,579 \text{ kN} < V_{z,pl,Rd} / 2 = 103,743 / 2 = 51,871 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en dwarskracht

art. 6.2.8

Combinatie: 4.2 x=0 mm $N_x=-0,24 \text{ kN}$ $V_y=-0,624 \text{ kN}$ $V_z=-8,881 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0 \text{ kNm}$ $M_z=0,936 \text{ kNm}$

$$V_{c,y,Rd} = V_{pl,y,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{1050 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 142,4 \text{ kN} \quad (6.18)$$

$$V_{y,Ed} = 0,624 \text{ kN} < V_{y,pl,Rd} / 2 = 142,442 / 2 = 71,221 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en normaalkracht

art. 6.2.9

Combinatie: 6.2 x=300 mm $N_x=0,199 \text{ kN}$ $V_y=0,517 \text{ kN}$ $V_z=-10,579 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-3,168 \text{ kNm}$ $M_z=-0,621 \text{ kNm}$

$$N_{Ed} < 0,25 N_{pl,Rd} = 0,25 \times 386,2 = 96,5 \text{ kN} \quad (6.33)$$

$$N_{Ed} < \frac{0,5 h_w t_w f_y}{\gamma_{M0}} = \frac{0,5 \times 126,2 \times 4,7 \times 235}{1,00} \times 10^{-3} = 69,7 \text{ kN} \quad (6.34)$$

Het effect van de normaalkracht op het vloeimoment hoeft niet in rekening te worden gebracht. (4)

Buiging en normaalkracht

art. 6.2.9

Combinatie: 4.2 x=300 mm $N_x=-0,24 \text{ kN}$ $V_y=-0,624 \text{ kN}$ $V_z=-8,922 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-2,67 \text{ kNm}$ $M_z=0,749 \text{ kNm}$

$$N_{Ed} < \frac{h_w t_w f_y}{\gamma_{M0}} = \frac{126,2 \times 4,7 \times 235}{1,00} \times 10^{-3} = 139,4 \text{ kN} \quad (6.34)$$

Het effect van de normaalkracht op het vloeimoment hoeft niet in rekening te worden gebracht. (4)

Buiging en normaalkracht

art. 6.2.9

Combinatie: 4.2 x=300 mm $N_x=-0,24 \text{ kN}$ $V_y=-0,624 \text{ kN}$ $V_z=-8,922 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-2,67 \text{ kNm}$ $M_z=0,749 \text{ kNm}$

$$\alpha = 2,00; \beta = 5 n = 5 \times 0,00 = 1,00$$

$$\left(\frac{M_{y,Ed}}{M_{N,y,Rd}} \right)^\alpha + \left(\frac{M_{z,Ed}}{M_{N,z,Rd}} \right)^\beta = \left(\frac{2,67}{20,772} \right)^2 + \left(\frac{0,749}{4,524} \right)^1 = 0,18 < 1,0 \quad (6.41)$$

Knikstabiliteit

art. 6.3.1.1

Combinatie: 4.2 x=0 mm $N_x=-0,24 \text{ kN}$ $V_y=-0,624 \text{ kN}$ $V_z=-8,881 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0 \text{ kNm}$ $M_z=-0,936 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{1500}{16,5} \frac{1}{93,9} = 0,966 \quad (6.50)$$

$$\text{Knikkromme } z-z \quad \alpha = 0,34$$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,34 \times (0,966 - 0,2) + 0,966^2] = 1,097$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{1,097 + \sqrt{1,097^2 - 0,966^2}} = 0,619 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_z A f_y}{\gamma_{M1}} = \frac{0,62 \times 1643,4 \times 235}{1,00} \times 10^{-3} = 238,9 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{0,2}{238,9} = 0,00 < 1,0 \quad (6.46)$$

Kipstabiliteit

art. 6.3.2.1

Combinatie: 6.2 x=300 mm

Nx=0,199 kN Vy=0,517 kN Vz=0,158 kN

Mx=0 kNm My=-3,168 kNm Mz=-0,621 kNm

Aantal kipsteunen: 0

$$d' = h - t = 140 - 6,9 = 133,1 \text{ mm} \quad I_w = \frac{(d')^2 b^3 t}{24} = \frac{133,1^2 \times 73^3 \times 6,9}{24} = 2 \times 10^9 \text{ mm}^6$$

torsiestijfheid volgens Roark geval 26

$$I_t = 24571 \text{ mm}^4$$

volgens NEN-EN 1993-1-1+C2+A1/NB:2016 nl figuren NB.33 en NB.34:

$$L_g = 1500 \text{ mm}$$

$$L_{st} = 1500 \text{ mm}$$

$$M_{y,1,Ed} = -0,01 \text{ kNm}$$

$$M_{y,2,Ed} = -0,011 \text{ kNm}$$

$$M_{yEd} (x=L_{st}/2=750 \text{ mm}) = -3,11 \text{ kNm}$$

Berekende equivalente belasting q = 11,022 kN/m

$$B^* = \frac{8 M}{8 |M| + q L_{st}^2} = \frac{8 \times 0,011 \times 10^6}{8 \times |0,011 \times 10^6| + 11,022 \times 1500^2} = 0,003 \quad \text{D.4.3 (3)}$$

$$\beta = \frac{M_{y,1,Ed}}{M_{y,2,Ed}} = \frac{-0,01}{-0,011} = 0,972 \quad C_1 = 1,129 \quad C_2 = 0$$

aangrijpingspunt belasting op z = 0 mm

$$L_{kip} = L_{st} = 1500 \text{ mm}$$

$$S = \frac{h}{2} \times \sqrt{\frac{E x I_z}{G x I_t}} = \frac{140}{2} \times \sqrt{\frac{210000 \times 449200}{80769 \times 24571}} = 483 \text{ mm} \quad (\text{NB.159})$$

$$C = \frac{\pi \times C_1 \times L_g}{L_{kip}} \times \left(\sqrt{1 + \left(\frac{\pi^2 \times S^2}{L_{kip}^2} \times (C_2^2 + 1) \right)} + \frac{\pi \times C_2 \times S}{L_{kip}} \right) = \quad (\text{NB.157})$$

$$= \frac{\pi \times 1,129 \times 1500}{1500} \times \left(\sqrt{1 + \left(\frac{\pi^2 \times 483^2}{1500^2} \times (0^2 + 1) \right)} + \frac{\pi \times 0 \times 483}{1500} \right) = 5,044$$

$$h / t_w = 140 / 4,7 = 29,8 < 75 \quad \rightarrow k_{red} = 1 \quad (\text{NB.153})$$

$$M_{cr} = k_{red} \times \frac{C}{L_g} \times \sqrt{E \times I_z \times G \times I_t} = \quad (\text{NB.148})$$

$$= 1 \times \frac{5,044}{1500} \times \sqrt{210000 \times 449200 \times 80769 \times 24571} \times 10^{-6} = 46,006 \text{ kNm}$$

$$\lambda_{Lt} = \sqrt{\frac{W_y f_y}{M_{cr}}} = \sqrt{\frac{88392 \times 235}{46006353}} = 0,672 > \lambda_{Lt,0} = 0,4$$

$$\text{Kipkromme b} \quad \alpha_{Lt} = 0,34$$

$$\Phi_{Lt} = 0,5 [1 + \alpha_{Lt} (\lambda_{Lt} - \lambda_{Lt,0}) + \beta \lambda_{Lt}^2] = 0,5 \times [1 + 0,34 \times (0,672 - 0,4) + 0,75 \times 0,672^2] = 0,716$$

$$\chi_{Lt} = \min \left(\frac{1}{\Phi_{Lt} + \sqrt{\Phi_{Lt}^2 - \beta \lambda_{Lt}^2}}, 1,0, \frac{1}{\lambda_{Lt}^2} \right) \quad (6.57)$$

$$= \min \left(\frac{1}{0,716 + \sqrt{0,716^2 - 0,75 \times 0,672^2}}, 1,0, \frac{1}{0,672^2} \right) = 0,883$$

$$\psi = \frac{M_1}{M_2} = \frac{-0,01}{-0,011} = 0,972 \quad k_c = \frac{1}{1,33 - 0,33 \psi} = \frac{1}{1,33 - 0,33 \times 0,972} = 0,991$$

$$f = 1 - 0,5 (1 - k_c) [1 - 2,0 (\lambda_{Lt} - 0,8)^2] = 1 - 0,5 \times (1 - 0,991) \times [1 - 2,0 \times (0,672 - 0,8)^2] = 0,996$$

$$\chi_{Lt,mod} = \frac{\chi_{Lt}}{f} = \frac{0,883}{0,996} = 0,887 \quad (6.58)$$

$$M_{b,Rd} = \chi_{Lt} W_y \frac{f_y}{\gamma_{M1}} = 0,887 \times 88392 \times \frac{235}{1,00} \times 10^{-6} = 18,4 \text{ kNm} \quad (6.55)$$

$$\frac{M_{Ed}}{M_{b,Rd}} = \frac{3,2}{18,4} = 0,17 < 1,0 \quad (6.54)$$

Prismatische, op buiging en druk belaste staven (maatgevend)

art. 6.3.3

Combinatie: 4.2 x=1200 mm Nx=-0,24 kN Vy=-0,624 kN Vz=-0,085 kN
 Mx=0 kNm My=-2,692 kNm Mz=0,187 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{1500}{57,4} \frac{1}{93,9} = 0,278 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{1500}{16,5} \frac{1}{93,9} = 0,966 \quad (6.50)$$

$$\text{Knikkromme } y-y \text{ a} \quad \alpha = 0,21$$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,21 \times (0,278 - 0,2) + 0,278^2] = 0,547$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,547 + \sqrt{0,547^2 - 0,278^2}} = 0,983 \quad (6.49)$$

Knikkromme $z-z$ $\alpha = 0,34$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,34 \times (0,966 - 0,2) + 0,966^2] = 1,097$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{1,097 + \sqrt{1,097^2 - 0,966^2}} = 0,619 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 1643 \times 10^{-3} = 386,2 \text{ kN}$$

$$M_{y,Rk} = f_y W_{pl,y} = 235 \times 88392 \times 10^{-6} = 20,8 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{pl,z} = 235 \times 19250 \times 10^{-6} = 4,5 \text{ kNm}$$

Interactiefactoren volgens methode 2 (EN 1993-1-1, Bijlage B)

$$\varphi = M_2 / M_1 = 0/0 = 1 \quad \alpha_h = M_h / M_s = 0/-2,667 = 0$$

$$C_{my} = 0,95 + 0,05 \alpha_h = 0,95 + 0,05 \times 0 = 0,95$$

$$k_{yy} = C_{my} \left(1 + (\lambda_y - 0,2) \frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} \right) = 0,95 \times \left(1 + (0,278 - 0,2) \times \frac{0,24}{0,983 \times 386,195/1,00} \right) = 0,95$$

$$\varphi = M_2 / M_1 = 0/0,936 = 0 \quad \rightarrow C_{mz} = 0,6 + 0,4 \varphi = 0,6 + 0,4 \times 0 = 0,6 > 0,4$$

$$k_{zz} = C_{mz} \left(1 + (2 \lambda_z - 0,6) \frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} \right) = 0,6 \times \left(1 + (2 \times 0,966 - 0,6) \times \frac{0,24}{0,619 \times 386,195/1,00} \right) = 0,601$$

$$k_{yz} = 0,6 k_{zz} = 0,6 \times 0,601 = 0,36$$

$$\varphi = M_2 / M_1 = 0/0 = 1 \quad \alpha_h = M_h / M_s = 0/-2,667 = 0$$

$$C_{mLT} = 0,95 + 0,05 \alpha_h = 0,95 + 0,05 \times 0 = 0,95$$

$$k_{zy} = \left(1 - \frac{0,1 \lambda_z}{(C_{mLT} - 0,25)} \frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} \right) = \left(1 - \frac{0,1 \times 0,966}{(0,95 - 0,25)} \times \frac{0,24}{0,619 \times 386,195/1,00} \right) = 1$$

$$\frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\gamma_{M1}} = \quad (6.61)$$

$$\frac{0,24}{0,983 \times 386,195 / 1,00} + 0,95 \times \frac{2,692}{0,91 \times \frac{20,772}{1,00}} + 0,36 \times \frac{0,936}{\frac{4,524}{1,00}} = 0,21 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\gamma_{M1}} = \quad (6.62)$$

$$\frac{0,24}{0,619 \times 386,195} + 1 \times \frac{2,692}{0,91 \times \frac{20,772}{1,00}} + 0,601 \times \frac{0,936}{\frac{4,524}{1,00}} = 0,27 < 1 \quad (6.62)$$

Doorbuiging

Combinatie: 9 x=749,1 mm

Nx=0,15 kN Vy=0,389 kN Vz=0,07 kN

Mx=0 kNm My=-2,57 kNm Mz=-0,292 kNm

Lokale knoopverplaatsingen d_{z1} = -897,9 mm d_{z2} = -839,9 mm

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = 0,6 - 0 = 0,6 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|0,6|}{1500 / 250} = \frac{|0,6|}{6} = 0,10 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = 0,6 - 0,3 = 0,3 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|0,3|}{1500 / 333} = \frac{|0,3|}{4,5} = 0,06 < 1,0$$

2.5.2 Staaf 20 - UNP160 (S 235)**Buigend moment**

art. 6.2.5

Combinatie: 6.2 x=2189,2 mm

Nx=-1,658 kN Vy=-0,049 kN Vz=0 kN

Mx=-0,013 kNm My=14,23 kNm Mz=-0,014 kNm

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{137331 \times 235}{1,00} \times 10^{-6} = 32,273 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{14,230}{32,273} = 0,44 < 1,0 \quad (6.12)$$

Buigend moment

art. 6.2.5

Combinatie: 4.2 x=3905 mm

Nx=-0,08 kN Vy=0,058 kN Vz=-1,29 kN

Mx=0,013 kNm My=3,117 kNm Mz=0,117 kNm

$$M_{z,c,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} f_y}{\gamma_{M0}} = \frac{35146 \times 235}{1,00} \times 10^{-6} = 8,259 \text{ kNm} \quad (6.13)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,117}{8,259} = 0,01 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)

art. 6.2.6

Combinatie: 6.2 x=0 mm

Nx=-1,658 kN Vy=-0,049 kN Vz=4,976 kN

Mx=-0,013 kNm My=8,783 kNm Mz=0,093 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{1217 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 165,1 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{5,0}{165,1} = 0,03 < 1,0 \quad (6.17)$$

Buiging en dwarskracht

art. 6.2.8

Combinatie: 6.2 x=1899,9 mm $N_x=-1,658 \text{ kN}$ $V_y=-0,049 \text{ kN}$ $V_z=0,658 \text{ kN}$
 $M_x=-0,013 \text{ kNm}$ $M_y=14,134 \text{ kNm}$ $M_z=0 \text{ kNm}$

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{1217 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 165,1 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 0,658 \text{ kN} < V_{z,pl,Rd} / 2 = 165,085 / 2 = 82,543 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en dwarskracht

art. 6.2.8

Combinatie: 4.2 x=3905 mm $N_x=-0,08 \text{ kN}$ $V_y=0,058 \text{ kN}$ $V_z=-1,29 \text{ kN}$
 $M_x=0,013 \text{ kNm}$ $M_y=3,117 \text{ kNm}$ $M_z=0,117 \text{ kNm}$

$$V_{c,y,Rd} = V_{pl,y,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{1356 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 183,9 \text{ kN} \quad (6.18)$$

$$V_{y,Ed} = 0,058 \text{ kN} < V_{y,pl,Rd} / 2 = 183,911 / 2 = 91,955 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Knikstabiliteit

art. 6.3.1.1

Combinatie: 6.2 x=0 mm $N_x=-1,658 \text{ kN}$ $V_y=-0,049 \text{ kN}$ $V_z=4,971 \text{ kN}$
 $M_x=0,013 \text{ kNm}$ $M_y=8,783 \text{ kNm}$ $M_z=-0,093 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{3905}{18,8} \frac{1}{93,9} = 2,209 \quad (6.50)$$

Knikkromme $z-z$ c $\alpha = 0,49$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,49 \times (2,209 - 0,2) + 2,209^2] = 3,432$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{3,432 + \sqrt{3,432^2 - 2,209^2}} = 0,165 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_z A f_y}{\gamma_{M1}} = \frac{0,17 \times 2398,3 \times 235}{1,00} \times 10^{-3} = 93 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{1,7}{93,0} = 0,02 < 1,0 \quad (6.46)$$

Prismatische, op buiging en druk belaste staven**art. 6.3.3**

Combinatie: 6.2 x=2189,2 mm $N_x=-1,658$ kN $V_y=-0,049$ kN $V_z=0$ kN
 $M_x=-0,013$ kNm $M_y=14,23$ kNm $M_z=-0,014$ kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{3905}{62,1} \frac{1}{93,9} = 0,67 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{3905}{18,8} \frac{1}{93,9} = 2,209 \quad (6.50)$$

Knikkromme $y-y$ c $\alpha = 0,49$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,49 \times (0,67 - 0,2) + 0,67^2] = 0,84$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,84 + \sqrt{0,84^2 - 0,67^2}} = 0,743 \quad (6.49)$$

Knikkromme $z-z$ c $\alpha = 0,49$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,49 \times (2,209 - 0,2) + 2,209^2] = 3,432$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{3,432 + \sqrt{3,432^2 - 2,209^2}} = 0,165 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 2398 \times 10^{-3} = 563,6 \text{ kN}$$

$$M_{y,Rk} = f_y W_{pl,y} = 235 \times 137331 \times 10^{-6} = 32,3 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{pl,z} = 235 \times 35146 \times 10^{-6} = 8,3 \text{ kNm}$$

$$\frac{N_{Ed}}{\chi_y N_{Rk}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.61)$$

$$\frac{1,658}{0,743 \times 563,592} + 1 \times \frac{14,23}{1 \times \frac{32,273}{1,00}} + 1 \times \frac{0,098}{\frac{8,259}{1,00}} = 0,46 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.62)$$

$$\frac{1,658}{0,165 \times 563,592} + 1 \times \frac{14,23}{32,273} + 1 \times \frac{0,098}{8,259} = 0,47 < 1 \quad (6.62)$$

$$\frac{1,00}{1,00} \quad 1 \times \frac{1,00}{1,00} \quad \frac{1,00}{1,00}$$

Doorbuiging

Combinatie: 9 x=1980,2 mm Nx=-1,297 kN Vy=-0,037 kN Vz=0,418 kN
 Mx=-0,01 kNm My=10,887 kNm Mz=-0,003 kNm

Lokale knoopverplaatsingen d_{z1} = -729 mm d_{z2} = -755,2 mm

$$W_{\text{eind},z} = W_z - W_{\text{Zeeg},z} = -10,1 - 0 = -10,1 \text{ mm}$$

$$\frac{|W_{\text{eind},z}|}{W_{\text{eind},z,\text{max}}} = \frac{|-10,1|}{3905 / 250} = \frac{|-10,1|}{15,6} = 0,65 < 1,0$$

$$W_{\text{bijk},z} = W_z - W_{\text{BGT Blijvend},z} = -10,1 + 1,8 = -8,4 \text{ mm}$$

$$\frac{|W_{\text{bijk},z}|}{W_{\text{bijk},z,\text{max}}} = \frac{|-8,4|}{3905 / 333} = \frac{|-8,4|}{11,7} = 0,71 < 1,0$$

2.5.3 Staaf 32 - L100X100X10 (S 235)**Axiale druk**

art. 6.2.4

Combinatie: 5.1 x=0 mm Nx=-4,023 kN Vy=0,871 kN Vz=-0,048 kN
 Mx=0 kNm My=0,018 kNm Mz=-0,57 kNm

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{1915,7 \times 235}{1,00} \times 10^{-3} = 450,198 \text{ kN} \quad (6.10)$$

$$\frac{N_{Ed}}{N_{c,Rd}} = \frac{4,0}{450,2} = 0,01 < 1,0 \quad (6.9)$$

Buigend moment

art. 6.2.5

Combinatie: 3.1 x=900 mm Nx=-3,927 kN Vy=1,74 kN Vz=-0,094 kN
 Mx=0 kNm My=-0,043 kNm Mz=0,807 kNm

$$M_{y,c,Rd} = M_{el,y,Rd} = \frac{W_{el,y,\text{min}} f_y}{\gamma_{M0}} = \frac{24604 \times 235}{1,00} \times 10^{-6} = 5,782 \text{ kNm} \quad (6.14)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,807}{5,782} = 0,14 < 1,0 \quad (6.12)$$

Buigend moment

art. 6.2.5

Combinatie: 4.2 x=0 mm Nx=-3,911 kN Vy=1,738 kN Vz=-0,096 kN
 Mx=0 kNm My=0,043 kNm Mz=-0,759 kNm

$$M_{z,c,Rd} = M_{el,z,Rd} = \frac{W_{el,z,\text{min}} f_y}{\gamma_{M0}} = \frac{24604 \times 235}{1,00} \times 10^{-6} = 5,782 \text{ kNm} \quad (6.14)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,043}{5,782} = 0,01 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)

art. 6.2.6

Combinatie: 3.1 x=0 mm $N_x=-3,927 \text{ kN}$ $V_y=1,74 \text{ kN}$ $V_z=-0,094 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0,041 \text{ kNm}$ $M_z=-0,758 \text{ kNm}$

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{916 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 124,3 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{1,7}{124,3} = 0,01 < 1,0 \quad (6.17)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 6.2 x=358,9 mm $N_x=-4,021 \text{ kN}$ $V_y=0,87 \text{ kN}$ $V_z=-0,047 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0 \text{ kNm}$ $M_z=-0,259 \text{ kNm}$

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{y,Ed}}{W_{y,el}} = \frac{4 \times 10^3}{1915,7} + \frac{0,3 \times 10^6}{24603,6} = 12,6 \text{ N/mm}^2$$

$$\sigma_{Ed} < \frac{f_y}{\gamma_{M0}} = \frac{235}{1,00} = 235 \text{ N/mm}^2 \quad (6.42)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 6.2 x=656,4 mm $N_x=-4,021 \text{ kN}$ $V_y=0,87 \text{ kN}$ $V_z=-0,047 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-0,014 \text{ kNm}$ $M_z=0 \text{ kNm}$

$$\sigma_{Ed} = \frac{N_{Ed}}{A} - \frac{M_{z,Ed}}{W_{z,el}} = \frac{4 \times 10^3}{1915,7} - \frac{0 \times 10^6}{62591,5} = 2,3 \text{ N/mm}^2$$

$$\sigma_{Ed} < \frac{f_y}{\gamma_{M0}} = \frac{235}{1,00} = 235 \text{ N/mm}^2 \quad (6.42)$$

Knikstabiliteit

art. 6.3.1.1

Combinatie: 5.1 x=0 mm $N_x=-4,023 \text{ kN}$ $V_y=0,871 \text{ kN}$ $V_z=-0,048 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0,018 \text{ kNm}$ $M_z=0,57 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} = \frac{1}{\lambda_1} = \frac{900}{30,4} \frac{1}{93,9} = 0,316 \quad (6.50)$$

Knikkromme $y-y$ $b \quad \alpha = 0,34$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,34 \times (0,316 - 0,2) + 0,316^2] = 0,569$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,569 + \sqrt{0,569^2 - 0,316^2}} = 0,958 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_y A f_y}{\gamma_{M1}} = \frac{0,96 \times 1915,7 \times 235}{1,00} \times 10^{-3} = 431,4 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{4,0}{431,4} = 0,01 < 1,0 \quad (6.46)$$

Prismatische, op buiging en druk belaste staven (maatgevend)**art. 6.3.3**

Combinatie: 3.1 x=899 mm

Nx=-3,927 kN Vy=1,74 kN Vz=-0,094 kN

Mx=0 kNm My=-0,043 kNm Mz=0,806 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{900}{30,4} \frac{1}{93,9} = 0,316 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{900}{30,4} \frac{1}{93,9} = 0,316 \quad (6.50)$$

Knikkromme y-y b $\alpha = 0,34$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,34 \times (0,316 - 0,2) + 0,316^2] = 0,569$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,569 + \sqrt{0,569^2 - 0,316^2}} = 0,958 \quad (6.49)$$

Knikkromme z-z b $\alpha = 0,34$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,34 \times (0,316 - 0,2) + 0,316^2] = 0,569$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{0,569 + \sqrt{0,569^2 - 0,316^2}} = 0,958 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 1916 \times 10^{-3} = 450,2 \text{ kN}$$

$$M_{y,Rk} = f_y W_{el,y} = 235 \times 24604 \times 10^{-6} = 5,8 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{el,z} = 235 \times 24604 \times 10^{-6} = 5,8 \text{ kNm}$$

$$\frac{N_{Ed}}{\chi_y N_{Rk}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.61)$$

$$\frac{3,927}{0,958 \times 450,198} + 1 \times \frac{0,806}{1 \times \frac{5,782}{1,00}} + 1 \times \frac{0,043}{\frac{5,782}{1,00}} = 0,16 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.62)$$

$$\frac{3,927}{0,958 \times 450,198} + 1 \times \frac{0,806}{1 \times \frac{5,782}{1,00}} + 1 \times \frac{0,043}{\frac{5,782}{1,00}} = 0,16 < 1 \quad (6.62)$$

Doorbuiging

Combinatie: 9 x=450 mm $N_x=-3,402 \text{ kN}$ $V_y=0,831 \text{ kN}$ $V_z=-0,047 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-0,003 \text{ kNm}$ $M_z=-0,132 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -731,2 \text{ mm}$ $d_{z2} = -731,2 \text{ mm}$

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|0|}{900 / 250} = \frac{|0|}{3,6} = 0,00 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|0|}{900 / 333} = \frac{|0|}{2,7} = 0,00 < 1,0$$

Doorbuiging

Combinatie: 8 x=450 mm $N_x=-3,326 \text{ kN}$ $V_y=1,474 \text{ kN}$ $V_z=-0,082 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-0,001 \text{ kNm}$ $M_z=0,018 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -725 \text{ mm}$ $d_{z2} = -725 \text{ mm}$

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|0|}{900 / 250} = \frac{|0|}{3,6} = 0,00 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|0|}{900 / 333} = \frac{|0|}{2,7} = 0,00 < 1,0$$

2.5.4 Staaf 39 - L50X50X5 (S 235)**Axiale druk****art. 6.2.4**

Combinatie: 5.1 x=0 mm $N_x=-1,017 \text{ kN}$ $V_y=-0,002 \text{ kN}$ $V_z=0,054 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-0,032 \text{ kNm}$ $M_z=0,005 \text{ kNm}$

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{480,4 \times 235}{1,00} \times 10^{-3} = 112,883 \text{ kN} \quad (6.10)$$

$$\frac{N_{Ed}}{N_{c,Rd}} = \frac{1,0}{112,9} = 0,01 < 1,0 \quad (6.9)$$

Buigend moment**art. 6.2.5**

Combinatie: 6.2 x=0 mm

Nx=-0,963 kN Vy=-0,002 kN Vz=0,054 kN

Mx=0 kNm My=-0,032 kNm Mz=0,005 kNm

$$M_{z,c,Rd} = M_{el,z,Rd} = \frac{W_{el,z,min} f_y}{\gamma_{M0}} = \frac{3047 \times 235}{1,00} \times 10^{-6} = 0,716 \text{ kNm} \quad (6.14)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,032}{0,716} = 0,05 < 1,0 \quad (6.12)$$

Buigend moment**art. 6.2.5**

Combinatie: 4.2 x=0 mm

Nx=-0,133 kN Vy=0,002 kN Vz=0,042 kN

Mx=0 kNm My=-0,025 kNm Mz=-0,006 kNm

$$M_{y,c,Rd} = M_{el,y,Rd} = \frac{W_{el,y,min} f_y}{\gamma_{M0}} = \frac{3047 \times 235}{1,00} \times 10^{-6} = 0,716 \text{ kNm} \quad (6.14)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,006}{0,716} = 0,01 < 1,0 \quad (6.12)$$

Buiging en normaalkracht**art. 6.2.9**

Combinatie: 5.1 x=793,7 mm

Nx=-1,017 kN Vy=-0,002 kN Vz=0,027 kN

Mx=0 kNm My=0 kNm Mz=0,004 kNm

$$\sigma_{Ed} = \frac{N_{Ed}}{A} - \frac{M_{y,Ed}}{W_{y,el}} = \frac{1 \times 10^3}{480,4} - \frac{0 \times 10^6}{7810,3} = 2,6 \text{ N/mm}^2$$

$$\sigma_{Ed} < \frac{f_y}{\gamma_{M0}} = \frac{235}{1,00} = 235 \text{ N/mm}^2 \quad (6.42)$$

Knikstabiliteit**art. 6.3.1.1**

Combinatie: 5.1 x=0 mm

Nx=-1,017 kN Vy=-0,002 kN Vz=0,054 kN

Mx=0 kNm My=-0,032 kNm Mz=-0,005 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{1749}{15,1} \frac{1}{93,9} = 1,233 \quad (6.50)$$

Knikkromme z-z b $\alpha = 0,34$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,34 \times (1,233 - 0,2) + 1,233^2] = 1,436$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{1,436 + \sqrt{1,436^2 - 1,233^2}} = 0,461 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_z A f_y}{\gamma_{M1}} = \frac{0,46 \times 480,4 \times 235}{1,00} \times 10^{-3} = 52 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{1,0}{52,0} = 0,02 < 1,0 \quad (6.46)$$

Prismatische, op buiging en druk belaste staven (maatgevend)**art. 6.3.3**

Combinatie: 5.1 x=0 mm

Nx=-1,017 kN Vy=-0,002 kN Vz=0,054 kN

Mx=0 kNm My=-0,032 kNm Mz=0,005 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{1749}{15,1} \frac{1}{93,9} = 1,233 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{1749}{15,1} \frac{1}{93,9} = 1,233 \quad (6.50)$$

Knikkromme y - y b $\alpha = 0,34$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,34 \times (1,233 - 0,2) + 1,233^2] = 1,436$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{1,436 + \sqrt{1,436^2 - 1,233^2}} = 0,461 \quad (6.49)$$

Knikkromme z - z b $\alpha = 0,34$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,34 \times (1,233 - 0,2) + 1,233^2] = 1,436$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{1,436 + \sqrt{1,436^2 - 1,233^2}} = 0,461 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 480 \times 10^{-3} = 112,9 \text{ kN}$$

$$M_{y,Rk} = f_y W_{el,y} = 235 \times 3047 \times 10^{-6} = 0,7 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{el,z} = 235 \times 3047 \times 10^{-6} = 0,7 \text{ kNm}$$

$$\frac{N_{Ed}}{\chi_y N_{Rk}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.61)$$

$$\frac{1,017}{0,461 \times 112,883} + 1 \times \frac{0,005}{1 \times \frac{0,716}{1,00}} + 1 \times \frac{0,032}{\frac{0,716}{1,00}} = 0,07 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.62)$$

$$\frac{1,017}{0,461 \times 112,883} + 1 \times \frac{0,005}{1 \times \frac{0,716}{1,00}} + 1 \times \frac{0,032}{\frac{0,716}{1,00}} = 0,07 < 1 \quad (6.62)$$

Doorbuiging

Combinatie: 8 x=874,6 mm

$N_x = -0,156 \text{ kN}$ $V_y = 0,001 \text{ kN}$ $V_z = 0,009 \text{ kN}$

$M_x = 0 \text{ kNm}$ $M_y = -0,001 \text{ kNm}$ $M_z = -0,003 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -749,2 \text{ mm}$ $d_{z2} = -765,1 \text{ mm}$

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|0|}{1749 / 250} = \frac{|0|}{7} = 0,01 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|0|}{1749 / 333} = \frac{|0|}{5,3} = 0,00 < 1,0$$

Doorbuiging

Combinatie: 9 x=874,6 mm

$N_x = -0,769 \text{ kN}$ $V_y = -0,002 \text{ kN}$ $V_z = 0,018 \text{ kN}$

$M_x = 0 \text{ kNm}$ $M_y = 0,002 \text{ kNm}$ $M_z = 0,003 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -704,7 \text{ mm}$ $d_{z2} = -717,9 \text{ mm}$

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|0|}{1749 / 250} = \frac{|0|}{7} = 0,00 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = 0 - 0 = 0 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|0|}{1749 / 333} = \frac{|0|}{5,3} = 0,00 < 1,0$$

2.5.5 Staaf 42 - UNP100 (S 235)

Axiale trek

art. 6.2.3

Combinatie: 4.2 x=3443,5 mm

$N_x = 6,214 \text{ kN}$ $V_y = 0,019 \text{ kN}$ $V_z = 0,035 \text{ kN}$

$M_x = -0,003 \text{ kNm}$ $M_y = 0,082 \text{ kNm}$ $M_z = 0 \text{ kNm}$

$$N_{\text{pl,Rd}} = \frac{A f_y}{\gamma_{M0}} = \frac{1342,7 \times 235}{1,00} \times 10^{-3} = 315,5 \text{ kN} \quad (6.6)$$

$$\frac{N_{\text{Ed}}}{N_{\text{t,Rd}}} = \frac{6,2}{315,5} = 0,02 < 1,0 \quad (6.5)$$

Buigend moment

art. 6.2.5

Combinatie: 4.2 x=960,9 mm

$N_x = 3,264 \text{ kN}$ $V_y = 0,002 \text{ kN}$ $V_z = 0 \text{ kN}$

$M_x = 0 \text{ kNm}$ $M_y = 0,137 \text{ kNm}$ $M_z = 0,002 \text{ kNm}$

$$M_{y,c,Rd} = M_{\text{pl,y,Rd}} = \frac{W_{\text{pl,y}} f_y}{\gamma_{M0}} = \frac{48863 \times 235}{1,00} \times 10^{-6} = 11,483 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,137}{11,483} = 0,01 < 1,0 \quad (6.12)$$

Buigend moment**art. 6.2.5**

Combinatie: 3.1 x=4562,1 mm $N_x=6,054 \text{ kN}$ $V_y=0,019 \text{ kN}$ $V_z=-0,295 \text{ kN}$
 $M_x=-0,003 \text{ kNm}$ $M_y=-0,063 \text{ kNm}$ $M_z=0,021 \text{ kNm}$

$$M_{z,c,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} f_y}{\gamma_{M0}} = \frac{16198 \times 235}{1,00} \times 10^{-6} = 3,806 \text{ kNm} \quad (6.13)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,021}{3,806} = 0,01 < 1,0 \quad (6.12)$$

Buiging en dwarskracht**art. 6.2.8**

Combinatie: 3.1 x=2281 mm $N_x=3,113 \text{ kN}$ $V_y=0,002 \text{ kN}$ $V_z=-0,391 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=-0,122 \text{ kNm}$ $M_z=0,004 \text{ kNm}$

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{612 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 83 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 0,391 \text{ kN} < V_{z,pl,Rd} / 2 = 83,035 / 2 = 41,517 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en dwarskracht**art. 6.2.8**

Combinatie: 3.1 x=4562,1 mm $N_x=6,054 \text{ kN}$ $V_y=0,019 \text{ kN}$ $V_z=-0,295 \text{ kN}$
 $M_x=-0,003 \text{ kNm}$ $M_y=-0,063 \text{ kNm}$ $M_z=0,021 \text{ kNm}$

$$V_{c,y,Rd} = V_{pl,y,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{845 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 114,6 \text{ kN} \quad (6.18)$$

$$V_{y,Ed} = 0,019 \text{ kN} < V_{y,pl,Rd} / 2 = 114,647 / 2 = 57,324 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Knikstabiliteit (maatgevend)**art. 6.3.1.1**

Combinatie: 5.1 x=0 mm $N_x=-0,712 \text{ kN}$ $V_y=0 \text{ kN}$ $V_z=0,135 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0 \text{ kNm}$ $M_z=0 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{9124}{14,7} \frac{1}{93,9} = 6,597 \quad (6.50)$$

$$\text{Knikkromme } z-z \quad \alpha = 0,49$$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,49 \times (6,597 - 0,2) + 6,597^2] = 23,828$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{23,828 + \sqrt{23,828^2 - 6,597^2}} = 0,021 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_z A f_y}{\gamma_{M1}} = \frac{0,021 \times 1342,7 \times 235}{1,00} \times 10^{-3} = 6,8 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{0,7}{6,8} = 0,11 < 1,0 \quad (6.46)$$

Doorbuiging

Combinatie: 8 x=3649,6 mm $N_x=4,998 \text{ kN}$ $V_y=0,015 \text{ kN}$ $V_z=-0,022 \text{ kN}$
 $M_x=-0,002 \text{ kNm}$ $M_y=0,069 \text{ kNm}$ $M_z=0,003 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -727,5 \text{ mm}$ $d_{z2} = 0 \text{ mm}$

$$w_{eind,z} = w_z - w_{Zeeg,z} = -0,5 - 0 = -0,5 \text{ mm}$$

$$\frac{|w_{eind,z}|}{w_{eind,z,max}} = \frac{|-0,5|}{9124 / 250} = \frac{|-0,5|}{36,5} = 0,01 < 1,0$$

$$w_{bijk,z} = w_z - w_{BGT \text{ Blijvend},z} = -0,5 + 0,3 = -0,2 \text{ mm}$$

$$\frac{|w_{bijk,z}|}{w_{bijk,z,max}} = \frac{|-0,2|}{9124 / 333} = \frac{|-0,2|}{27,4} = 0,01 < 1,0$$

2.5.6 Staaf 62 - K60/3 (S 235)**Axiale druk****art. 6.2.4**

Combinatie: 4.2 x=3397,3 mm $N_x=-5,58 \text{ kN}$ $V_y=-0,033 \text{ kN}$ $V_z=0 \text{ kN}$
 $M_x=-0,037 \text{ kNm}$ $M_y=0,016 \text{ kNm}$ $M_z=0,001 \text{ kNm}$

$$N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} = \frac{666,5 \times 235}{1,00} \times 10^{-3} = 156,631 \text{ kN} \quad (6.10)$$

$$\frac{N_{Ed}}{N_{c,Rd}} = \frac{5,6}{156,6} = 0,04 < 1,0 \quad (6.9)$$

Buigend moment**art. 6.2.5**

Combinatie: 3.1 x=0 mm $N_x=-4,409 \text{ kN}$ $V_y=-0,013 \text{ kN}$ $V_z=0,058 \text{ kN}$
 $M_x=-0,025 \text{ kNm}$ $M_y=-0,013 \text{ kNm}$ $M_z=0,042 \text{ kNm}$

$$M_{z,c,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} f_y}{\gamma_{M0}} = \frac{14097 \times 235}{1,00} \times 10^{-6} = 3,313 \text{ kNm} \quad (6.13)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,042}{3,313} = 0,01 < 1,0 \quad (6.12)$$

Buigend moment**art. 6.2.5**

Combinatie: 2.2 x=2281 mm $N_x=-3,44 \text{ kN}$ $V_y=-0,005 \text{ kN}$ $V_z=-0,076 \text{ kN}$
 $M_x=-0,011 \text{ kNm}$ $M_y=-0,027 \text{ kNm}$ $M_z=0,005 \text{ kNm}$

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{14097 \times 235}{1,00} \times 10^{-6} = 3,313 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,027}{3,313} = 0,01 < 1,0 \quad (6.12)$$

Wringing (torsie)

art. 6.2.7

Combinatie: 3.1 x=4562,1 mm $N_x=-5,561 \text{ kN}$ $V_y=-0,033 \text{ kN}$ $V_z=-0,064 \text{ kN}$
 $M_x=-0,038 \text{ kNm}$ $M_y=-0,022 \text{ kNm}$ $M_z=-0,038 \text{ kNm}$

$$R_c = 1.5 t = 1,5 \times 3 = 4,5 \text{ mm}$$

$$A_p = (d-t)(b-t) - R_c^2 (4 - \pi) = (60 - 3) \times (60 - 3) - 4,5^2 \times (4 - \pi) = 3232 \text{ mm}^2$$

$$p = 2 [(d-t) + (b-t)] - 2R_c (4 - \pi) = 2 \times [(60 - 3) + (60 - 3)] - 2 \times 4,5 \times (4 - \pi) = 220,3 \text{ mm}$$

$$J = \frac{4 A_p^2 t}{p} = \frac{4 \times 3232^2 \times 3}{220,3} = 568928 \text{ mm}^4 \quad \text{St. Venants constante}$$

$$C_w = 0 \text{ mm}^6 \quad \text{Welvingsconstante}$$

$$\tau_{t,Ed} = \frac{T_{Ed} t}{J} = \frac{37719 \times 3}{568928} = 0,2 \text{ N/mm}^2 \quad (\text{St. Venants})$$

$$\sigma_x = \frac{N_x}{A} + \frac{M_y e}{I_y} + \frac{M_z e}{I_z} = -8,3 + -1,8 + -3,2 = -13,4 \text{ N/mm}^2$$

$$\tau_z = \frac{V_z S}{b I_y} = 0,0 \text{ N/mm}^2 \quad \tau_y = \frac{V_y S}{b I_z} = 0,0 \text{ N/mm}^2$$

$$\left(\frac{\sigma_x}{f_y / \gamma_{M0}} \right)^2 + 3 \left(\frac{\tau}{f_y / \gamma_{M0}} \right)^2 = \left(\frac{-13,4}{235/1,00} \right)^2 + 3 \left(\frac{0,0}{235/1,00} \right)^2 = 0,00 < 1,0 \quad (6.1)$$

Buiging en dwarskracht

art. 6.2.8

Combinatie: 2.2 x=2281 mm $N_x=-3,44 \text{ kN}$ $V_y=-0,005 \text{ kN}$ $V_z=-0,076 \text{ kN}$
 $M_x=-0,011 \text{ kNm}$ $M_y=-0,027 \text{ kNm}$ $M_z=0,005 \text{ kNm}$

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{334 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 45,2 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 0,076 \text{ kN} < V_{z,pl,Rd} / 2 = 45,248 / 2 = 22,624 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en dwarskracht

art. 6.2.8

Combinatie: 3.1 x=0 mm $N_x=-4,409 \text{ kN}$ $V_y=-0,013 \text{ kN}$ $V_z=0,058 \text{ kN}$
 $M_x=-0,025 \text{ kNm}$ $M_y=-0,013 \text{ kNm}$ $M_z=0,042 \text{ kNm}$

$$V_{c,y,Rd} = V_{pl,y,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{334 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 45,2 \text{ kN} \quad (6.18)$$

$$V_{y,Ed} = 0,013 \text{ kN} < V_{y,pl,Rd} / 2 = 45,248 / 2 = 22,624 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en normaalkracht

art. 6.2.9

Combinatie: 2.2 x=2281 mm Nx=-3,44 kN Vy=-0,005 kN Vz=-0,076 kN
Mx=-0,011 kNm My=-0,027 kNm Mz=0,005 kNm

$n = N_{Ed} / N_{pl,Rd} = 0,02$ $a_w = (A - 2 b t_f) / A = (666,5 - 2 \times 60 \times 3) / 666,5 = 0,46$

$$M_{N,y,Rd} = M_{pl,y,Rd} (1-n)/(1-0,5a_w) = 3,313 \times (1-0,02)/(1-0,5 \times 0,46) = 3,313 \text{ kNm} \quad (6.39)$$

$$\frac{M_{y,Ed}}{M_{N,y,Rd}} = \frac{0,027}{3,313} = 0,01 < 1,0 \quad (6.31)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 3.1 x=0 mm $N_x=-4,409 \text{ kN}$ $V_y=-0,013 \text{ kN}$ $V_z=0,058 \text{ kN}$
 $M_x=-0,025 \text{ kNm}$ $M_y=-0,013 \text{ kNm}$ $M_z=0,042 \text{ kNm}$
 $n = N_{Ed} / N_{pl,Rd} = 0,03$ $a_f = (A - 2 h t_w) / A = (666,5 - 2 \times 60 \times 3) / 666,5 = 0,46$

$$M_{N,y,Rd} = M_{pl,y,Rd} (1-n)/(1-0,5a_f) = 3,313 \times (1-0,03)/(1-0,5 \times 0,46) = 3,313 \text{ kNm} \quad (6.40)$$

$$\frac{M_{z,Ed}}{M_{Nz,Rd}} = \frac{0,042}{3,313} = 0,01 < 1,0 \quad (6.31)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 3.1 x=6843 mm Nx=-3,95 kN Vy=-0,009 kN Vz=-0,063 kN
Mx=-0,025 kNm My=-0,02 kNm Mz=-0,04 kNm

$$\alpha = \beta = \frac{1,66}{1 - 1,13 n^2} = \frac{1,66}{1 - 1,13 0,03^2} = 1,66$$

$$\left(\frac{M_{y,Ed}}{M_{N,y,Rd}} \right)^{\alpha} + \left(\frac{M_{z,Ed}}{M_{N,z,Rd}} \right)^{\beta} = \left(\frac{0,02}{3,313} \right)^{1,66} + \left(\frac{0,04}{3,313} \right)^{1,66} = 0,00 < 1,0 \quad (6.41)$$

Knikstabilität

art. 6.3.1.1

Combinatie: 4.2 x=0 mm $N_x=-4,421 \text{ kN}$ $V_y=-0,012 \text{ kN}$ $V_z=0,058 \text{ kN}$
 $M_x=0,025 \text{ kNm}$ $M_y=-0,013 \text{ kNm}$ $M_z=-0,042 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{6843}{23,1} \frac{1}{93,9} = 3,157 \quad (6.50)$$

Knikkromme $z-z_a$ $\alpha = 0,21$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,21 \times (3,157 - 0,2) + 3,157^2] = 5,794$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{5,794 + \sqrt{5,794^2 - 3,157^2}} = 0,094 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_z A f_y}{\gamma_{M1}} = \frac{0,09 \times 666,5 \times 235}{1,00} \times 10^{-3} = 14,7 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{4,4}{14,7} = 0,30 < 1,0 \quad (6.46)$$

Prismatische, op buiging en druk belaste staven (maatgevend)**art. 6.3.3**

Combinatie: 4.2 x=2281 mm Nx=-4,421 kN Vy=-0,012 kN Vz=-0,067 kN
 Mx=-0,025 kNm My=-0,022 kNm Mz=0,013 kNm

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{6843}{23,1} \frac{1}{93,9} = 3,157 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{6843}{23,1} \frac{1}{93,9} = 3,157 \quad (6.50)$$

Knikkromme $y-y$ a $\alpha = 0,21$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 \times [1 + 0,21 \times (3,157 - 0,2) + 3,157^2] = 5,794$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{5,794 + \sqrt{5,794^2 - 3,157^2}} = 0,094 \quad (6.49)$$

Knikkromme $z-z$ a $\alpha = 0,21$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,21 \times (3,157 - 0,2) + 3,157^2] = 5,794$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{5,794 + \sqrt{5,794^2 - 3,157^2}} = 0,094 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 667 \times 10^{-3} = 156,6 \text{ kN}$$

$$M_{y,Rk} = f_y W_{pl,y} = 235 \times 14097 \times 10^{-6} = 3,3 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{pl,z} = 235 \times 14097 \times 10^{-6} = 3,3 \text{ kNm}$$

Interactiefactoren volgens methode 2 (EN 1993-1-1, Bijlage B)

$$\varphi = M_2/M_1 = 0,013/0,02 = 0,65 \quad \alpha_s = M_s/M_h = -0,016/0,02 = -0,8$$

$$C_{my} = 0,1 - 0,8 \alpha_s = 0,1 - 0,8 \times -0,8 = 0,74 > 0,4$$

$$k_{yy} = C_{my} \left(1 + 0,8 \frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} \right) = 0,74 \times \left(1 + 0,8 \times \frac{5,58}{0,094 \times 156,631/1,00} \right) = 0,965$$

$$\varphi = M_2/M_1 = 0,04/-0,042 = -0,96 \quad \alpha_s = M_s/M_h = 0/-0,042 = 0$$

$$C_{mz} = 0,1(1 - \varphi) - 0,8 \alpha_s = 0,1 \times (1 - -0,96) - 0,8 \times 0 = 0,4 < 0,4$$

$$k_{zz} = C_{mz} \left(1 + 0,8 \frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} \right) = 0,4 \times \left(1 + 0,8 \times \frac{5,58}{0,094 \times 156,631 / 1,00} \right) = 0,521$$

$$k_{yz} = 0,6 k_{zz} = 0,6 \times 0,521 = 0,313 \quad k_{zy} = 0,6 k_{yy} = 0,6 \times 0,965 = 0,579$$

$$\frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.61)$$

$$\frac{5,58}{0,094 \times 156,631 / 1,00} + 0,965 \times \frac{0,022}{1 \times \frac{3,313}{1,00}} + 0,313 \times \frac{0,042}{\frac{3,313}{1,00}} = 0,39 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\frac{M_{z,Rk}}{\gamma_{M1}}} = \quad (6.62)$$

$$\frac{5,58}{0,094 \times 156,631 / 1,00} + 0,579 \times \frac{0,022}{1 \times \frac{3,313}{1,00}} + 0,521 \times \frac{0,042}{\frac{3,313}{1,00}} = 0,39 < 1 \quad (6.62)$$

Doorbuiging

Combinatie: 8 x=3421,5 mm

$N_x = -4,693 \text{ kN}$ $V_y = -0,025 \text{ kN}$ $V_z = -0,001 \text{ kN}$
 $M_x = -0,028 \text{ kNm}$ $M_y = 0,014 \text{ kNm}$ $M_z = 0 \text{ kNm}$

Lokale knoopverplaatsingen $d_{z1} = -135,4 \text{ mm}$ $d_{z2} = -229,1 \text{ mm}$

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = -0,3 - 0 = -0,3 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|-0,3|}{6843 / 250} = \frac{|-0,3|}{27,4} = 0,01 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = -0,3 + 0,2 = -0,1 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|-0,1|}{6843 / 333} = \frac{|-0,1|}{20,5} = 0,01 < 1,0$$

2.5.7 Staaf 66 - K50/3 (S 235)

Buigend moment

art. 6.2.5

Combinatie: 3.1 x=450 mm

$N_x = -0,085 \text{ kN}$ $V_y = 0,176 \text{ kN}$ $V_z = 0,338 \text{ kN}$
 $M_x = 0,04 \text{ kNm}$ $M_y = 0,272 \text{ kNm}$ $M_z = 0,007 \text{ kNm}$

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{9785 \times 235}{1,00} \times 10^{-6} = 2,299 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,272}{2,299} = 0,12 < 1,0 \quad (6.12)$$

Buigend moment

art. 6.2.5

Combinatie: 3.1 x=0 mm $N_x=-0,085$ kN $V_y=0,176$ kN $V_z=0,359$ kN
 $M_x=0,04$ kNm $M_y=0,115$ kNm $M_z=-0,072$ kNm

$$M_{z,c,Rd} = M_{pl,z,Rd} = \frac{W_{pl,z} f_y}{\gamma_{M0}} = \frac{9785 \times 235}{1,00} \times 10^{-6} = 2,299 \text{ kNm} \quad (6.13)$$

$$\frac{M_{z,Ed}}{M_{z,c,Rd}} = \frac{0,072}{2,299} = 0,03 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)

art. 6.2.6

Combinatie: 3.1 x=900 mm $N_x=-0,085$ kN $V_y=0$ kN $V_z=-0,768$ kN
 $M_x=0,04$ kNm $M_y=-0,069$ kNm $M_z=0,008$ kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{279 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 37,9 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{0,8}{37,9} = 0,02 < 1,0 \quad (6.17)$$

Wringing (torsie)

art. 6.2.7

Combinatie: 3.1 x=450 mm $N_x=-0,085$ kN $V_y=0,176$ kN $V_z=0,338$ kN
 $M_x=0,04$ kNm $M_y=0,272$ kNm $M_z=0,007$ kNm

$$R_c = 1.5 t = 1,5 \times 3 = 4,5 \text{ mm}$$

$$A_p = (d-t)(b-t) - R_c^2 (4 - \pi) = (50 - 3) \times (50 - 3) - 4,5^2 \times (4 - \pi) = 2192 \text{ mm}^2$$

$$p = 2 [(d-t) + (b-t)] - 2R_c (4 - \pi) = 2 \times [(50 - 3) + (50 - 3)] - 2 \times 4,5 \times (4 - \pi) = 180,3 \text{ mm}$$

$$J = \frac{4 A_p^2 t}{p} = \frac{4 \times 2192^2 \times 3}{180,3} = 319725 \text{ mm}^4 \quad \text{St. Venants constante}$$

$$C_w = 0 \text{ mm}^6 \quad \text{Welvingsconstante}$$

$$\tau_{t,Ed} = \frac{T_{Ed} t}{J} = \frac{39965 \times 3}{319725} = 0,4 \text{ N/mm}^2 \quad (\text{St. Venants})$$

$$\sigma_x = \frac{N_x}{A} + \frac{M_y e}{I_y} + \frac{M_z e}{I_z} = -0,2 + -33,3 + -0,9 = -34,4 \text{ N/mm}^2$$

$$\tau_z = \frac{V_z S}{b I_y} = 0,0 \text{ N/mm}^2$$

$$\tau_y = \frac{V_y S}{b I_z} = 0,0 \text{ N/mm}^2$$

$$\left(\frac{\sigma_x}{f_y / \gamma_{M0}} \right)^2 + 3 \left(\frac{\tau}{f_y / \gamma_{M0}} \right)^2 = \left(\frac{-34,4}{235/1,00} \right)^2 + 3 \left(\frac{0,0}{235/1,00} \right)^2 = 0,02 < 1,0 \quad (6.1)$$

Buiging en dwarskracht

art. 6.2.8

Combinatie: 3.1 x=450 mm

Nx=-0,085 kN Vy=0,176 kN Vz=0,338 kN
 Mx=0,04 kNm My=0,272 kNm Mz=0,007 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{279 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 37,9 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 0,338 \text{ kN} < V_{z,pl,Rd} / 2 = 37,854 / 2 = 18,927 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en dwarskracht

art. 6.2.8

Combinatie: 3.1 x=0 mm

Nx=-0,085 kN Vy=0,176 kN Vz=0,359 kN
 Mx=0,04 kNm My=0,115 kNm Mz=-0,072 kNm

$$V_{c,y,Rd} = V_{pl,y,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{279 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 37,9 \text{ kN} \quad (6.18)$$

$$V_{y,Ed} = 0,176 \text{ kN} < V_{y,pl,Rd} / 2 = 37,854 / 2 = 18,927 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht. (2)

Buiging en normaalkracht

art. 6.2.9

Combinatie: 3.1 x=450 mm

Nx=-0,085 kN Vy=0,176 kN Vz=0,338 kN
 Mx=0,04 kNm My=0,272 kNm Mz=0,007 kNm

$$n = N_{Ed} / N_{pl,Rd} = 0 \quad a_w = (A - 2 b t_f) / A = (557,9 - 2 \times 50 \times 3) / 557,9 = 0,46$$

$$M_{N,y,Rd} = M_{pl,y,Rd} (1-n) / (1-0,5a_w) = 2,299 \times (1-0) / (1-0,5 \times 0,46) = 2,299 \text{ kNm} \quad (6.39)$$

$$\frac{M_{y,Ed}}{M_{N,y,Rd}} = \frac{0,272}{2,299} = 0,12 < 1,0 \quad (6.31)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 3.1 x=0 mm

Nx=-0,085 kN Vy=0,176 kN Vz=0,359 kN
 Mx=0,04 kNm My=0,115 kNm Mz=-0,072 kNm

$$n = N_{Ed} / N_{pl,Rd} = 0 \quad a_f = (A - 2 h t_w) / A = (557,9 - 2 \times 50 \times 3) / 557,9 = 0,46$$

$$M_{N,y,Rd} = M_{pl,y,Rd} (1-n)/(1-0,5a_f) = 2,299 \times (1-0)/(1-0,5 \times 0,46) = 2,299 \text{ kNm} \quad (6.40)$$

$$\frac{M_{z,Ed}}{M_{N,z,Rd}} = \frac{0,072}{2,299} = 0,03 < 1,0 \quad (6.31)$$

Buiging en normaalkracht

art. 6.2.9

Combinatie: 3.1 x=450 mm $N_x=-0,085 \text{ kN}$ $V_y=0,176 \text{ kN}$ $V_z=0,338 \text{ kN}$
 $M_x=0,04 \text{ kNm}$ $M_y=0,272 \text{ kNm}$ $M_z=0,007 \text{ kNm}$

$$\alpha = \beta = \frac{1,66}{1 - 1,13 n^2} = \frac{1,66}{1 - 1,13 0,00^2} = 1,66$$

$$\left(\frac{M_{y,Ed}}{M_{N,y,Rd}} \right)^\alpha + \left(\frac{M_{z,Ed}}{M_{N,z,Rd}} \right)^\beta = \left(\frac{0,272}{2,299} \right)^{1,66} + \left(\frac{0,007}{2,299} \right)^{1,66} = 0,03 < 1,0 \quad (6.41)$$

Knikstabiliteit

art. 6.3.1.1

Combinatie: 3.1 x=0 mm $N_x=-0,085 \text{ kN}$ $V_y=0,176 \text{ kN}$ $V_z=0,359 \text{ kN}$
 $M_x=-0,04 \text{ kNm}$ $M_y=0,115 \text{ kNm}$ $M_z=0,072 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{900}{19,1} \frac{1}{93,9} = 0,501 \quad (6.50)$$

Knikkromme $y-y$ a $\alpha = 0,21$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 [1 + 0,21 \times (0,501 - 0,2) + 0,501^2] = 0,657$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,657 + \sqrt{0,657^2 - 0,501^2}} = 0,924 \quad (6.49)$$

$$N_{b,Rd} = \frac{\chi_y A f_y}{\gamma_{M1}} = \frac{0,92 \times 557,9 \times 235}{1,00} \times 10^{-3} = 121,1 \text{ kN} \quad (6.47)$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{0,1}{121,1} = 0,00 < 1,0 \quad (6.46)$$

Prismatische, op buiging en druk belaste staven (maatgevend)

art. 6.3.3

Combinatie: 3.1 x=450 mm $N_x=-0,085 \text{ kN}$ $V_y=0,176 \text{ kN}$ $V_z=0,338 \text{ kN}$
 $M_x=0,04 \text{ kNm}$ $M_y=0,272 \text{ kNm}$ $M_z=0,007 \text{ kNm}$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_y = \frac{L_{cr,y}}{i_y} \frac{1}{\lambda_1} = \frac{900}{19,1} \frac{1}{93,9} = 0,501 \quad (6.50)$$

$$\lambda_1 = \pi \sqrt{\frac{E}{f_y}} = \pi \sqrt{\frac{210000}{235}} = 93,9 \quad \lambda_z = \frac{L_{cr,z}}{i_z} \frac{1}{\lambda_1} = \frac{900}{19,1} \frac{1}{93,9} = 0,501 \quad (6.50)$$

Knikkromme $y-y$ a $\alpha = 0,21$

$$\Phi_y = 0,5 [1 + \alpha (\lambda_y - 0,2) + \lambda_y^2] = 0,5 [1 + 0,21 \times (0,501 - 0,2) + 0,501^2] = 0,657$$

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \lambda_y^2}} = \frac{1}{0,657 + \sqrt{0,657^2 - 0,501^2}} = 0,924 \quad (6.49)$$

Knikkromme $z-z$ a $\alpha = 0,21$

$$\Phi_z = 0,5 [1 + \alpha (\lambda_z - 0,2) + \lambda_z^2] = 0,5 \times [1 + 0,21 \times (0,501 - 0,2) + 0,501^2] = 0,657$$

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \lambda_z^2}} = \frac{1}{0,657 + \sqrt{0,657^2 - 0,501^2}} = 0,924 \quad (6.49)$$

$$N_{Rk} = f_y A = 235 \times 558 \times 10^{-3} = 131,1 \text{ kN}$$

$$M_{y,Rk} = f_y W_{pl,y} = 235 \times 9785 \times 10^{-6} = 2,3 \text{ kNm}$$

$$M_{z,Rk} = f_y W_{pl,z} = 235 \times 9785 \times 10^{-6} = 2,3 \text{ kNm}$$

Interactiefactoren volgens methode 2 (EN 1993-1-1, Bijlage B)

$$\varphi = M_2/M_1 = 0,068/-0,116 = -0,59 \quad \alpha_h = M_h/M_s = -0,116/-0,272 = 0,43$$

$$C_{my} = 0,95 + 0,05 \alpha_h = 0,95 + 0,05 \times 0,43 = 0,971$$

$$k_{yy} = C_{my} \left(1 + (\lambda_y - 0,2) \frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} \right) = 0,971 \times \left(1 + (0,501 - 0,2) \times \frac{0,085}{0,924 \times 131,102/1,00} \right) = 0,971$$

$$\varphi = M_2/M_1 = 0/0,072 = 0 \quad \alpha_s = M_s/M_h = -0,007/0,072 = -0,1$$

$$C_{mz} = 0,1 - 0,8 \alpha_s = 0,1 - 0,8 \times -0,1 = 0,4 < 0,4$$

$$k_{zz} = C_{mz} \left(1 + (\lambda_z - 0,2) \frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} \right) = 0,4 \times \left(1 + (0,501 - 0,2) \times \frac{0,085}{0,924 \times 131,102/1,00} \right) = 0,4$$

$$k_{yz} = 0,6k_{zz} = 0,6 \times 0,4 = 0,24 \quad k_{zy} = 0,6k_{yy} = 0,6 \times 0,971 = 0,583$$

$$\frac{N_{Ed}}{\chi_y N_{Rk} / \gamma_{M1}} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\gamma_{M1}} = \quad (6.61)$$

$$\frac{0,085}{0,924 \times 131,102 / 1,00} + 0,971 \times \frac{0,272}{1 \times \frac{2,299}{1,00}} + 0,24 \times \frac{0,072}{\frac{2,299}{1,00}} = 0,12 < 1 \quad (6.61)$$

$$\frac{N_{Ed}}{\chi_z N_{Rk} / \gamma_{M1}} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{Lt} \frac{M_{y,Rk}}{\gamma_{M1}}} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\gamma_{M1}} = \quad (6.62)$$

$$\frac{0,085}{0,924 \times 131,102 / 1,00} + 0,583 \times \frac{0,272}{1 \times \frac{2,299}{1,00}} + 0,4 \times \frac{0,072}{\frac{2,299}{1,00}} = 0,08 < 1 \quad (6.62)$$

Doorbuiging

Combinatie: 8 x=450 mm

Nx=-0,059 kN Vy=0,141 kN Vz=0,286 kN

Mx=0,03 kNm My=0,217 kNm Mz=0,007 kNm

Lokale knoopverplaatsingen d_{z1} = -187,3 mm d_{z2} = -189,8 mm

$$w_{\text{eind},z} = w_z - w_{\text{Zeeg},z} = -0,4 - 0 = -0,4 \text{ mm}$$

$$\frac{|w_{\text{eind},z}|}{w_{\text{eind},z,\text{max}}} = \frac{|-0,4|}{900 / 250} = \frac{|-0,4|}{3,6} = 0,10 < 1,0$$

$$w_{\text{bijk},z} = w_z - w_{\text{BGT Blijvend},z} = -0,4 + 0,1 = -0,2 \text{ mm}$$

$$\frac{|w_{\text{bijk},z}|}{w_{\text{bijk},z,\text{max}}} = \frac{|-0,2|}{900 / 333} = \frac{|-0,2|}{2,7} = 0,08 < 1,0$$

2.5.8 Staaf 71 - IPE100 (S 235)**Buigend moment**

art. 6.2.5

Combinatie: 3.1 x=1140,5 mm

Nx=0,014 kN Vy=0 kN Vz=0 kN

Mx=0 kNm My=0,297 kNm Mz=0 kNm

$$M_{y,c,Rd} = M_{pl,y,Rd} = \frac{W_{pl,y} f_y}{\gamma_{M0}} = \frac{39439 \times 235}{1,00} \times 10^{-6} = 9,268 \text{ kNm} \quad (6.13)$$

$$\frac{M_{y,Ed}}{M_{y,c,Rd}} = \frac{0,297}{9,268} = 0,03 < 1,0 \quad (6.12)$$

Dwarskracht (afschuiving)

art. 6.2.6

Combinatie: 4.2 x=0 mm

Nx=0,016 kN Vy=0 kN Vz=0,52 kN

Mx=0 kNm My=0 kNm Mz=0 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{509 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 69,1 \text{ kN} \quad (6.18)$$

$$\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{0,5}{69,1} = 0,01 < 1,0 \quad (6.17)$$

Buiging en dwarskracht

art. 6.2.8

Combinatie: 3.1 x=1140,5 mm

Nx=0,014 kN Vy=0 kN Vz=0 kN

Mx=0 kNm My=0,297 kNm Mz=0 kNm

$$V_{c,z,Rd} = V_{pl,z,Rd} = \frac{A_v (f_y / \sqrt{3})}{\gamma_{M0}} = \frac{509 \times (235 / \sqrt{3})}{1,00} \times 10^{-3} = 69,1 \text{ kN} \quad (6.18)$$

$$V_{z,Ed} = 0,000 \text{ kN} < V_{z,pl,Rd} / 2 = 69,083 / 2 = 34,541 \text{ kN}$$

Het effect van de dwarskracht op de momentweerstand hoeft niet in rekening te worden gebracht.

(2)

Kipstabiliteit (maatgevend)

art. 6.3.2.1

Combinatie: 3.1 $x=1140,5 \text{ mm}$ $N_x=0,014 \text{ kN}$ $V_y=0 \text{ kN}$ $V_z=0 \text{ kN}$
 $M_x=0 \text{ kNm}$ $M_y=0,297 \text{ kNm}$ $M_z=0 \text{ kNm}$

Aantal kipsteunen: 0
 $d' = h - t = 100 - 5,7 = 94,3 \text{ mm}$ $I_w = \frac{(d')^2 b^3 t}{24} = \frac{94,3^2 \times 55^3 \times 5,7}{24} = 0 \times 10^9 \text{ mm}^6$

torsiestijfheid volgens Roark geval 26 $I_t = 12088 \text{ mm}^4$

volgens NEN-EN 1993-1-1+C2+A1/NB:2016 nl figuren NB.33 en NB.34:

$L_g = 2281 \text{ mm}$ $L_{st} = 2281 \text{ mm}$

$M_{y,1,Ed} = 0 \text{ kNm}$ $M_{y,2,Ed} = 0 \text{ kNm}$ $M_{yEd} (x=L_{st}/2 = 1141 \text{ mm}) = -0,297 \text{ kNm}$

Berekende equivalente belasting $q = -0,455 \text{ kN/m}$

$$B^* = \frac{8 M}{8 |M| + q L_{st}^2} = \frac{8 \times 0 \times 10^6}{8 \times |0 \times 10^6| + -0,455 \times 2281^2} = 0 \quad \text{D.4.3 (3)}$$

$$\beta = \frac{M_{y,1,Ed}}{M_{y,2,Ed}} = \frac{0}{0} = 1 \quad C_1 = 1,13 \quad C_2 = 0,461$$

aangrijpingspunt belasting op $z = -50 \text{ mm}$

$L_{kip} = L_{st} = 2281 \text{ mm}$

$$S = \frac{h}{2} \times \sqrt{\frac{E \times I_z}{G \times I_t}} = \frac{100}{2} \times \sqrt{\frac{210000 \times 159207}{80769 \times 12088}} = 293 \text{ mm} \quad \text{(NB.159)}$$

$$C = \frac{\pi \times C_1 \times L_g}{L_{kip}} \times \left(\sqrt{1 + \left(\frac{\pi^2 \times S^2}{L_{kip}^2} \times (C_2^2 + 1) \right)} + \frac{\pi \times C_2 \times S}{L_{kip}} \right) = \quad \text{(NB.157)}$$

$$= \frac{\pi \times 1,13 \times 2281}{2281} \times \left(\sqrt{1 + \left(\frac{\pi^2 \times 293^2}{2281^2} \times (0,461^2 + 1) \right)} + \frac{\pi \times 0,461 \times 293}{2281} \right) = 4,542$$

$$h/t_w = 100 / 4,1 = 24,4 < 75 \quad \rightarrow k_{red} = 1 \quad \text{(NB.153)}$$

$$M_{cr} = k_{red} \times \frac{C}{L_g} \times \sqrt{E \times I_z \times G \times I_t} = \quad \text{(NB.148)}$$

$$= 1 \times \frac{4,542}{2281} \times \sqrt{210000 \times 159207 \times 80769 \times 12088} \times 10^{-6} = 11,377 \text{ kNm}$$

$$\lambda_{Lt} = \sqrt{\frac{W_y f_y}{M_{cr}}} = \sqrt{\frac{39439 \times 235}{11377333}} = 0,903 > \lambda_{Lt,0} = 0,4$$

Kipkromme b $\alpha_{Lt} = 0,34$

$$\Phi_{Lt} = 0,5 [1 + \alpha_{Lt} (\lambda_{Lt} - \lambda_{Lt,0}) + \beta \lambda_{Lt}^2] = 0,5 \times [1 + 0,34 \times (0,903 - 0,4) + 0,75 \times 0,903^2] = 0,891$$

$$\chi_{Lt} = \min \left(\frac{1}{\Phi_{Lt} + \sqrt{\Phi_{Lt}^2 - \beta \lambda_{Lt}^2}}; 1,0; \frac{1}{\lambda_{Lt}^2} \right) \quad \text{(6.57)}$$

$$= \min \left(\frac{1}{0,891 + \sqrt{0,891^2 - 0,75 \times 0,903^2}}; 1,0; \frac{1}{0,903^2} \right) = 0,758$$

$$k_c = 0,94$$

$$f = 1 - 0,5 (1 - k_c) [1 - 2,0 (\lambda_{Lt} - 0,8)^2] = 1 - 0,5 \times (1 - 0,94) \times [1 - 2,0 \times (0,903 - 0,8)^2] = 0,971$$

$$\chi_{Lt,mod} = \frac{\chi_{Lt}}{f} = \frac{0,758}{0,971} = 0,781 \quad (6.58)$$

$$M_{b,Rd} = \chi_{Lt} W_y \frac{f_y}{\gamma_{M1}} = 0,781 \times 39439 \times \frac{235}{1,00} \times 10^{-6} = 7,2 \text{ kNm} \quad (6.55)$$

$$\frac{M_{Ed}}{M_{b,Rd}} = \frac{0,3}{7,2} = 0,04 < 1,0 \quad (6.54)$$

Doorbuiging

Combinatie: 8 x=1140 mm

Nx=0,021 kN Vy=0 kN Vz=0 kN

Mx=0 kNm My=0,239 kNm Mz=0 kNm

Lokale knoopverplaatsingen d_{z1} = -753 mm d_{z2} = -565,4 mm

$$w_{eind,z} = w_z - w_{Zeeg,z} = -0,4 - 0 = -0,4 \text{ mm}$$

$$\frac{|w_{eind,z}|}{w_{eind,z,max}} = \frac{|-0,4|}{2281 / 250} = \frac{|-0,4|}{9,1} = 0,04 < 1,0$$

$$w_{bijk,z} = w_z - w_{BGT Blijvend,z} = -0,4 + 0,1 = -0,2 \text{ mm}$$

$$\frac{|w_{bijk,z}|}{w_{bijk,z,max}} = \frac{|-0,2|}{2281 / 333} = \frac{|-0,2|}{6,8} = 0,03 < 1,0$$

Bestand : 1264-5.3 Landhoofd.xfem

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1. Invoergegevens

Gevolgklasse : CC1

Zwaartekrachtversnelling g : 9,81 m/s²**1.1 KNOPEN**

Knoop- nummer	Coördinaten			Opleggingen					
	X [mm]	Y [mm]	Z [mm]	Tx	Ty	Tz	Rx	Ry	Rz
1	-1100	0	-300						
21	2600	0	-300						
45	0	0	0						
49	0	900	0						
51	0	1500	0						
84	750	1200	0						
113	1500	0	0						
117	1500	900	0						
119	1500	1500	0						
314	-1100	0	1000						
320	0	0	1000						
324	0	900	1000						
326	0	1500	1000						
328	200	900	1000						
334	1300	900	1000						
336	1500	0	1000						
340	1500	900	1000						
342	1500	1500	1000						
348	2600	0	1000						

1.2 PLATEN**Plaat 1**

Plaatdikte	200 mm	Materiaal Beton C20/25
Elasticiteitsmodulus	8322,76418184453 N/mm ²	Poison ratio 0,20
Beddingconstante	4000 kN/m ³	
Elementtype	Plaat	Constructieklasse S4
Betonsterkteklasse	C20/25	Kruipcoëfficiënt 2,70
Betonstaalsoort	B 500 B	Korrel diameter 31,50 mm
Hoek betondrukdiagonaal	22	

Bovenzijde

Milieuklassen	XC1
Betonoppervlak	Controleerbaar

 ΔC_{dev} 5 mm

Dekking 25 mm

Nominale dekking c_{nom} 15 mm

Wapening in X-ri. 8-150

Wapening in Y-ri. 8-150

1e laag Wapening in X-ri.

Onderzijde

XC1
Controleerbaar

25 mm

15 mm

8-150

8-150

Wapening in X-ri.

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Plaat 2

Plaatdikte	200 mm	Materiaal Beton C20/25
Elasticiteitsmodulus	8322,76418184453 N/mm ²	Poison ratio 0,20

Elementtype	Plaat	Constructieklasse S4
Betonsterkteklasse	C20/25	Kruipcoëfficiënt 2,70
Betonstaalsoort	B 500 B	Korrel diameter 31,50 mm
Hoek betondrukdiagonaal	22	
	<u>Bovenzijde</u>	<u>Onderzijde</u>
Milieuklassen	XC1	XC1
Betonoppervlak	Controleerbaar	Controleerbaar
ΔC_{dev}	5 mm	
Dekking	25 mm	25 mm
Nominale dekking c_{nom}	15 mm	15 mm
Wapening in X-ri.	8-150	8-150
Wapening in Y-ri.	8-150	8-150
1e laag	Wapening in X-ri.	Wapening in X-ri.

EN 1992-1-1 (4.1)

Plaat 3

Plaatdikte	200 mm	Materiaal Beton C20/25
Elasticiteitsmodulus	8322,76418184453 N/mm ²	Poisson ratio 0,20
Elementtype	Plaat	Constructieklasse S4
Betonsterkteklasse	C20/25	Kruipcoëfficiënt 2,70
Betonstaalsoort	B 500 B	Korrel diameter 31,50 mm
Hoek betondrukdiagonaal	22	
	<u>Bovenzijde</u>	<u>Onderzijde</u>
Milieuklassen	XC1	XC1
Betonoppervlak	Controleerbaar	Controleerbaar
ΔC_{dev}	5 mm	
Dekking	25 mm	25 mm
Nominale dekking c_{nom}	15 mm	15 mm
Wapening in X-ri.	8-150	8-150
Wapening in Y-ri.	8-150	8-150
1e laag	Wapening in X-ri.	Wapening in X-ri.

EN 1992-1-1 (4.1)

Plaat 4

Plaatdikte	200 mm	Materiaal Beton C20/25
Elasticiteitsmodulus	8322,76418184453 N/mm ²	Poisson ratio 0,20
Elementtype	Plaat	Constructieklasse S4
Betonsterkteklasse	C20/25	Kruipcoëfficiënt 2,70
Betonstaalsoort	B 500 B	Korrel diameter 31,50 mm
Hoek betondrukdiagonaal	22	
	<u>Bovenzijde</u>	<u>Onderzijde</u>
Milieuklassen	XC1	XC1
Betonoppervlak	Controleerbaar	Controleerbaar
ΔC_{dev}	5 mm	
Dekking	25 mm	25 mm
Nominale dekking c_{nom}	15 mm	15 mm
Wapening in X-ri.	8-150	8-150
Wapening in Y-ri.	8-150	8-150
1e laag	Wapening in X-ri.	Wapening in X-ri.

EN 1992-1-1 (4.1)

Plaat 5

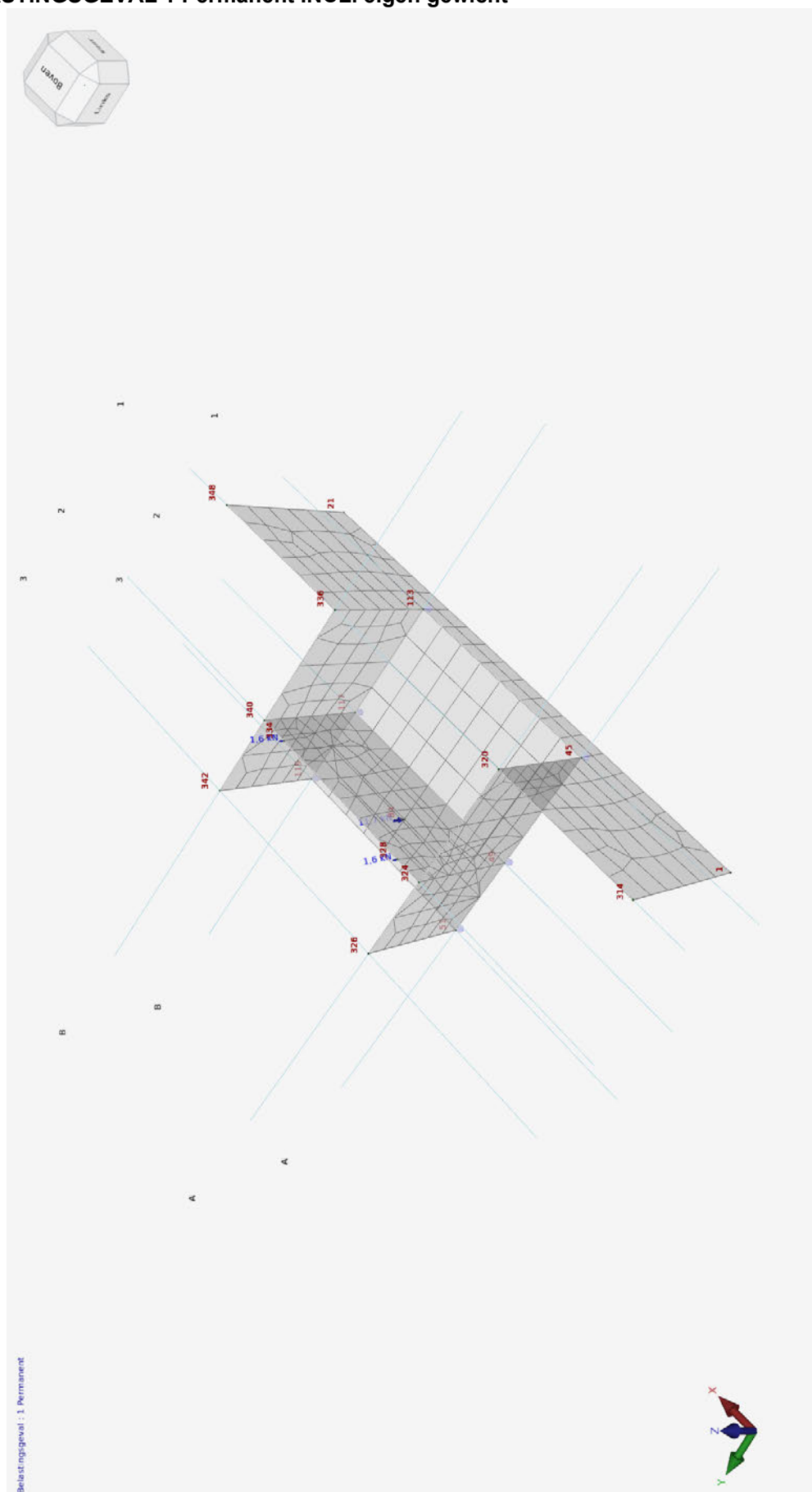
Plaatdikte	150 mm	Materiaal Beton C20/25
Elasticiteitsmodulus	8322,76418184453 N/mm ²	Poisson ratio 0,20
Elementtype	Plaat	Constructieklasse S4
Betonsterkteklasse	C20/25	Kruipcoëfficiënt 2,70
Betonstaalsoort	B 500 B	Korrel diameter 31,50 mm
Hoek betondrukdiagonaal	22	

	<u>Bovenzijde</u>	<u>Onderzijde</u>	
Milieuklassen	XC1	XC1	
Betonoppervlak	Controleerbaar	Controleerbaar	
ΔC_{dev}	5 mm		
Dekking	25 mm	25 mm	
Nominale dekking c_{nom}	15 mm	15 mm	EN 1992-1-1 (4.1)
Wapening in X-ri.	8-150	8-150	
Wapening in Y-ri.	8-150	8-150	
1e laag	Wapening in X-ri.	Wapening in X-ri.	

1.3 BELASTINGSGEVALLEN

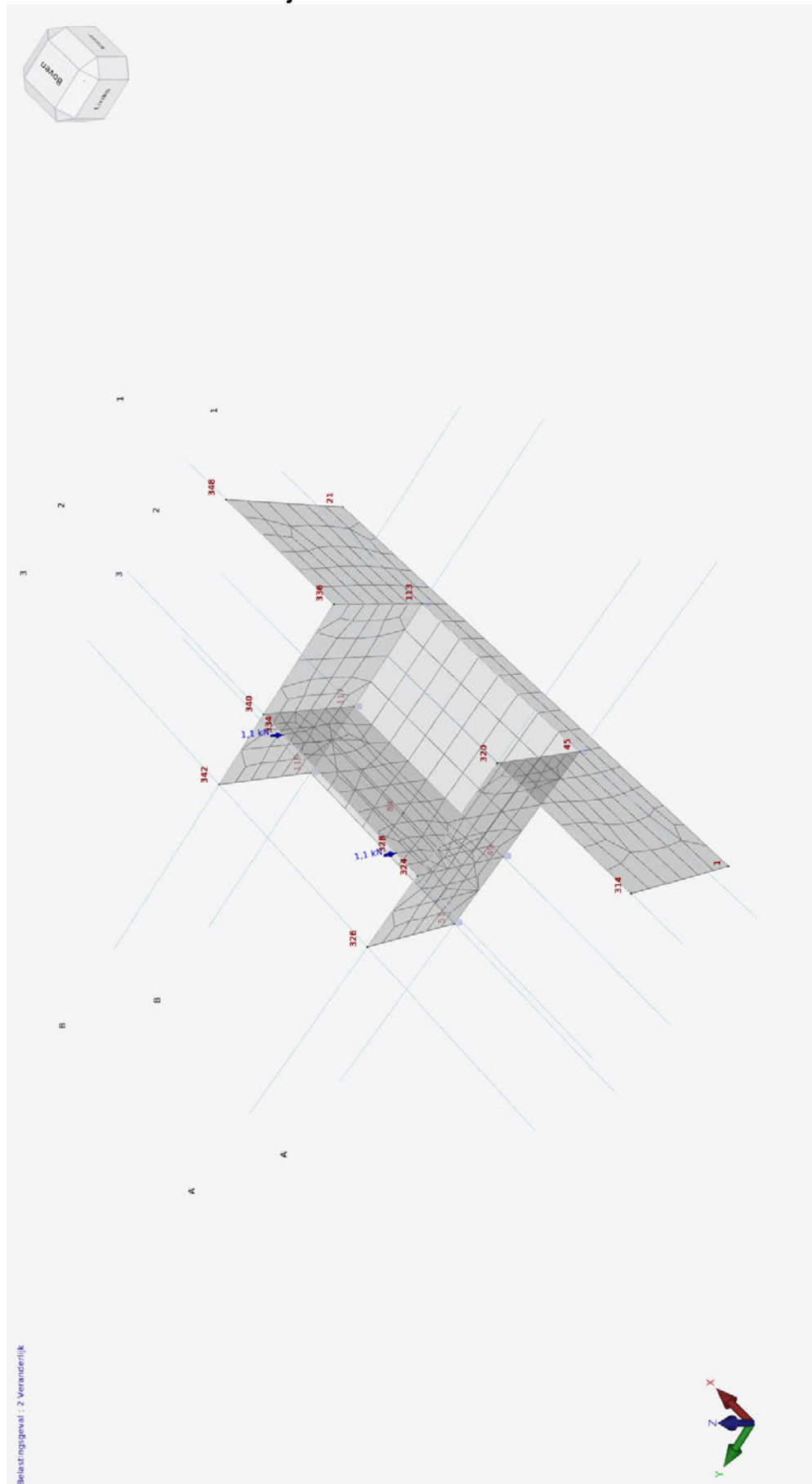
Nr.	Omschrijving	Type	ψ_0	ψ_1	ψ_2
1	Permanent	Permanent incl. eigen gewicht	1,00	1,00	1,00
2	Veranderlijk	A:Woonfunctie en logiesfunctie	0,40	0,50	0,30

Totaal eigen gewicht: : 4432 kg.

1.4 BELASTINGSGEVAL 1 Permanent INCL. eigen gewicht

1.4.1 Knoopbelastingen

Knoop- nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
84			-11,700			
328			-1,600			
334			-1,600			

1.5 BELASTINGSGEVAL 2 Veranderlijk

1.5.1 Knoopbelastingen

Knoop- nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
328			-1,100			
334			-1,100			

2.Berekeningsresultaten**2.1 KNOPEN - Imperfectie scheefstand**

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
1	-1100	-300	-1100	-300
21	2600	-300	2600	-300
45	2	0	-2	0
49	2	0	-2	0
51	2	0	-2	0
84	752	0	749	0
113	1502	0	1499	0
117	1502	0	1499	0
119	1502	0	1499	0
314	-1094	1000	-1107	1000
320	7	1000	-7	1000
324	7	1000	-7	1000
326	7	1000	-7	1000
328	207	1000	194	1000
334	1307	1000	1294	1000
336	1507	1000	1494	1000
340	1507	1000	1494	1000
342	1507	1000	1494	1000
348	2607	1000	2594	1000
349	2	0	-2	0
350	2	0	-2	0
351	2	0	-2	0
352	189	0	186	0
353	377	0	374	0
354	564	0	561	0
355	752	0	749	0
356	939	0	936	0
357	1127	0	1124	0
358	1314	0	1311	0
359	1502	0	1499	0
360	1502	0	1499	0
361	1502	0	1499	0
362	1314	0	1311	0
363	1127	0	1124	0
364	939	0	936	0
365	752	0	749	0
366	564	0	561	0
367	377	0	374	0
368	189	0	186	0
369	752	0	749	0
370	752	0	749	0
371	752	0	749	0
372	938	0	935	0
373	1125	0	1122	0
374	1313	0	1310	0
375	1126	0	1123	0
376	1313	0	1310	0
377	938	0	935	0
378	1126	0	1123	0
379	1313	0	1310	0

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
380	938	0	935	0
381	565	0	562	0
382	378	0	375	0
383	190	0	187	0
384	377	0	374	0
385	565	0	562	0
386	190	0	187	0
387	377	0	374	0
388	565	0	562	0
389	190	0	187	0
390	2	0	-2	0
391	189	0	186	0
392	377	0	374	0
393	564	0	561	0
394	752	0	749	0
395	939	0	936	0
396	1127	0	1124	0
397	1314	0	1311	0
398	1502	0	1499	0
399	752	0	749	0
400	544	0	541	0
401	324	0	321	0
402	553	0	550	0
403	360	0	357	0
404	187	0	184	0
405	959	0	956	0
406	1179	0	1176	0
407	752	0	749	0
408	950	0	947	0
409	1144	0	1141	0
410	1316	0	1313	0
411	553	0	550	0
412	360	0	357	0
413	187	0	184	0
414	950	0	947	0
415	1144	0	1141	0
416	1316	0	1313	0
417	2	167	-2	167
418	3	333	-3	333
419	4	500	-4	500
420	5	667	-5	667
421	6	833	-6	833
422	7	1000	-7	1000
423	7	1000	-7	1000
424	7	1000	-7	1000
425	6	833	-6	833
426	5	667	-5	667
427	4	500	-4	500
428	3	333	-3	333
429	2	167	-2	167
430	4	500	-4	500
431	4	500	-4	500
432	4	500	-4	500
433	4	500	-4	500

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
434	4	500	-4	500
435	5	740	-5	740
436	5	729	-5	729
437	5	683	-5	683
438	6	837	-6	837
439	5	683	-5	683
440	5	729	-5	729
441	6	837	-6	837
442	3	260	-3	260
443	3	317	-3	317
444	3	271	-3	271
445	2	163	-2	163
446	3	271	-3	271
447	3	317	-3	317
448	2	163	-2	163
449	2	167	-2	167
450	3	333	-3	333
451	4	500	-4	500
452	5	667	-5	667
453	6	833	-6	833
454	7	1000	-7	1000
455	4	500	-4	500
456	4	500	-4	500
457	4	500	-4	500
458	5	701	-5	701
459	5	674	-5	674
460	6	829	-6	829
461	5	674	-5	674
462	6	829	-6	829
463	3	299	-3	299
464	3	326	-3	326
465	2	171	-2	171
466	3	326	-3	326
467	2	171	-2	171
468	1502	167	1498	167
469	1503	333	1497	333
470	1504	500	1496	500
471	1505	667	1495	667
472	1506	833	1494	833
473	1507	1000	1494	1000
474	1507	1000	1494	1000
475	1507	1000	1494	1000
476	1506	833	1494	833
477	1505	667	1495	667
478	1504	500	1496	500
479	1503	333	1497	333
480	1502	167	1498	167
481	1504	500	1496	500
482	1504	500	1496	500
483	1504	500	1496	500
484	1504	500	1496	500
485	1504	500	1496	500
486	1505	740	1495	740
487	1505	683	1495	683

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
488	1505	729	1495	729
489	1506	837	1494	837
490	1505	683	1495	683
491	1505	729	1495	729
492	1506	837	1494	837
493	1503	260	1497	260
494	1503	271	1497	271
495	1503	317	1497	317
496	1502	163	1498	163
497	1503	317	1497	317
498	1503	271	1497	271
499	1502	163	1498	163
500	1502	167	1498	167
501	1503	333	1497	333
502	1504	500	1496	500
503	1505	667	1495	667
504	1506	833	1494	833
505	1507	1000	1494	1000
506	1504	500	1496	500
507	1504	500	1496	500
508	1504	500	1496	500
509	1505	701	1495	701
510	1505	674	1495	674
511	1506	829	1494	829
512	1505	674	1495	674
513	1506	829	1494	829
514	1503	299	1497	299
515	1503	326	1497	326
516	1502	171	1498	171
517	1503	326	1497	326
518	1502	171	1498	171
519	107	1000	94	1000
520	390	1000	377	1000
521	573	1000	560	1000
522	757	1000	744	1000
523	940	1000	927	1000
524	1123	1000	1110	1000
525	1407	1000	1394	1000
526	753	206	747	206
527	754	406	746	406
528	755	603	745	603
529	755	799	745	799
530	1083	788	1072	788
531	1081	606	1072	606
532	1094	425	1087	425
533	1146	231	1141	231
534	930	410	922	410
535	927	798	916	798
536	924	603	915	603
537	942	210	937	210
538	1315	877	1303	877
539	1317	751	1307	751
540	1349	626	1339	626
541	1359	478	1351	478

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
542	1360	329	1353	329
543	1330	180	1325	180
544	1217	611	1208	611
545	1225	463	1217	463
546	1246	340	1240	340
547	1203	755	1192	755
548	1221	874	1210	874
549	1413	869	1401	869
550	1405	765	1394	765
551	359	231	354	231
552	413	425	406	425
553	428	606	419	606
554	428	788	417	788
555	578	410	570	410
556	585	603	576	603
557	584	798	573	798
558	563	210	558	210
559	175	180	170	180
560	147	329	140	329
561	149	478	141	478
562	161	626	151	626
563	193	751	183	751
564	197	877	185	877
565	292	611	283	611
566	283	463	275	463
567	260	340	254	340
568	308	755	297	755
569	290	874	279	874
570	99	869	87	869
571	106	765	95	765
572	-1099	-83	-1101	-83
573	-1098	133	-1102	133
574	-1097	350	-1103	350
575	-1096	567	-1104	567
576	-1095	783	-1105	783
577	-902	1000	-915	1000
578	-714	1000	-727	1000
579	-530	1000	-543	1000
580	-348	1000	-361	1000
581	-169	1000	-182	1000
582	1682	1000	1669	1000
583	1861	1000	1848	1000
584	2043	1000	2030	1000
585	2227	1000	2214	1000
586	2415	1000	2402	1000
587	2605	783	2595	783
588	2604	567	2596	567
589	2603	350	2597	350
590	2602	133	2598	133
591	2601	-83	2599	-83
592	2415	-300	2415	-300
593	2230	-300	2230	-300
594	2045	-300	2045	-300
595	1860	-300	1860	-300

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
596	1675	-300	1675	-300
597	1490	-300	1490	-300
598	1305	-300	1305	-300
599	1120	-300	1120	-300
600	935	-300	935	-300
601	750	-300	750	-300
602	565	-300	565	-300
603	380	-300	380	-300
604	195	-300	195	-300
605	10	-300	10	-300
606	-175	-300	-175	-300
607	-360	-300	-360	-300
608	-545	-300	-545	-300
609	-730	-300	-730	-300
610	-915	-300	-915	-300
611	751	-150	749	-150
612	5	-149	3	-149
613	-848	356	-854	356
614	-617	348	-623	348
615	-402	342	-408	342
616	-197	338	-203	338
617	-373	-151	-375	-151
618	-392	3	-395	3
619	-402	170	-407	170
620	-184	-147	-185	-147
621	-193	8	-196	8
622	-197	171	-202	171
623	-618	160	-622	160
624	-850	141	-854	141
625	-600	-17	-602	-17
626	-833	-84	-835	-84
627	-557	-159	-558	-159
628	-708	-187	-709	-187
629	-391	513	-399	513
630	-373	674	-382	674
631	-359	836	-370	836
632	-184	670	-194	670
633	-192	505	-200	505
634	-177	834	-188	834
635	-596	530	-605	530
636	-823	589	-832	589
637	-539	838	-550	838
638	-711	836	-722	836
639	-884	801	-895	801
640	-551	681	-561	681
641	-695	705	-705	705
642	378	-150	377	-150
643	564	-150	563	-150
644	192	-150	190	-150
645	1497	-149	1495	-149
646	1123	-150	1122	-150
647	1310	-150	1308	-150
648	937	-150	936	-150
649	1703	338	1697	338

Knoop- nummer	1/200 in +X		1/200 in -X	
	X [mm]	Z [mm]	X [mm]	Z [mm]
650	1908	342	1902	342
651	2123	348	2117	348
652	2354	356	2348	356
653	1907	170	1902	170
654	1895	3	1892	3
655	1875	-151	1873	-151
656	1702	171	1697	171
657	1696	8	1693	8
658	1685	-147	1684	-147
659	2122	160	2118	160
660	2354	141	2350	141
661	2335	-84	2333	-84
662	2102	-17	2100	-17
663	2058	-159	2057	-159
664	2209	-187	2208	-187
665	1899	513	1891	513
666	1882	674	1873	674
667	1870	836	1859	836
668	2105	530	2096	530
669	2332	589	2323	589
670	2050	838	2039	838
671	2222	836	2211	836
672	2395	801	2384	801
673	2061	681	2051	681
674	2205	705	2195	705
675	1694	670	1684	670
676	1700	505	1692	505
677	1688	834	1677	834

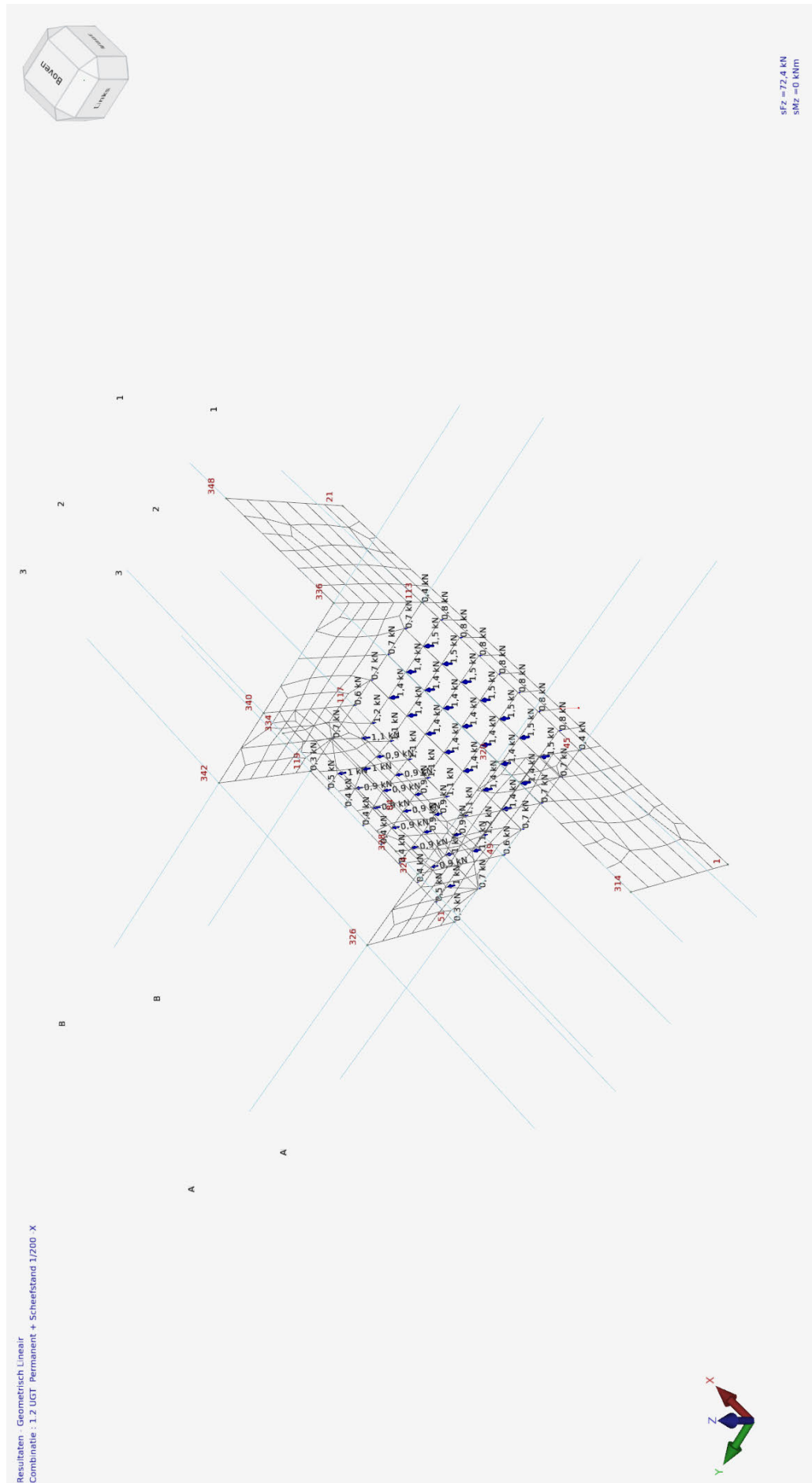
2.2 UITERSTE GRENSTOESTANDEN (UGT)

2.2.1 Belastingscombinaties

(GL) Geometrisch lineaire krachtsverdeling

Combinatie nummer	Omschrijving	Type
1.1	Permanent + Scheefstand 1/200 +X	UGT
2.2	Permanent + Scheefstand 1/200 -X	UGT
3.1	Veranderlijk + Scheefstand 1/200 +X	UGT
4.2	Veranderlijk + Scheefstand 1/200 -X	UGT

Combinatie nummer	Belasting ($\psi \times \gamma$)				
	1	2			
1.1	1,00 x 1,22	0,40 x 1,35			
2.2	1,00 x 1,22	0,40 x 1,35			
3.1	1,00 x 1,08	1,00 x 1,35			
4.2	1,00 x 1,08	1,00 x 1,35			



2.2.2 Omhullende reactiekrachten

Knoop- nummer	Comb. nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
45	1.1	0,000	0,000	0,382			
	3.1	0,000	0,000	0,342			
49	1.1		0,000	0,641			
	3.1		0,000	0,587			
51	1.1		0,000	0,278			
	3.1		0,000	0,259			
84	1.1		0,000	0,911			
	3.1		0,000	0,842			
113	1.1	0,000	0,000	0,382			
	3.1	0,000	0,000	0,342			
117	1.1		0,000	0,641			
	3.1		0,000	0,587			
119	1.1		0,000	0,278			
	3.1		0,000	0,259			
349	1.1		0,000	0,740			
	3.1		0,000	0,666			
350	1.1		0,000	0,716			
	3.1		0,000	0,648			
351	1.1		0,000	0,690			
	3.1		0,000	0,628			
352	1.1		0,000	1,182			
	3.1		0,000	1,082			
353	1.1		0,000	1,103			
	3.1		0,000	1,010			
354	1.1		0,000	1,119			
	3.1		0,000	1,024			
355	1.1		0,000	1,116			
	3.1		0,000	1,022			
356	1.1		0,000	1,119			
	3.1		0,000	1,024			
357	1.1		0,000	1,103			
	3.1		0,000	1,010			
358	1.1		0,000	1,182			
	3.1		0,000	1,082			
359	1.1		0,000	0,690			
	3.1		0,000	0,628			
360	1.1		0,000	0,716			
	3.1		0,000	0,648			
361	1.1		0,000	0,740			
	3.1		0,000	0,666			
362	1.1		0,000	0,761			
	3.1		0,000	0,681			
363	1.1		0,000	0,758			
	3.1		0,000	0,679			
364	1.1		0,000	0,756			
	3.1		0,000	0,677			
365	1.1		0,000	0,755			
	3.1		0,000	0,676			
366	1.1		0,000	0,756			

Knoop- nummer	Comb. nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
366	3.1		0,000	0,677			
367	1.1		0,000	0,758			
	3.1		0,000	0,679			
368	1.1		0,000	0,761			
	3.1		0,000	0,681			
369	1.1		0,000	1,461			
	3.1		0,000	1,314			
370	1.1		0,000	1,413			
	3.1		0,000	1,278			
371	1.1		0,000	1,368			
	3.1		0,000	1,245			
372	1.1		0,000	1,414			
	3.1		0,000	1,280			
373	1.1		0,000	1,420			
	3.1		0,000	1,285			
374	1.1		0,000	1,427			
	3.1		0,000	1,291			
375	1.1		0,000	1,468			
	3.1		0,000	1,321			
376	1.1		0,000	1,474			
	3.1		0,000	1,327			
377	1.1		0,000	1,463			
	3.1		0,000	1,316			
378	1.1		0,000	1,373			
	3.1		0,000	1,250			
379	1.1		0,000	1,378			
	3.1		0,000	1,254			
380	1.1		0,000	1,370			
	3.1		0,000	1,246			
381	1.1		0,000	1,414			
	3.1		0,000	1,280			
382	1.1		0,000	1,420			
	3.1		0,000	1,285			
383	1.1		0,000	1,427			
	3.1		0,000	1,291			
384	1.1		0,000	1,373			
	3.1		0,000	1,250			
385	1.1		0,000	1,370			
	3.1		0,000	1,246			
386	1.1		0,000	1,378			
	3.1		0,000	1,254			
387	1.1		0,000	1,468			
	3.1		0,000	1,321			
388	1.1		0,000	1,463			
	3.1		0,000	1,316			
389	1.1		0,000	1,474			
	3.1		0,000	1,327			
390	1.1		0,000	0,741			
	3.1		0,000	0,684			
391	1.1		0,000	0,467			
	3.1		0,000	0,436			
392	1.1		0,000	0,397			

Knoop- nummer	Comb. nummer	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
392	3.1		0,000	0,370			
393	1.1		0,000	0,412			
	3.1		0,000	0,384			
394	1.1		0,000	0,411			
	3.1		0,000	0,383			
395	1.1		0,000	0,412			
	3.1		0,000	0,384			
396	1.1		0,000	0,397			
	3.1		0,000	0,370			
397	1.1		0,000	0,467			
	3.1		0,000	0,436			
398	1.1		0,000	0,741			
	3.1		0,000	0,684			
399	1.1		0,000	0,866			
	3.1		0,000	0,803			
400	1.1		0,000	0,906			
	3.1		0,000	0,837			
401	1.1		0,000	1,004			
	3.1		0,000	0,927			
402	1.1		0,000	0,865			
	3.1		0,000	0,803			
403	1.1		0,000	0,888			
	3.1		0,000	0,824			
404	1.1		0,000	1,049			
	3.1		0,000	0,974			
405	1.1		0,000	0,906			
	3.1		0,000	0,837			
406	1.1		0,000	1,004			
	3.1		0,000	0,927			
407	1.1		0,000	0,911			
	3.1		0,000	0,838			
408	1.1		0,000	0,911			
	3.1		0,000	0,837			
409	1.1		0,000	0,934			
	3.1		0,000	0,859			
410	1.1		0,000	1,109			
	3.1		0,000	1,019			
411	1.1		0,000	0,911			
	3.1		0,000	0,837			
412	1.1		0,000	0,934			
	3.1		0,000	0,859			
413	1.1		0,000	1,109			
	3.1		0,000	1,019			
414	1.1		0,000	0,865			
	3.1		0,000	0,803			
415	1.1		0,000	0,888			
	3.1		0,000	0,824			
416	1.1		0,000	1,049			
	3.1		0,000	0,974			
Minimale / maximale waarden							
119	3.1			0,259			
389	1.1			1,474			

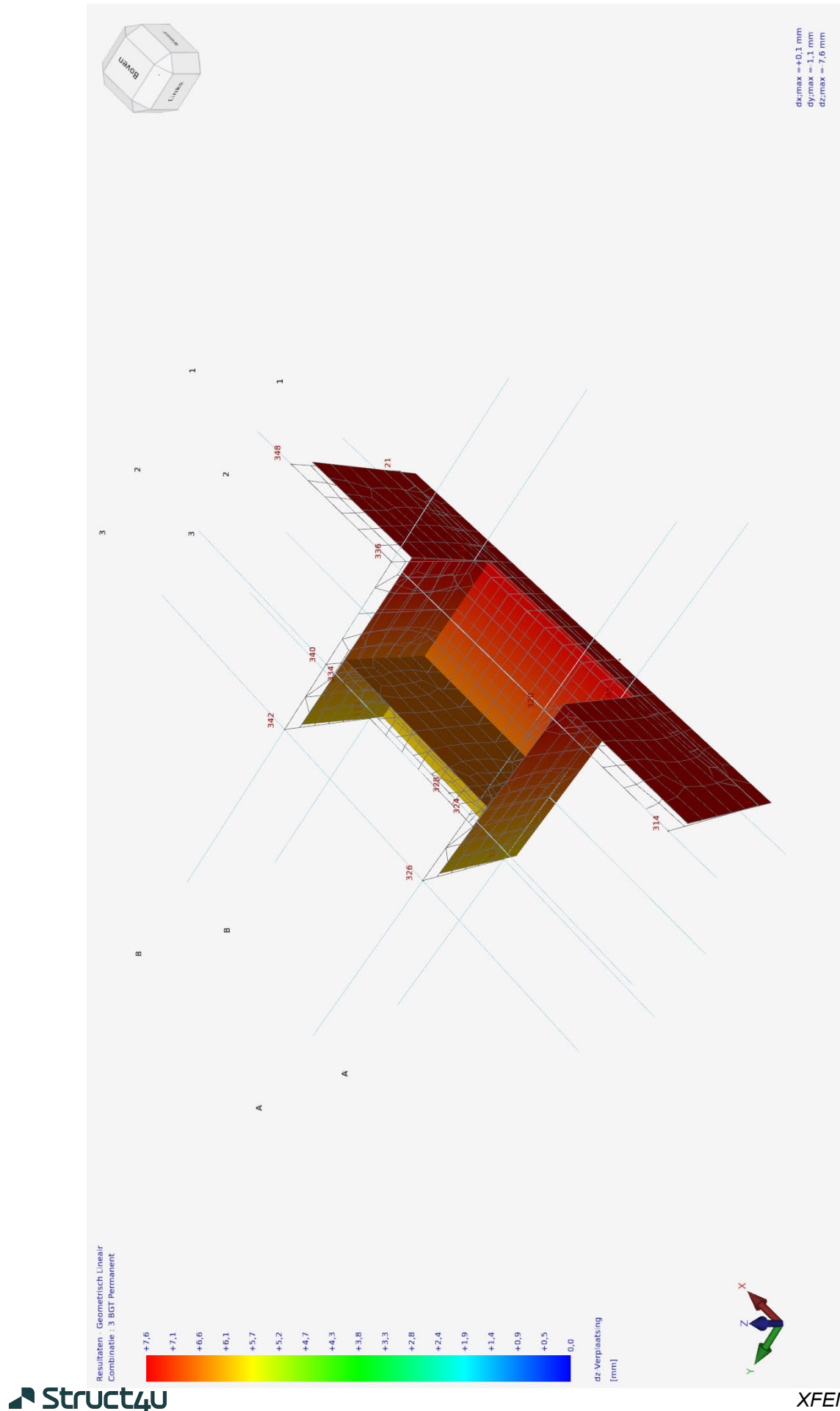
2.2.3 Omhullende staafkrachten

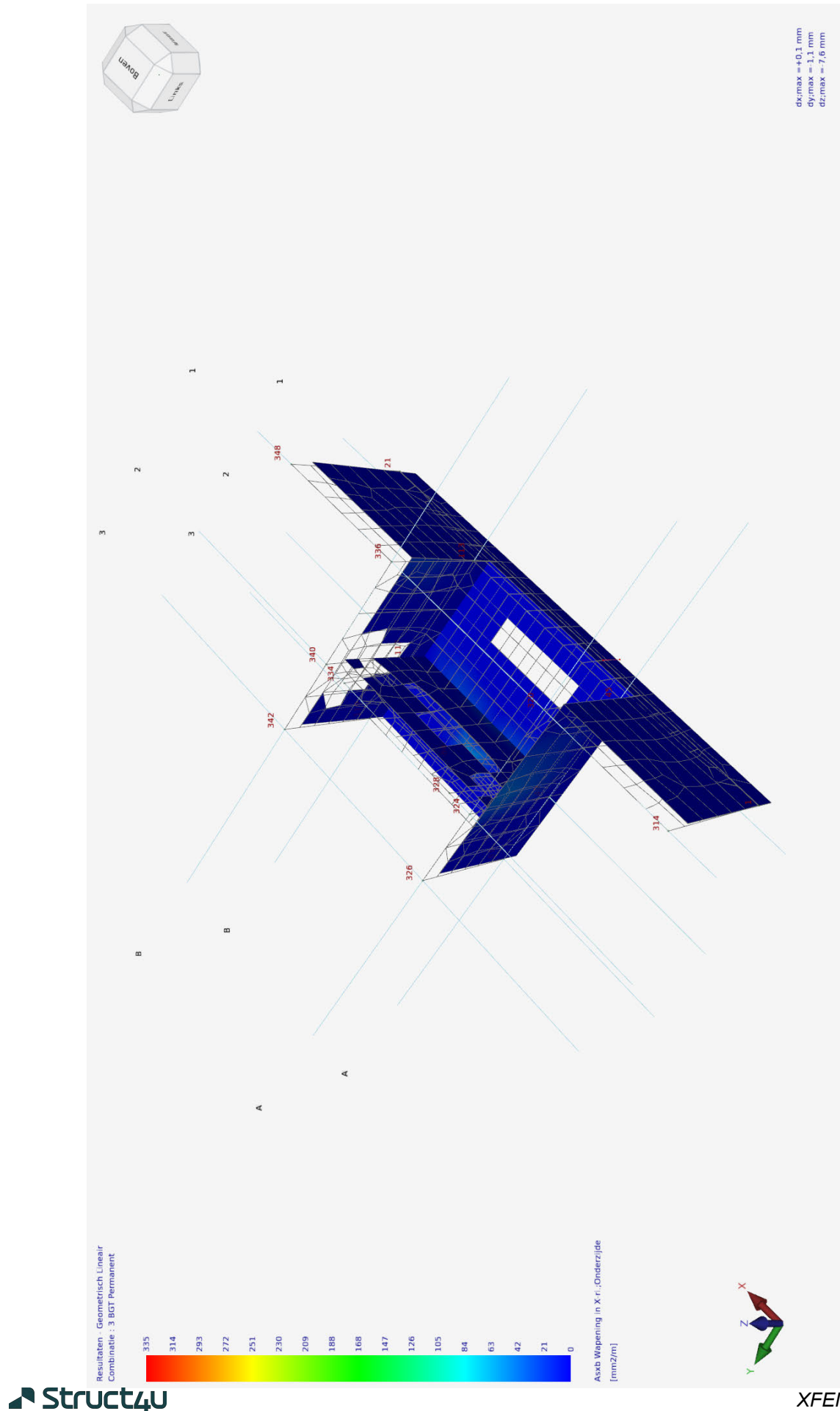
Staaf- nummer	Comb. nummer	Knoop- nummer	x-lokaal [mm]	Nx-lokaal [kN]	Vy-lokaal [kN]	Vz-lokaal [kN]	Mx-lokaal [kNm]	My-lokaal [kNm]	Mz-lokaal [kNm]
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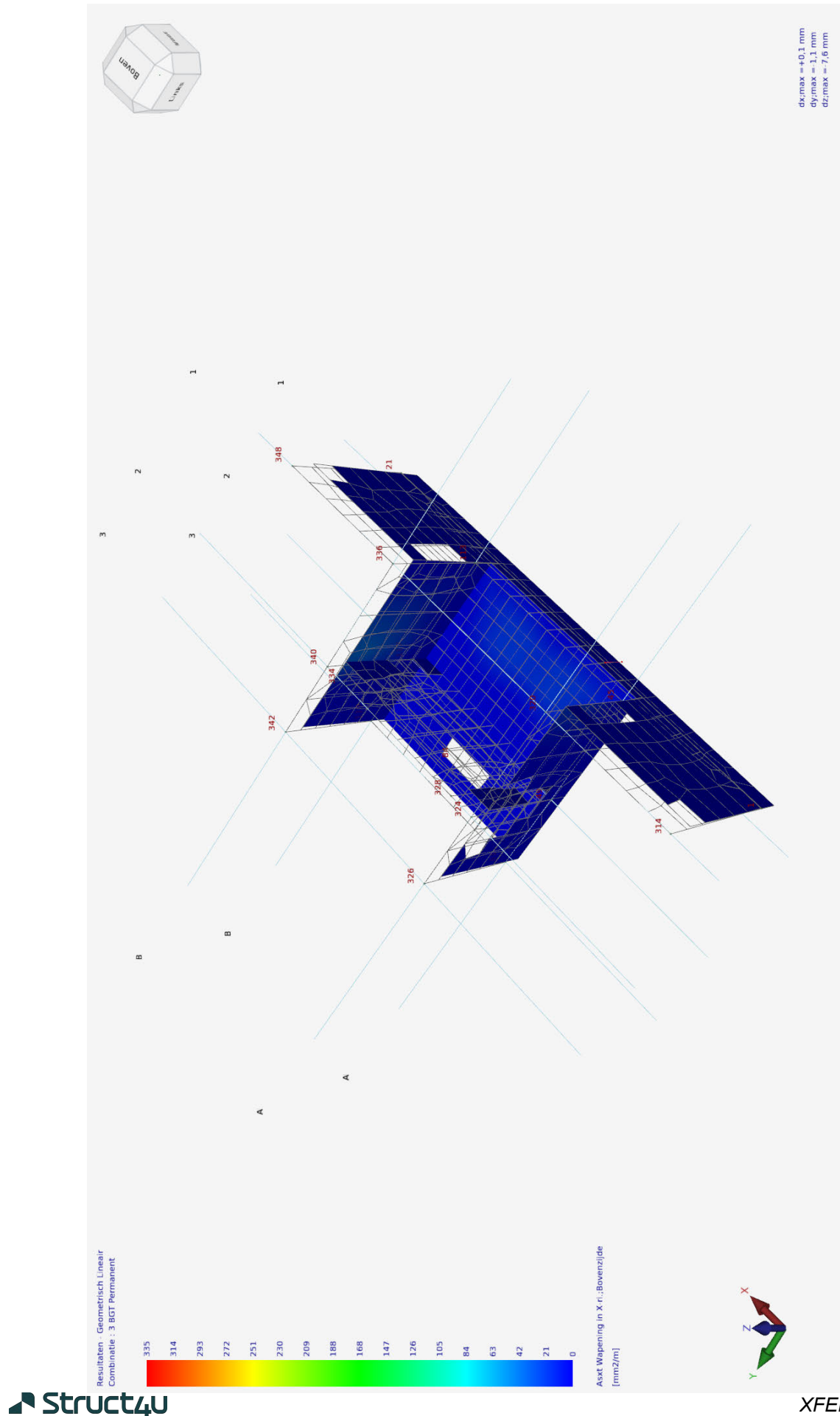
2.3 BRUIKBAARHEIDSGRENSTOESTANDEN (BGT)**2.3 1 Belastingscombinaties****(GL) Geometrisch lineaire krachtsverdeling**

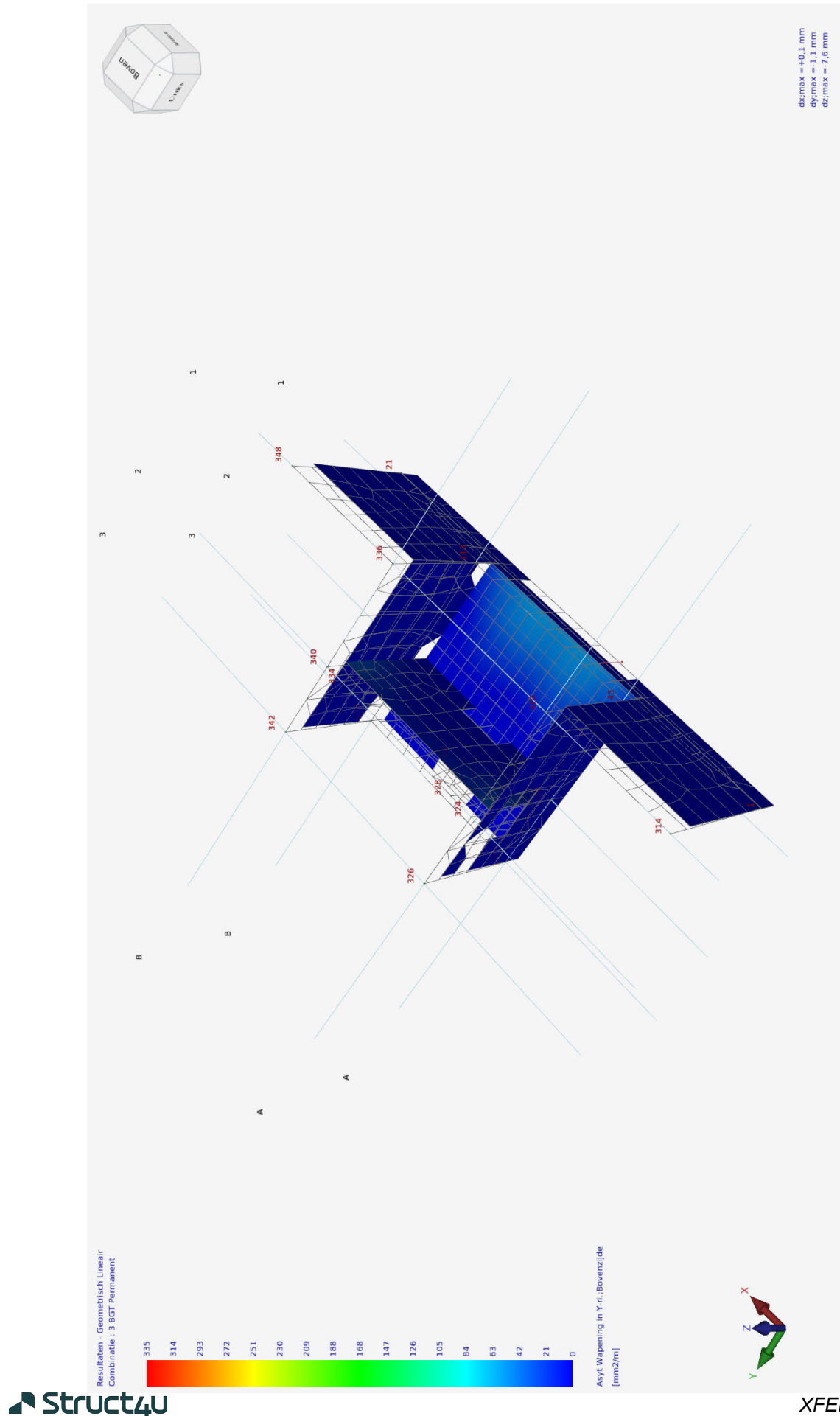
Combinatie nummer	Omschrijving	Type
5	Permanent	BGT
6	Veranderlijk	BGT
7	BGT Blijvend	BGT Blijvend
8	BGT Quasi-blijvend	BGT Quasi-blijvend

Combinatie nummer	Belasting ($\psi \times \gamma$)				
	1	2			
5	1,00 x 1,00	0,40 x 1,00			
6	1,00 x 1,00	1,00 x 1,00			
7	1,00 x 1,00				
8	1,00 x 1,00	0,30 x 1,00			









2.3.2 Omhullende knoopverplaatsingen

Knoop-nummer	Comb.-nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
1	5	0,0	0,4	-7,6	1,0	0,0	-0,1
	6	0,0	0,4	-7,6	0,9	0,0	-0,1
	7	0,0	0,5	-7,5	1,1	0,0	-0,1
21	5	0,0	0,4	-7,6	1,0	0,0	0,1
	6	0,0	0,4	-7,6	0,9	0,0	0,1
	7	0,0	0,5	-7,5	1,1	0,0	0,1
45	6	0,0	0,0	-7,5	1,0	-0,1	0,0
	7	0,0	0,0	-7,4	1,2	-0,1	0,0
49	6	0,0	0,0	-6,6	1,0	0,0	0,0
	7	0,0	0,0	-6,3	1,1	0,0	0,0
51	6	0,0	0,0	-6,0	1,0	0,0	0,0
	7	0,0	0,0	-5,6	1,1	0,0	0,0
84	5	0,0	0,0	-6,1	1,0	0,0	0,0
	6	0,0	0,0	-6,3	0,9	0,0	0,0
	7	0,0	0,0	-6,0	1,1	0,0	0,0
113	6	0,0	0,0	-7,5	1,0	0,1	0,0
	7	0,0	0,0	-7,4	1,2	0,1	0,0
117	6	0,0	0,0	-6,6	1,0	0,0	0,0
	7	0,0	0,0	-6,3	1,1	0,0	0,0
119	6	0,0	0,0	-6,0	1,0	0,0	0,0
	7	0,0	0,0	-5,6	1,1	0,0	0,0
314	5	-0,1	-0,9	-7,6	1,0	0,0	-0,1
	6	-0,1	-0,8	-7,6	0,9	0,0	-0,1
	7	-0,1	-1,0	-7,5	1,1	0,0	-0,1
320	6	-0,1	-0,9	-7,5	1,0	-0,1	-0,2
	7	-0,1	-1,1	-7,4	1,1	-0,1	-0,2
324	6	0,0	-0,9	-6,6	1,0	0,0	-0,1
	7	0,0	-1,1	-6,3	1,2	0,0	-0,1
326	5	0,0	-1,0	-5,8	0,0	0,0	0,0
	6	0,0	-0,9	-6,0	0,0	0,0	0,0
	7	0,0	-1,1	-5,6	0,0	0,0	0,0
328	5	0,0	-1,1	-6,4	1,1	0,0	0,0
	6	0,0	-0,9	-6,6	1,0	0,0	0,0
	7	0,0	-1,1	-6,3	1,2	0,0	0,0
334	5	0,0	-1,1	-6,4	1,1	0,0	0,0
	6	0,0	-0,9	-6,6	1,0	0,0	0,0
	7	0,0	-1,1	-6,3	1,2	0,0	0,0
336	6	0,1	-0,9	-7,5	1,0	0,1	0,2
	7	0,1	-1,1	-7,4	1,1	0,1	0,2
340	6	0,0	-0,9	-6,6	1,0	0,0	0,1
	7	0,0	-1,1	-6,3	1,2	0,0	0,1
342	5	0,0	-1,0	-5,8	0,0	0,0	0,0
	6	0,0	-0,9	-6,0	0,0	0,0	0,0
	7	0,0	-1,1	-5,6	0,0	0,0	0,0
348	5	0,1	-0,9	-7,6	1,0	0,0	0,1
	6	0,1	-0,8	-7,6	0,9	0,0	0,1
	7	0,1	-1,0	-7,5	1,1	0,0	0,1
Minimale / maximale waarden							
314	6	-0,1					

Knoop-nummer	Comb.-nummer	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
348	6	0,1					
328	7		-1,1				
21	7		0,5				
1	6			-7,6			
119	7			-5,6			
326	5				0,0		
334	7				1,2		
45	6					-0,1	
113	6					0,1	
320	6						-0,2
336	6						0,2

2.4 Wapeningsberekening

Cement publicatie 2021 editie 8: 'Wapenen van Schijven en Platen'

Auteurs: Dr.ir.drs. René Braam en Prof.dr.ir. Johan Blaauwendraad

Plaat-nummer	Knoop-nummer	Asxt [mm ² /m]	Asyt [mm ² /m]	Asxb [mm ² /m]	Asyb [mm ² /m]	Asw [mm ² /m]
1	84	0	0	65	48	0
1	84	0	0	65	48	0
1	381	31	35	0	0	0
1	364	9	66	3	3	0
2	438	0	0	50	15	0
2	438	0	0	50	15	0
2	320	32	9	0	9	0
2	425	31	22	0	0	0
3	336	0	9	32	9	0
3	476	0	0	31	22	0
3	489	50	15	0	0	0
3	489	50	15	0	0	0
4	355	0	0	30	1	0
4	522	0	20	0	17	0
4	472	11	47	0	0	0
4	340	4	49	3	0	0
5	476	0	0	17	40	0
5	336	3	0	9	49	0
5	368	16	22	10	10	0
5	45	0	22	13	0	0

2.4.1 Knoop 84 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,59 \text{ kN/m} \quad n_{yy} = -6,69 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = 3,346 \text{ kNm/m} \quad m_{yy} = 3,09 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

$$v_x = 0,98 \text{ kN/m} \quad v_y = 0,00 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{0,98^2 + 0,00^2} = 0,98 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,00}{0,98} = 0,000 \quad \varphi_0 = 0,0$$

$$\sin \varphi_0 = 0,000 \quad \cos \varphi_0 = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 65 / (1000 \times 167) = 0,000388$$

$$\rho_{ly} = A_{sly} / (b_w d) = 48 / (1000 \times 167) = 0,000288$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000388 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2 \varphi_0 = 1,59 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -1595 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000388 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 36,63 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,734 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(36,63; 73,73) = 73,73 \text{ kN}$$

$v_0 < V_{Rdc} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-3,35}{0,154} + (1 - 0,50) \times 1,59 = -20,94 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-3,09}{0,154} + (1 - 0,50) \times -6,69 = -23,44 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Toetsing betondrukkracht

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

$$= \left| \frac{1}{2} (-20,94 + -23,44) - \sqrt{\frac{1}{4} (-20,94 - -23,44)^2 + 0,00^2} \right| = 23,44 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{3,35}{0,154} + 0,50 \times 1,59 = 22,54 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{3,09}{0,154} + 0,50 \times -6,69 = 16,75 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

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

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

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

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

Toetsing betondrukkracht

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

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 22,54 + 0,00 = 22,54 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 16,75 + 0,00 = 16,75 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{22,54 \times 10^3}{435} = 52 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{16,75 \times 10^3}{435} = 39 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 65 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 48 \text{ mm}^2/\text{m}$$

2.4.2 Knoop 84 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,31 \text{ kN/m} \quad n_{yy} = -5,48 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = 2,742 \text{ kNm/m} \quad m_{yy} = 2,54 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-2,74}{0,154} + (1 - 0,50) \times 1,31 = -17,17 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-2,54}{0,154} + (1 - 0,50) \times -5,48 = -19,22 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{2,74}{0,154} + 0,50 \times 1,31 = 18,47 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{2,54}{0,154} + 0,50 \times -5,48 = 13,74 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 18,47 + 0,00 = 18,47 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 13,74 + 0,00 = 13,74 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{18,47 \times 10^{-3}}{65} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 65 / 51300 = 0,001263 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,001263 = 1162 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,001263} (1 + 6,68 \times 0,001263)}{200000} = -0,002104$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{\text{syb}}}{A_{\text{syb}}} = \frac{13,74 \times 10^{-3}}{48} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 48 / 51300 = 0,000939 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000939 = 1561 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000939} (1 + 6,68 \times 0,000939)}{200000} = -0,003312$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000856 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 200 \times 0,000856 = 0,171 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.3 Knoop 381 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 3,14 \text{ kN/m} \quad n_{yy} = 3,68 \text{ kN/m} \quad n_{xy} = -0,33 \text{ kN/m}$$

$$m_{xx} = -1,120 \text{ kNm/m} \quad m_{yy} = -1,30 \text{ kNm/m} \quad m_{xy} = -0,30 \text{ kNm/m}$$

$$v_x = 3,46 \text{ kN/m} \quad v_y = -0,95 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{3,46^2 + (-0,95)^2} = 3,59 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-0,95}{3,46} = -0,275 \quad \varphi_0 = -15,4^\circ$$

$$\sin \varphi_0 = -0,265 \quad \cos \varphi_0 = 0,964$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 31 / (1000 \times 167) = 0,000183$$

$$\rho_{ly} = A_{sly} / (b_w d) = 35 / (1000 \times 167) = 0,000208$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000185 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 3,34 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -3345 / 200000 = -0,0167 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000185 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 28,35 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,515 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(28,35; 73,52) = 73,52 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{1,12}{0,154} + (1 - 0,50) \times 3,14 = 8,85 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,30}{0,154} + (1 - 0,50) \times 3,68 = 10,31 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,30}{0,154} + (1 - 0,50) \times -0,33 = 1,79 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 1,79 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkraft

$$n_{ct} = 2 n_{0t} = 2 \times 1,79 = 3,59 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 8,85 + 1,79 = 10,64 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 10,31 + 1,79 = 12,10 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{10,64 \times 10^{-3}}{435} = 24 \text{ mm}^2/\text{m}$$

$$A_{syt,ULS} = \frac{n_{syt}}{f_{yd}} = \frac{12,10 \times 10^{-3}}{435} = 28 \text{ mm}^2/\text{m}$$

Onverschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-1,12}{0,154} + 0,50 \times 3,14 = -5,71 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,30}{0,154} + 0,50 \times 3,68 = -6,63 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,30}{0,154} + 0,50 \times -0,33 = -2,12 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 2,12 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

Toetsing betondrukkraft

$$n_{cb} = \left| \frac{1}{2} (n_{xxb} + n_{yyb}) - \sqrt{\frac{1}{4} (n_{xxb} - n_{yyb})^2 + n_{xyb}^2} \right| =$$

$$= \left| \frac{1}{2} (-5,71 + -6,63) - \sqrt{\frac{1}{4} (-5,71 - -6,63)^2 + -2,12^2} \right| = 8,34 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

$$A_{sxt,min} = 31 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 35 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.4 Knoop 381 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 2,57 \text{ kN/m} \quad n_{yy} = 3,02 \text{ kN/m} \quad n_{xy} = -0,27 \text{ kN/m}$$

$$m_{xx} = -0,917 \text{ kNm/m} \quad m_{yy} = -1,07 \text{ kNm/m} \quad m_{xy} = -0,25 \text{ kNm/m}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,92}{0,154} + (1 - 0,50) \times 2,57 = 7,24 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,07}{0,154} + (1 - 0,50) \times 3,02 = 8,44 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,25}{0,154} + (1 - 0,50) \times -0,27 = 1,47 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 1,47 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 7,24 + 1,47 = 8,71 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 8,44 + 1,47 = 9,91 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{8,71 \times 10^3}{31} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 31 / 51300 = 0,000596 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000596 = 2366 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000596} (1 + 6,68 \times 0,000596)}{200000} = -0,006019$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{9,91 \times 10^3}{35} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 35 / 51300 = 0,000678 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000678 = 2118 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000678} (1 + 6,68 \times 0,000678)}{200000} = -0,005124$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschi

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,92}{0,154} + 0,50 \times 2,57 = -4,67 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,07}{0,154} + 0,50 \times 3,02 = -5,43 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,25}{0,154} + 0,50 \times -0,27 = -1,74 \text{ kN/m}$$

$$n_{0b} = | n_{xyb} | = 1,74 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

2.4.5 Knoop 364 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,66 \text{ kN/m} \quad n_{yy} = 21,07 \text{ kN/m} \quad n_{xy} = -2,71 \text{ kN/m}$$

$$m_{xx} = -0,059 \text{ kNm/m} \quad m_{yy} = -1,58 \text{ kNm/m} \quad m_{xy} = 0,10 \text{ kNm/m}$$

$$v_x = -3,98 \text{ kN/m} \quad v_y = 0,72 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-3,98^2 + 0,72^2} = 4,04 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,72}{-3,98} = -0,181 \quad \varphi_0 = -10,3^\circ$$

$$\sin \varphi_0 = -0,178 \quad \cos \varphi_0 = 0,984$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 9 / (1000 \times 167) = 0,000055$$

$$\rho_{ly} = A_{sly} / (b_w d) = 66 / (1000 \times 167) = 0,000392$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000066 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 3,23 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -3230 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000066 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 20,01 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,53 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(20,01; 73,53) = 73,53 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,06}{0,154} + (1 - 0,50) \times 1,66 = 1,22 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,58}{0,154} + (1 - 0,50) \times 21,07 = 20,80 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,10}{0,154} + (1 - 0,50) \times -2,71 = -2,00 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,00 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkkracht

$$n_{ct} = 2 n_{0t} = 2 \times 2,00 = 3,99 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 1,22 + 2,00 = 3,21 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{0t} = 20,80 + 2,00 = 22,79 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{3,21 \times 10^3}{435} = 7 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{22,79 \times 10^3}{435} = 52 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,06}{0,154} + 0,50 \times 1,66 = 0,45 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,58}{0,154} + 0,50 \times 21,07 = 0,27 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,10}{0,154} + 0,50 \times -2,71 = -0,71 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 0,71 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkkracht

$$n_{cb} = 2 n_{0b} = 2 \times 0,71 = 1,42 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 0,45 + 0,71 = 1,16 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,27 + 0,71 = 0,98 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{1,16 \times 10^3}{435} = 3 \text{ mm}^2/\text{m}$$

$$A_{\text{syb,ULS}} = \frac{n_{\text{syb}}}{f_{\text{yd}}} = \frac{0,98 \times 10^{-3}}{435} = 2 \text{ mm}^2/\text{m}$$

$$A_{\text{sxt,min}} = 9 \text{ mm}^2/\text{m}$$

$$A_{\text{syt,min}} = 66 \text{ mm}^2/\text{m}$$

$$A_{\text{sxb,min}} = 3 \text{ mm}^2/\text{m}$$

$$A_{\text{syb,min}} = 3 \text{ mm}^2/\text{m}$$

2.4.6 Knoop 364 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = 1,36 \text{ kN/m}$$

$$n_{yy} = 17,26 \text{ kN/m}$$

$$n_{xy} = -2,22 \text{ kN/m}$$

$$m_{xx} = -0,049 \text{ kNm/m}$$

$$m_{yy} = -1,29 \text{ kNm/m}$$

$$m_{xy} = 0,08 \text{ kNm/m}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,05}{0,154} + (1 - 0,50) \times 1,36 = 1,00 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,29}{0,154} + (1 - 0,50) \times 17,26 = 17,04 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,08}{0,154} + (1 - 0,50) \times -2,22 = -1,64 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 1,64 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja → Geval 1 wapening in x- en y-richting

$$2: n_{xxt} n_{yyt} < n_{0t}^2$$

$$n_{yyt} < -n_{0t}$$

nee

$$3: n_{xxt} n_{yyt} < n_{0t}^2$$

$$n_{xxt} < -n_{0t}$$

nee

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

$$n_{xxt} < 0 \quad n_{yyt} < 0$$

nee

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 1,00 + 1,64 = 2,63 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 17,04 + 1,64 = 18,67 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{2,63 \times 10^{-3}}{9} = 285 \text{ MPa}$$

$$k_x = \min \left[\frac{c}{c_{\text{nom}}}; 2 \right] = \min \left[\frac{25}{15}; 2 \right] = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); h/2] = \min [2,5 \times (200 - 167); 200/2] = 83 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 9 / 82500 = 0,000112$$

...(7.10)

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000112 = 12234 \text{ mm}$$

...(7.11)

$$s_{r,\text{max}} > \max [(50 - 0,8 f_{c,k}) \emptyset; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,00018} (1 + 6,68 \times 0,00018)}{200000} = -0,023162$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syf}}{A_{syf}} = \frac{18,67 \times 10^3}{66} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (200 - 167) ; 200 / 2] = 83 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 66 / 82500 = 0,000794 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \sigma_s / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000794 = 1824 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \sigma_s ; 15 \sigma_s] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,001277} (1 + 6,68 \times 0,001277)}{200000} = -0,002065$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,05}{0,154} + 0,50 \times 1,36 = 0,37 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,29}{0,154} + 0,50 \times 17,26 = 0,22 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,08}{0,154} + 0,50 \times -2,22 = -0,58 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 0,58 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 0,37 + 0,58 = 0,95 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,22 + 0,58 = 0,80 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{0,95 \times 10^3}{3} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (200 - 167) ; 200 / 2] = 83 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 3 / 82500 = 0,00004 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,00004 = 33832 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000065} (1 + 6,68 \times 0,000065)}{200000} = -0,066818$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000854 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000854 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{0,80 \times 10^3}{3} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (200 - 167) ; 200 / 2] = 83 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 3 / 82500 = 0,000034 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000034 = 40039 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000055} (1 + 6,68 \times 0,000055)}{200000} = -0,079307$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000856 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000856 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.7 Knoop 438 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 3,49 \text{ kN/m} \quad n_{yy} = -1,77 \text{ kN/m} \quad n_{xy} = -0,87 \text{ kN/m}$$

$$m_{xx} = 1,728 \text{ kNm/m} \quad m_{yy} = 0,30 \text{ kNm/m} \quad m_{xy} = -0,60 \text{ kNm/m}$$

$$v_x = 5,98 \text{ kN/m} \quad v_y = -0,02 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{5,98^2 + (-0,02)^2} = 5,98 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-0,02}{5,98} = -0,003 \quad \varphi_0 = -0,2$$

$$\sin \varphi_0 = -0,003 \quad \cos \varphi_0 = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 50 / (1000 \times 167) = 0,000298$$

$$\rho_{ly} = A_{sly} / (b_w d) = 15 / (1000 \times 167) = 0,000093$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000298 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 3,49 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -3493 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000298 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 33,28 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,497 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(33,28; 73,5) = 73,5 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-1,73}{0,154} + (1 - 0,50) \times 3,49 = -9,49 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,30}{0,154} + (1 - 0,50) \times -1,77 = -2,85 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,60}{0,154} + (1 - 0,50) \times -0,87 = 3,44 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 3,44 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Toetsing betondrukkracht

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

$$= \left| \frac{1}{2} (-9,49 + -2,85) - \sqrt{\frac{1}{4} (-9,49 - -2,85)^2 + 3,44^2} \right| = 10,95 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{1,73}{0,154} + 0,50 \times 3,49 = 12,98 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,30}{0,154} + 0,50 \times -1,77 = 1,08 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,60}{0,154} + 0,50 \times -0,87 = -4,31 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 4,31 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkracht

$$n_{cb} = 2 n_{0b} = 2 \times 4,31 = 8,62 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 12,98 + 4,31 = 17,29 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 1,08 + 4,31 = 5,39 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{17,29 \times 10^3}{435} = 40 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{5,39 \times 10^3}{435} = 12 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 50 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 15 \text{ mm}^2/\text{m}$$

2.4.8 Knoop 438 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = 2,87 \text{ kN/m}$$

$$n_{yy} = -1,44 \text{ kN/m}$$

$$n_{xy} = -0,70 \text{ kN/m}$$

$$m_{xx} = 1,416 \text{ kNm/m}$$

$$m_{yy} = 0,25 \text{ kNm/m}$$

$$m_{xy} = -0,49 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma)n_{xx} = \frac{-1,42}{0,154} + (1 - 0,50) \times 2,87 = -7,77 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma)n_{yy} = \frac{-0,25}{0,154} + (1 - 0,50) \times -1,44 = -2,33 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma)n_{xy} = \frac{0,49}{0,154} + (1 - 0,50) \times -0,70 = 2,83 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,83 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{1,42}{0,154} + 0,50 \times 2,87 = 10,64 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,25}{0,154} + 0,50 \times -1,44 = 0,89 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,49}{0,154} + 0,50 \times -0,70 = -3,53 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,53 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 10,64 + 3,53 = 14,17 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,89 + 3,53 = 4,42 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{14,17 \times 10^{-3}}{50} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 50 / 51300 = 0,000969 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,\text{eff}} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000969 = 1489 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50 - 0,8 f_{c,k}) \varnothing; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000969} (1 + 6,68 \times 0,000969)}{200000} = -0,003167$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{\text{syb}}}{A_{\text{syb}}} = \frac{4,42 \times 10^3}{15} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 15 / 51300 = 0,000302 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,\text{eff}} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000302 = 4616 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50 - 0,8 f_{c,k}) \varnothing; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000302} (1 + 6,68 \times 0,000302)}{200000} = -0,013244$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.9 Knoop 320 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 0,80 \text{ kN/m} \quad n_{yy} = -1,72 \text{ kN/m} \quad n_{xy} = 2,92 \text{ kN/m}$$

$$m_{xx} = -0,694 \text{ kNm/m} \quad m_{yy} = 0,21 \text{ kNm/m} \quad m_{xy} = -0,73 \text{ kNm/m}$$

$$v_x = -1,00 \text{ kN/m} \quad v_y = 1,47 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-1,00^2 + 1,47^2} = 1,78 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{1,47}{-1,00} = -1,468 \quad \varphi_0 = -55,7^\circ$$

$$\sin \varphi_0 = -0,826 \quad \cos \varphi_0 = 0,563$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 0 / (1000 \times 167) = 0$$

$$\rho_{ly} = A_{sly} / (b_w d) = 9 / (1000 \times 167) = 0,000054$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000037 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = -3,64 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 3637 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000037 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 17,3 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 74,39 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(17,3; 74,39) = 74,39 \text{ kN}$$

$v_0 < V_{Rdc} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,69}{0,154} + (1 - 0,50) \times 0,80 = 4,91 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,21}{0,154} + (1 - 0,50) \times -1,72 = -2,23 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,73}{0,154} + (1 - 0,50) \times 2,92 = 6,21 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 6,21 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkraft

$$n_{ct} = 2 n_{ot} = 2 \times 6,21 = 12,42 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{ot} = 4,91 + 6,21 = 11,12 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{ot} = -2,23 + 6,21 = 3,98 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{11,12 \times 10^3}{435} = 26 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{3,98 \times 10^3}{435} = 9 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,69}{0,154} + 0,50 \times 0,80 = -4,11 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,21}{0,154} + 0,50 \times -1,72 = 0,51 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,73}{0,154} + 0,50 \times 2,92 = -3,29 \text{ kN/m}$$

$$n_{ob} = |n_{xyb}| = 3,29 \text{ kN/m}$$

$$1: n_{xxb} > -n_{ob} \quad n_{yyb} > -n_{ob} \quad \text{nee}$$

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

$$3: n_{xxb} n_{yyb} < n_{ob}^2 \quad n_{xxb} < -n_{ob} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Toetsing betondrukkraft

$$n_{cb} = (-n_{xxb}) + \frac{n_{ob}^2}{(-n_{xxb})} = 4,11 + \frac{3,29^2}{4,11} = 6,75 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{syb} = n_{yyb} + \frac{n_{ob}^2}{(-n_{xxb})} = 0,51 + \frac{3,29^2}{4,11} = 3,15 \text{ kN/m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{3,15 \times 10^3}{435} = 7 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 32 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 9 \text{ mm}^2/\text{m}$$

2.4.10 Knoop 320 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = 0,66 \text{ kN/m}$$

$$n_{yy} = -1,41 \text{ kN/m}$$

$$n_{xy} = 2,39 \text{ kN/m}$$

$$m_{xx} = -0,568 \text{ kNm/m}$$

$$m_{yy} = 0,17 \text{ kNm/m}$$

$$m_{xy} = -0,60 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,57}{0,154} + (1 - 0,50) \times 0,66 = 4,02 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,17}{0,154} + (1 - 0,50) \times -1,41 = -1,83 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,60}{0,154} + (1 - 0,50) \times 2,39 = 5,09 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 5,09 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 4,02 + 5,09 = 9,11 \text{ kN/m}$$

$$n_{synt} = n_{yyt} + n_{0t} = -1,83 + 5,09 = 3,26 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{9,11 \times 10^3}{32} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 32 / 51300 = 0,000623 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff,y} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000623 = 2268 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 9 / 51300 = 0,000178 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,z} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000178 = 7738 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k})\varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3(h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,874}{200} + \frac{0,487}{200}} = 147 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000623} (1 + 6,68 \times 0,000623)}{200000} = -0,005699$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 147 \times 0,000855 = 0,126 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{3,26 \times 10^3}{9} = 356 \text{ MPa}$$

$$k_x = \min \left[\frac{c}{c_{nom}} ; 2 \right] = \min \left[\frac{25}{15} ; 2 \right] = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 9 / 82500 = 0,000111 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,y} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000111 = 12376 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k})\varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3(h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 32 / 82500 = 0,000387 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,z} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000387 = 3595 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k})\varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3(h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,874}{200} + \frac{0,487}{200}} = 147 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000178} (1 + 6,68 \times 0,000178)}{200000} = -0,023037$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001069 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 147 \times 0,001069 = 0,157 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,57}{0,154} + 0,50 \times 0,66 = -3,36 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,17}{0,154} + 0,50 \times -1,41 = 0,42 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,60}{0,154} + 0,50 \times 2,39 = -2,70 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 2,70 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

$$3: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{xxb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Berekening van scheurwijdte

$$n_{syb} = n_{yyb} + \frac{n_{0b}^2}{(-n_{xxb})} = 0,42 + \frac{2,70^2}{3,36} = 2,58 \text{ kN/m}$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{2,58 \times 10^3}{9} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 9 / 51300 = 0,000177 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000177 = 7804 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000177} (1 + 6,68 \times 0,000177)}{200000} = -0,023609$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.11 Knoop 425 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,36 \text{ kN/m} \quad n_{yy} = -2,55 \text{ kN/m} \quad n_{xy} = 2,67 \text{ kN/m}$$

$$m_{xx} = -0,657 \text{ kNm/m} \quad m_{yy} = -0,47 \text{ kNm/m} \quad m_{xy} = -0,69 \text{ kNm/m}$$

$$v_x = 4,82 \text{ kN/m} \quad v_y = 0,88 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{4,82^2 + 0,88^2} = 4,90 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,88}{4,82} = 0,183 \quad \varphi_0 = 10,3^\circ$$

$$\sin \varphi_0 = 0,180 \quad \cos \varphi_0 = 0,984$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 31 / (1000 \times 167) = 0,000185$$

$$\rho_{ly} = A_{sly} / (b_w d) = 22 / (1000 \times 167) = 0,000131$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000184 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 2,18 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -2176 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000184 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 28,42 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,662 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(28,42; 73,66) = 73,66 \text{ kN}$$

$v_0 < V_{Rdc} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,66}{0,154} + (1 - 0,50) \times 1,36 = 4,95 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,47}{0,154} + (1 - 0,50) \times -2,55 = 1,77 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,69}{0,154} + (1 - 0,50) \times 2,67 = 5,82 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 5,82 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkkracht

$$n_{ct} = 2 n_{0t} = 2 \times 5,82 = 11,63 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 4,95 + 5,82 = 10,76 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 1,77 + 5,82 = 7,59 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{10,76 \times 10^{-3}}{435} = 25 \text{ mm}^2/\text{m}$$

$$A_{syt,ULS} = \frac{n_{syt}}{f_{yd}} = \frac{7,59 \times 10^{-3}}{435} = 17 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,66}{0,154} + 0,50 \times 1,36 = -3,59 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,47}{0,154} + 0,50 \times -2,55 = -4,33 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,69}{0,154} + 0,50 \times 2,67 = -3,15 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,15 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

Toetsing betondrukkkracht

$$n_{cb} = \left| \frac{1}{2} (n_{xxb} + n_{yyb}) - \sqrt{\frac{1}{4} (n_{xxb} - n_{yyb})^2 + n_{xyb}^2} \right| =$$

$$= \left| \frac{1}{2} (-3,59 + -4,33) - \sqrt{\frac{1}{4} (-3,59 - -4,33)^2 + -3,15^2} \right| = 7,13 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

$$A_{sxt,min} = 31 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 22 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.12 Knoop 425 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,11 \text{ kN/m} \quad n_{yy} = -2,09 \text{ kN/m} \quad n_{xy} = 2,19 \text{ kN/m}$$

$$m_{xx} = -0,538 \text{ kNm/m} \quad m_{yy} = -0,38 \text{ kNm/m} \quad m_{xy} = -0,57 \text{ kNm/m}$$

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,54}{0,154} + (1 - 0,50) \times 1,11 = 4,05 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,38}{0,154} + (1 - 0,50) \times -2,09 = 1,45 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,57}{0,154} + (1 - 0,50) \times 2,19 = 4,77 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 4,77 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 4,05 + 4,77 = 8,82 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 1,45 + 4,77 = 6,22 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{8,82 \times 10^3}{31} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 31 / 51300 = 0,000603 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff,y} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000603 = 2340 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 22 / 51300 = 0,000425 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff,z} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000425 = 3310 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,753}{200} + \frac{0,658}{200}} = 142 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000603} (1 + 6,68 \times 0,000603)}{200000} = -0,005933$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{6,22 \times 10^3}{22} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 22 / 51300 = 0,000425 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,y} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000425 = 3310 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k}) \varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 31 / 51300 = 0,000603 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,z} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000603 = 2340 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k}) \varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,753}{200} + \frac{0,658}{200}} = 142 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000425} (1 + 6,68 \times 0,000425)}{200000} = -0,008998$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,54}{0,154} + 0,50 \times 1,11 = -2,94 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,38}{0,154} + 0,50 \times -2,09 = -3,54 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,57}{0,154} + 0,50 \times 2,19 = -2,58 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 2,58 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

2.4.13 Knoop 336 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 0,80 \text{ kN/m} \quad n_{yy} = -1,72 \text{ kN/m} \quad n_{xy} = 2,92 \text{ kN/m}$$

$$m_{xx} = 0,694 \text{ kNm/m} \quad m_{yy} = -0,21 \text{ kNm/m} \quad m_{xy} = 0,73 \text{ kNm/m}$$

$$v_x = 1,00 \text{ kN/m} \quad v_y = -1,47 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{1,00^2 + (-1,47)^2} = 1,78 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-1,47}{1,00} = -1,468 \quad \varphi_0 = -55,7^\circ$$

$$\sin \varphi_0 = -0,826 \quad \cos \varphi_0 = 0,563$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 0 / (1000 \times 167) = 0$$

$$\rho_{ly} = A_{sly} / (b_w d) = 9 / (1000 \times 167) = 0,000054$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000037 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = -3,64 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 3637 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000037 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 17,3 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 74,39 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(17,3; 74,39) = 74,39 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,69}{0,154} + (1 - 0,50) \times 0,80 = -4,11 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,21}{0,154} + (1 - 0,50) \times (-1,72) = 0,51 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,73}{0,154} + (1 - 0,50) \times 2,92 = -3,29 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 3,29 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Toetsing betondrukkraft

$$n_{ct} = (-n_{xxt}) + \frac{n_{0t}^2}{(-n_{xxt})} = 4,11 + \frac{3,29^2}{4,11} = 6,75 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{synt} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = 0,51 + \frac{3,29^2}{4,11} = 3,15 \text{ kN/m}$$

$$A_{synt,ULS} = \frac{n_{synt}}{f_{yd}} = \frac{3,15 \times 10^3}{435} = 7 \text{ mm}^2/\text{m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,69}{0,154} + 0,50 \times 0,80 = 4,91 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,21}{0,154} + 0,50 \times -1,72 = -2,23 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,73}{0,154} + 0,50 \times 2,92 = 6,21 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 6,21 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkraft

$$n_{cb} = 2 n_{0b} = 2 \times 6,21 = 12,42 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 4,91 + 6,21 = 11,12 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = -2,23 + 6,21 = 3,98 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{11,12 \times 10^3}{435} = 26 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{3,98 \times 10^3}{435} = 9 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 9 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 32 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.14 Knoop 336 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = 0,66 \text{ kN/m}$$

$$n_{yy} = -1,41 \text{ kN/m}$$

$$n_{xy} = 2,39 \text{ kN/m}$$

$$m_{xx} = 0,568 \text{ kNm/m}$$

$$m_{yy} = -0,17 \text{ kNm/m}$$

$$m_{xy} = 0,60 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,57}{0,154} + (1 - 0,50) \times 0,66 = -3,36 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,17}{0,154} + (1 - 0,50) \times -1,41 = 0,42 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,60}{0,154} + (1 - 0,50) \times 2,39 = -2,70 \text{ kN/m}$$

$$n_{ot} = |n_{xyt}| = 2,70 \text{ kN/m}$$

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

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

$$3: n_{xxt} n_{yyt} < n_{ot}^2 \quad n_{xxt} < -n_{ot} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Berekening van scheurwijdte

$$n_{sy} = n_{yyt} + \frac{n_{ot}^2}{(-n_{xxt})} = 0,42 + \frac{2,70^2}{3,36} = 2,58 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sy}}{A_{sy}} = \frac{2,58 \times 10^3}{9} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 9 / 51300 = 0,000177 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000177 = 7804 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{\tau_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000177} (1 + 6,68 \times 0,000177)}{200000} = -0,023609$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,57}{0,154} + 0,50 \times 0,66 = 4,02 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,17}{0,154} + 0,50 \times -1,41 = -1,83 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,60}{0,154} + 0,50 \times 2,39 = 5,09 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 5,09 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 4,02 + 5,09 = 9,11 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = -1,83 + 5,09 = 3,26 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{9,11 \times 10^{-3}}{32} = 285 \text{ MPa}$$

$$k_x = \min \left[\frac{c}{c_{nom}}; 2 \right] = \min \left[\frac{25}{15}; 2 \right] = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 32 / 51300 = 0,000623 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,y} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000623 = 2268 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k})\varnothing; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{eff} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 9 / 51300 = 0,000178 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,z} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000178 = 7738 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k})\varnothing; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,874}{200} + \frac{0,487}{200}} = 147 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000623} (1 + 6,68 \times 0,000623)}{200000} = -0,005699$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 147 \times 0,000855 = 0,126 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{3,26 \times 10^3}{9} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$\rho_{p,eff,y} = A_s / A_{c,eff} = 9 / 82500 = 0,000111 \quad \dots(7.10)$$

$$s_{r,max,y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff,y} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000111 = 12376 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,y} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max,y} = 272 \text{ mm}$$

$$s_{r,max,y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,y} = 200 \text{ mm} \quad \dots(7.14)$$

$$\rho_{p,eff,z} = A_s / A_{c,eff} = 32 / 82500 = 0,000387 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff,z} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000387 = 3595 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,874}{200} + \frac{0,487}{200}} = 147 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000178} (1 + 6,68 \times 0,000178)}{200000} = -0,023037$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001069 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 147 \times 0,001069 = 0,157 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.15 Knoop 476 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 1,36 \text{ kN/m} \quad n_{yy} = -2,55 \text{ kN/m} \quad n_{xy} = 2,67 \text{ kN/m}$$

$$m_{xx} = 0,657 \text{ kNm/m} \quad m_{yy} = 0,47 \text{ kNm/m} \quad m_{xy} = 0,69 \text{ kNm/m}$$

$$v_x = -4,82 \text{ kN/m} \quad v_y = -0,88 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{(-4,82)^2 + (-0,88)^2} = 4,90 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-0,88}{-4,82} = 0,183 \quad \varphi_0 = 10,3^\circ$$

$$\sin \varphi_0 = 0,180 \quad \cos \varphi_0 = 0,984$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 31 / (1000 \times 167) = 0,000185$$

$$\rho_{ly} = A_{sly} / (b_w d) = 22 / (1000 \times 167) = 0,000131$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000184 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 2,18 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -2176 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000184 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 28,42 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,662 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(28,42; 73,66) = 73,66 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenshil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,66}{0,154} + (1 - 0,50) \times 1,36 = -3,59 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,47}{0,154} + (1 - 0,50) \times -2,55 = -4,33 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,69}{0,154} + (1 - 0,50) \times 2,67 = -3,15 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 3,15 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Toetsing betondrukkracht

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

$$= \left| \frac{1}{2} (-3,59 + -4,33) - \sqrt{\frac{1}{4} (-3,59 - -4,33)^2 + -3,15^2} \right| = 7,13 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,66}{0,154} + 0,50 \times 1,36 = 4,95 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,47}{0,154} + 0,50 \times -2,55 = 1,77 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,69}{0,154} + 0,50 \times 2,67 = 5,82 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 5,82 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkracht

$$n_{cb} = 2 n_{0b} = 2 \times 5,82 = 11,63 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 4,95 + 5,82 = 10,76 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 1,77 + 5,82 = 7,59 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{10,76 \times 10^3}{435} = 25 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{7,59 \times 10^3}{435} = 17 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 31 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 22 \text{ mm}^2/\text{m}$$

2.4.16 Knoop 476 - BGT Combinatie: 5 Permanent

$h = 200 \text{ mm}$

$d_t = 46 \text{ mm}$

$d_b = 46 \text{ mm}$

$d_v = 154 \text{ mm}$

$n_{xx} = 1,11 \text{ kN/m}$

$n_{yy} = -2,09 \text{ kN/m}$

$n_{xy} = 2,19 \text{ kN/m}$

$m_{xx} = 0,538 \text{ kNm/m}$

$m_{yy} = 0,38 \text{ kNm/m}$

$m_{xy} = 0,57 \text{ kNm/m}$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,54}{0,154} + (1 - 0,50) \times 1,11 = -2,94 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,38}{0,154} + (1 - 0,50) \times -2,09 = -3,54 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,57}{0,154} + (1 - 0,50) \times 2,19 = -2,58 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,58 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,54}{0,154} + 0,50 \times 1,11 = 4,05 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,38}{0,154} + 0,50 \times -2,09 = 1,45 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,57}{0,154} + 0,50 \times 2,19 = 4,77 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 4,77 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 4,05 + 4,77 = 8,82 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 1,45 + 4,77 = 6,22 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{8,82 \times 10^3}{31} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff},y} = A_s / A_{c,\text{eff}} = 31 / 51300 = 0,000603 \quad \dots(7.10)$$

$$s_{r,\text{max},y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},y} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000603 = 2340 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},y} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},y} = 272 \text{ mm}$$

$$s_{r,\text{max},y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max},y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff},z} = A_s / A_{c,\text{eff}} = 22 / 51300 = 0,000425 \quad \dots(7.10)$$

$$s_{r,\text{max},z} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},z} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000425 = 3310 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},z} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},z} = 272 \text{ mm}$$

$$s_{r,\text{max},z} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max},z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,\text{max}} = \frac{1}{\frac{\cos\theta}{s_{r,\text{max},y}} + \frac{\sin\theta}{s_{r,\text{max},z}}} = \frac{1}{\frac{0,753}{200} + \frac{0,658}{200}} = 142 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000603} (1 + 6,68 \times 0,000603)}{200000} = -0,005933$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{\text{syb}}}{A_{\text{syb}}} = \frac{6,22 \times 10^3}{22} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff},y} = A_s / A_{c,\text{eff}} = 22 / 51300 = 0,000425 \quad \dots(7.10)$$

$$s_{r,\text{max},y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},y} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000425 = 3310 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},y} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},y} = 272 \text{ mm}$$

$$s_{r,\text{max},y} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max},y} = 200 \text{ mm} \quad \dots(7.14)$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff},z} = A_s / A_{c,\text{eff}} = 31 / 51300 = 0,000603 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff,z} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000603 = 2340 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h - x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max,z} = 200 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos\theta}{s_{r,max,y}} + \frac{\sin\theta}{s_{r,max,z}}} = \frac{1}{\frac{0,753}{200} + \frac{0,658}{200}} = 142 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000425} (1 + 6,68 \times 0,000425)}{200000} = -0,008998$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.17 Knoop 489 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 3,49 \text{ kN/m} \quad n_{yy} = -1,77 \text{ kN/m} \quad n_{xy} = -0,87 \text{ kN/m}$$

$$m_{xx} = -1,728 \text{ kNm/m} \quad m_{yy} = -0,30 \text{ kNm/m} \quad m_{xy} = 0,60 \text{ kNm/m}$$

$$v_x = -5,98 \text{ kN/m} \quad v_y = 0,02 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-5,98^2 + 0,02^2} = 5,98 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,02}{-5,98} = -0,003 \quad \varphi_0 = -0,2$$

$$\sin \varphi_0 = -0,003 \quad \cos \varphi_0 = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 50 / (1000 \times 167) = 0,000298$$

$$\rho_{ly} = A_{sly} / (b_w d) = 15 / (1000 \times 167) = 0,000093$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000298 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 3,49 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -3493 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000298 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 33,28 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,497 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(33,28; 73,5) = 73,5 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{1,73}{0,154} + (1 - 0,50) \times 3,49 = 12,98 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,30}{0,154} + (1 - 0,50) \times -1,77 = 1,08 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,60}{0,154} + (1 - 0,50) \times -0,87 = -4,31 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 4,31 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkraft

$$n_{ct} = 2 n_{0t} = 2 \times 4,31 = 8,62 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 12,98 + 4,31 = 17,29 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{0t} = 1,08 + 4,31 = 5,39 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{17,29 \times 10^{-3}}{435} = 40 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{5,39 \times 10^{-3}}{435} = 12 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-1,73}{0,154} + 0,50 \times 3,49 = -9,49 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,30}{0,154} + 0,50 \times -1,77 = -2,85 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,60}{0,154} + 0,50 \times -0,87 = 3,44 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,44 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

Toetsing betondrukkraft

$$n_{cb} = \left| \frac{1}{2} (n_{xxb} + n_{yyb}) - \sqrt{\frac{1}{4} (n_{xxb} - n_{yyb})^2 + n_{xyb}^2} \right| =$$

$$= \left| \frac{1}{2} (-9,49 + -2,85) - \sqrt{\frac{1}{4} (-9,49 - -2,85)^2 + 3,44^2} \right| = 10,95 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

$$A_{sxt,min} = 50 \text{ mm}^2/\text{m}$$

$$A_{syx,min} = 15 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.18 Knoop 489 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = 2,87 \text{ kN/m} \quad n_{yy} = -1,44 \text{ kN/m} \quad n_{xy} = -0,70 \text{ kN/m}$$

$$m_{xx} = -1,416 \text{ kNm/m} \quad m_{yy} = -0,25 \text{ kNm/m} \quad m_{xy} = 0,49 \text{ kNm/m}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{1,42}{0,154} + (1 - 0,50) \times 2,87 = 10,64 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,25}{0,154} + (1 - 0,50) \times -1,44 = 0,89 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,49}{0,154} + (1 - 0,50) \times -0,70 = -3,53 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 3,53 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 10,64 + 3,53 = 14,17 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 0,89 + 3,53 = 4,42 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{14,17 \times 10^3}{50} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 50 / 51300 = 0,000969 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000969 = 1489 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000969} (1 + 6,68 \times 0,000969)}{200000} = -0,003167$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{4,42 \times 10^3}{15} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 15 / 51300 = 0,000302 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000302 = 4616 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000302} (1 + 6,68 \times 0,000302)}{200000} = -0,013244$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000855 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschiil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-1,42}{0,154} + 0,50 \times 2,87 = -7,77 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,25}{0,154} + 0,50 \times -1,44 = -2,33 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,49}{0,154} + 0,50 \times -0,70 = 2,83 \text{ kN/m}$$

$$n_{0b} = | n_{xyb} | = 2,83 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

2.4.19 Knoop 355 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -11,19 \text{ kN/m} \quad n_{yy} = -4,91 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = 2,444 \text{ kNm/m} \quad m_{yy} = 0,41 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

$$v_x = -5,59 \text{ kN/m} \quad v_y = 0,00 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-5,59^2 + 0,00^2} = 5,59 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,00}{-5,59} = 0,000 \quad \varphi_0 = 0,0$$

$$\sin \varphi_0 = 0,000 \quad \cos \varphi_0 = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 30 / (1000 \times 167) = 0,000177$$

$$\rho_{ly} = A_{sly} / (b_w d) = 1 / (1000 \times 167) = 0,000004$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000177 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = -11,19 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 11193 / 200000 = 0,1 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000177 \times 20)^{1/3} + 0,15 \times 0,1] \times 1000 \times 167 \times 10^{-3} = 29,76 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0,1) \times 1000 \times 167 \times 10^{-3} = 75,336 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(29,76; 75,34) = 75,34 \text{ kN}$$

$$v_0 < V_{Rd,c} \rightarrow \text{Er is geen dwarskrachtwapening nodig.}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-2,44}{0,154} + (1 - 0,50) \times -11,19 = -21,48 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,41}{0,154} + (1 - 0,50) \times -4,91 = -5,13 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Toetsing betondrukkracht

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

$$= \left| \frac{1}{2} (-21,48 + -5,13) - \sqrt{\frac{1}{4} (-21,48 - -5,13)^2 + 0,00^2} \right| = 21,48 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{2,44}{0,154} + 0,50 \times -11,19 = 10,29 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,41}{0,154} + 0,50 \times -4,91 = 0,22 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

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

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

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

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

Toetsing betondrukkracht

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

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 10,29 + 0,00 = 10,29 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,22 + 0,00 = 0,22 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{10,29 \times 10^{-3}}{435} = 24 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{0,22 \times 10^{-3}}{435} = 1 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 30 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 1 \text{ mm}^2/\text{m}$$

2.4.20 Knoop 355 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -9,12 \text{ kN/m} \quad n_{yy} = -4,01 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = 2,005 \text{ kNm/m} \quad m_{yy} = 0,34 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-2,00}{0,154} + (1 - 0,50) \times -9,12 = -17,59 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,34}{0,154} + (1 - 0,50) \times -4,01 = -4,20 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Onderscil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{2,00}{0,154} + 0,50 \times -9,12 = 8,47 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,34}{0,154} + 0,50 \times -4,01 = 0,19 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 8,47 + 0,00 = 8,47 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,19 + 0,00 = 0,19 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{8,47 \times 10^3}{30} = 286 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 30 / 51300 = 0,000576 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000576 = 2444 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50-0,8f_{c,k})\emptyset; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{286 - 0,4 \frac{2,21}{0,000576} (1 + 6,68 \times 0,000576)}{200000} = -0,006267$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{286}{200000} = 0,000859 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000859 = 0,172 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{\text{syb}}}{A_{\text{syb}}} = \frac{0,19 \times 10^3}{1} = 294 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); (h-x) / 3] = \min [2,5 \times (200 - 167); (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 1 / 51300 = 0,000013 \quad \dots(7.10)$$

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000013 = 108237 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max}} > \max [(50-0,8f_{c,k})\emptyset; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,\text{max}} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,\text{max}} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{294 - 0,4 \frac{2,21}{0,000013} (1 + 6,68 \times 0,000013)}{200000} = -0,35003$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{294}{200000} = 0,000883 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000883 = 0,177 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.21 Knoop 522 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -1,08 \text{ kN/m} \quad n_{yy} = 15,93 \text{ kN/m} \quad n_{xy} = 0,00 \text{ kN/m}$$

$$m_{xx} = -0,010 \text{ kNm/m} \quad m_{yy} = -0,12 \text{ kNm/m} \quad m_{xy} = 0,00 \text{ kNm/m}$$

$$v_x = -0,08 \text{ kN/m} \quad v_y = 0,00 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-0,08^2 + 0,00^2} = 0,08 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,00}{-0,08} = 0,000 \quad \varphi_0 = 0,0$$

$$\sin \varphi_0 = 0,000 \quad \cos \varphi_0 = 1,000$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 0 / (1000 \times 167) = 0$$

$$\rho_{ly} = A_{sly} / (b_w d) = 20 / (1000 \times 167) = 0,00012$$

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

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = -1,08 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 1079 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 0,14 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 74,069 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(0,14; 74,07) = 74,07 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,01}{0,154} + (1 - 0,50) \times -1,08 = -0,47 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,12}{0,154} + (1 - 0,50) \times 15,93 = 8,72 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Toetsing betondrukkraft

$$n_{ct} = (-n_{xxt}) + \frac{n_{0t}^2}{(-n_{xxt})} = 0,47 + \frac{0,00^2}{0,47} = 0,47 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{syx} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = 8,72 + \frac{0,00^2}{0,47} = 8,72 \text{ kN/m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{8,72 \times 10^{-3}}{435} = 20 \text{ mm}^2/\text{m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,01}{0,154} + 0,50 \times -1,08 = -0,61 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,12}{0,154} + 0,50 \times 15,93 = 7,20 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

$$3: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{xxb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Toetsing betondrukkraft

$$n_{cb} = (-n_{xxb}) + \frac{n_{0b}^2}{(-n_{xxb})} = 0,61 + \frac{0,00^2}{0,61} = 0,61 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{syb} = n_{yyb} + \frac{n_{0b}^2}{(-n_{xxb})} = 7,20 + \frac{0,00^2}{0,61} = 7,20 \text{ kN/m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{7,20 \times 10^{-3}}{435} = 17 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.22 Knoop 522 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = -0,88 \text{ kN/m}$$

$$n_{yy} = 13,03 \text{ kN/m}$$

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

$$m_{xx} = -0,008 \text{ kNm/m}$$

$$m_{yy} = -0,10 \text{ kNm/m}$$

$$m_{xy} = 0,00 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,01}{0,154} + (1 - 0,50) \times -0,88 = -0,39 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,10}{0,154} + (1 - 0,50) \times 13,03 = 7,13 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,00}{0,154} + (1 - 0,50) \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Berekening van scheurwijdte

$$n_{synt} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = 7,13 + \frac{0,00^2}{-0,39} = 7,13 \text{ kN/m}$$

$$\sigma_s = \frac{n_{synt}}{A_{synt}} = \frac{7,13 \times 10^3}{20} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h/2] = \min [2,5 \times (200 - 167) ; 200/2] = 83 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 20 / 82500 = 0,000243 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000243 = 5705 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000391} (1 + 6,68 \times 0,000391)}{200000} = -0,009556$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001067 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,001067 = 0,213 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,01}{0,154} + 0,50 \times -0,88 = -0,50 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,10}{0,154} + 0,50 \times 13,03 = 5,89 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,00}{0,154} + 0,50 \times 0,00 = 0,00 \text{ kN/m}$$

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

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

$$3: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{xxb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Berekening van scheurwijdte

$$n_{syb} = n_{yyb} + \frac{n_{0b}^2}{(-n_{xxb})} = 5,89 + \frac{0,00^2}{0,50} = 5,89 \text{ kN/m}$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{5,89 \times 10^{-3}}{17} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (200 - 167) ; 200 / 2] = 83 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 17 / 82500 = 0,000201 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000201 = 6884 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000323} (1 + 6,68 \times 0,000323)}{200000} = -0,011938$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \quad \rightarrow \quad \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001067 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,001067 = 0,213 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.23 Knoop 472 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -1,81 \text{ kN/m} \quad n_{yy} = 8,69 \text{ kN/m} \quad n_{xy} = 0,78 \text{ kN/m}$$

$$m_{xx} = -0,269 \text{ kNm/m} \quad m_{yy} = -1,42 \text{ kNm/m} \quad m_{xy} = -0,38 \text{ kNm/m}$$

$$v_x = -0,67 \text{ kN/m} \quad v_y = -3,90 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-0,67^2 + -3,90^2} = 3,96 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-3,90}{-0,67} = 5,846 \quad \varphi_0 = 80,3^\circ$$

$$\sin \varphi_0 = 0,986 \quad \cos \varphi_0 = 0,169$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 11 / (1000 \times 167) = 0,000064$$

$$\rho_{ly} = A_{sly} / (b_w d) = 47 / (1000 \times 167) = 0,000283$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000277 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 8,65 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -8649 / 200000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000277 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 31,83 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 72,851 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(31,83; 72,85) = 72,85 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,27}{0,154} + (1 - 0,50) \times -1,81 = 0,84 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,42}{0,154} + (1 - 0,50) \times 8,69 = 13,55 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,38}{0,154} + (1 - 0,50) \times 0,78 = 2,89 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,89 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkkracht

$$n_{ct} = 2 n_{0t} = 2 \times 2,89 = 5,78 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 0,84 + 2,89 = 3,73 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{0t} = 13,55 + 2,89 = 16,44 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{3,73 \times 10^3}{435} = 9 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{16,44 \times 10^3}{435} = 38 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,27}{0,154} + 0,50 \times -1,81 = -2,65 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,42}{0,154} + 0,50 \times 8,69 = -4,87 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,38}{0,154} + 0,50 \times 0,78 = -2,11 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 2,11 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

Toetsing betondrukkkracht

$$n_{cb} = \left| \frac{1}{2} (n_{xxb} + n_{yyb}) - \sqrt{\frac{1}{4} (n_{xxb} - n_{yyb})^2 + n_{xyb}^2} \right| =$$

$$= \left| \frac{1}{2} (-2,65 + -4,87) - \sqrt{\frac{1}{4} (-2,65 - -4,87)^2 + -2,11^2} \right| = 6,14 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

$$A_{sxt,min} = 11 \text{ mm}^2/\text{m}$$

$$A_{syx,min} = 47 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.24 Knoop 472 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -1,46 \text{ kN/m} \quad n_{yy} = 7,13 \text{ kN/m} \quad n_{xy} = 0,60 \text{ kN/m}$$

$$m_{xx} = -0,220 \text{ kNm/m} \quad m_{yy} = -1,16 \text{ kNm/m} \quad m_{xy} = -0,32 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,22}{0,154} + (1 - 0,50) \times -1,46 = 0,70 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,16}{0,154} + (1 - 0,50) \times 7,13 = 11,11 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,32}{0,154} + (1 - 0,50) \times 0,60 = 2,35 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,35 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 0,70 + 2,35 = 3,05 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 11,11 + 2,35 = 13,46 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{3,05 \times 10^3}{11} = 284 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 11 / 51300 = 0,000209 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000209 = 6585 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{284 - 0,4 \frac{2,21}{0,000209} (1 + 6,68 \times 0,000209)}{200000} = -0,019739$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{284}{200000} = 0,000852 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000852 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{13,46 \times 10^3}{47} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 47 / 51300 = 0,000922 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000922 = 1588 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \varnothing ; 15\varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000922} (1 + 6,68 \times 0,000922)}{200000} = -0,003403$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000854 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000854 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschiil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,22}{0,154} + 0,50 \times -1,46 = -2,16 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,16}{0,154} + 0,50 \times 7,13 = -3,99 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,32}{0,154} + 0,50 \times 0,60 = -1,75 \text{ kN/m}$$

$$n_{0b} = | n_{xyb} | = 1,75 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

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

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

$$4: n_{xxb} n_{yyb} > n_{0b}^2 \quad n_{xxb} < 0 \quad n_{yyb} < 0 \quad \text{ja} \rightarrow \text{Geval 4 geen wapening}$$

2.4.25 Knoop 340 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 200 \text{ mm} \quad d_t = 46 \text{ mm} \quad d_b = 46 \text{ mm} \quad d_v = 154 \text{ mm}$$

$$n_{xx} = -0,23 \text{ kN/m} \quad n_{yy} = 9,21 \text{ kN/m} \quad n_{xy} = 0,90 \text{ kN/m}$$

$$m_{xx} = 0,126 \text{ kNm/m} \quad m_{yy} = -1,54 \text{ kNm/m} \quad m_{xy} = -0,30 \text{ kNm/m}$$

$$v_x = 1,06 \text{ kN/m} \quad v_y = -1,64 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{1,06^2 + (-1,64)^2} = 1,95 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-1,64}{1,06} = -1,549 \quad \varphi_0 = -57,2^\circ$$

$$\sin \varphi_0 = -0,840 \quad \cos \varphi_0 = 0,542$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 4 / (1000 \times 167) = 0,000023$$

$$\rho_{ly} = A_{sly} / (b_w d) = 49 / (1000 \times 167) = 0,000292$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000213 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 5,62 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{167}} = 2,094 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -5618 / 200000 = -0,028 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000213 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 167 \times 10^{-3} = 29,47 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 167 \times 10^{-3} = 73,23 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(29,47; 73,23) = 73,23 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,13}{0,154} + (1 - 0,50) \times -0,23 = -0,94 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,54}{0,154} + (1 - 0,50) \times 9,21 = 14,60 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,30}{0,154} + (1 - 0,50) \times 0,90 = 2,39 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,39 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkracht

$$n_{ct} = 2 n_{0t} = 2 \times 2,39 = 4,77 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = -0,94 + 2,39 = 1,45 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{0t} = 14,60 + 2,39 = 16,98 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{1,45 \times 10^3}{435} = 3 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{16,98 \times 10^3}{435} = 39 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,13}{0,154} + 0,50 \times -0,23 = 0,70 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,54}{0,154} + 0,50 \times 9,21 = -5,38 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,30}{0,154} + 0,50 \times 0,90 = -1,49 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 1,49 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

$$2: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{yyb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Toetsing betondrukkracht

$$n_{cb} = (-n_{yyb}) + \frac{n_{0b}^2}{(-n_{yyb})} = 5,38 + \frac{1,49^2}{5,38} = 5,80 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 46 \times 10^{-3} = 614,67 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + \frac{n_{0b}^2}{(-n_{yyb})} = 0,70 + \frac{1,49^2}{5,38} = 1,12 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{1,12 \times 10^3}{435} = 3 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 49 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 3 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.26 Knoop 340 - BGT Combinatie: 5 Permanent

$$h = 200 \text{ mm}$$

$$d_t = 46 \text{ mm}$$

$$d_b = 46 \text{ mm}$$

$$d_v = 154 \text{ mm}$$

$$n_{xx} = -0,19 \text{ kN/m}$$

$$n_{yy} = 7,55 \text{ kN/m}$$

$$n_{xy} = 0,69 \text{ kN/m}$$

$$m_{xx} = 0,104 \text{ kNm/m}$$

$$m_{yy} = -1,26 \text{ kNm/m}$$

$$m_{xy} = -0,24 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,10}{0,154} + (1 - 0,50) \times -0,19 = -0,77 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{1,26}{0,154} + (1 - 0,50) \times 7,55 = 11,96 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,24}{0,154} + (1 - 0,50) \times 0,69 = 1,93 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 1,93 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{ja} \rightarrow \text{Geval 1 wapening in x- en y-richting}$$

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

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = -0,77 + 1,93 = 1,17 \text{ kN/m}$$

$$n_{syt} = n_{yyt} + n_{0t} = 11,96 + 1,93 = 13,90 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{1,17 \times 10^3}{4} = 299 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 4 / 82500 = 0,000047 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000047 = 28792 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h - x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{299 - 0,4 \frac{2,21}{0,000076} (1 + 6,68 \times 0,000076)}{200000} = -0,056562$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{299}{200000} = 0,000896 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000896 = 0,179 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syt}}{A_{syt}} = \frac{13,90 \times 10^3}{49} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 49 / 51300 = 0,000952 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000952 = 1541 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000952} (1 + 6,68 \times 0,000952)}{200000} = -0,003251$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000854 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000854 = 0,171 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschi

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,10}{0,154} + 0,50 \times -0,19 = 0,58 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-1,26}{0,154} + 0,50 \times 7,55 = -4,41 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,24}{0,154} + 0,50 \times 0,69 = -1,24 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 1,24 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

$$2: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{yyb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + \frac{n_{0b}^2}{(-n_{yyb})} = 0,58 + \frac{1,24^2}{4,41} = 0,93 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{0,93 \times 10^3}{3} = 289 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (200 - 167) ; (200 - 46) / 3] = 51 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 3 / 51300 = 0,000063 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000063 = 21804 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (200 - 46) = 200 \text{ mm} \rightarrow s_{r,max} = 200 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{289 - 0,4 \frac{2,21}{0,000063} (1 + 6,68 \times 0,000063)}{200000} = -0,069185$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{289}{200000} = 0,000868 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 200 \times 0,000868 = 0,174 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.27 Knoop 476 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 150 \text{ mm} \quad d_t = 41 \text{ mm} \quad d_b = 41 \text{ mm} \quad d_v = 109 \text{ mm}$$

$$n_{xx} = 0,00 \text{ kN/m} \quad n_{yy} = 7,51 \text{ kN/m} \quad n_{xy} = -3,52 \text{ kN/m}$$

$$m_{xx} = 0,147 \text{ kNm/m} \quad m_{yy} = 0,63 \text{ kNm/m} \quad m_{xy} = -0,30 \text{ kNm/m}$$

$$v_x = 0,78 \text{ kN/m} \quad v_y = -1,78 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{0,78^2 + (-1,78)^2} = 1,94 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-1,78}{0,78} = -2,298 \quad \varphi_0 = -66,5^\circ$$

$$\sin \varphi_0 = -0,917 \quad \cos \varphi_0 = 0,399$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 17 / (1000 \times 117) = 0,000143$$

$$\rho_{ly} = A_{sly} / (b_w d) = 40 / (1000 \times 117) = 0,000345$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000313 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 8,89 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{117}} = 2,307 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -8889 / 150000 = -0,1 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000313 \times 20)^{1/3} + 0,15 \times -0,1] \times 1000 \times 117 \times 10^{-3} = 22,98 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times -0,1) \times 1000 \times 117 \times 10^{-3} = 50,758 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(22,98; 50,76) = 50,76 \text{ kN}$$

$$v_0 < V_{Rd,c} \rightarrow \text{Er is geen dwarskrachtwapening nodig.}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,15}{0,109} + (1 - 0,50) \times 0,00 = -1,35 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,63}{0,109} + (1 - 0,50) \times 7,51 = -2,06 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,30}{0,109} + (1 - 0,50) \times -3,52 = 0,96 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 0,96 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Toetsing betondrukkracht

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

$$= \left| \frac{1}{2} (-1,35 + -2,06) - \sqrt{\frac{1}{4} (-1,35 - -2,06)^2 + 0,96^2} \right| = 2,73 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,15}{0,109} + 0,50 \times 0,00 = 1,35 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,63}{0,109} + 0,50 \times 7,51 = 9,57 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,30}{0,109} + 0,50 \times -3,52 = -4,48 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 4,48 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkracht

$$n_{cb} = 2 n_{0b} = 2 \times 4,48 = 8,96 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 1,35 + 4,48 = 5,83 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 9,57 + 4,48 = 14,05 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{5,83 \times 10^3}{435} = 13 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{14,05 \times 10^3}{435} = 32 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 17 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 40 \text{ mm}^2/\text{m}$$

2.4.28 Knoop 476 - BGT Combinatie: 5 Permanent

$$h = 150 \text{ mm} \quad d_t = 41 \text{ mm} \quad d_b = 41 \text{ mm} \quad d_v = 109 \text{ mm}$$

$$n_{xx} = 0,00 \text{ kN/m} \quad n_{yy} = 6,15 \text{ kN/m} \quad n_{xy} = -2,89 \text{ kN/m}$$

$$m_{xx} = 0,120 \text{ kNm/m} \quad m_{yy} = 0,52 \text{ kNm/m} \quad m_{xy} = -0,24 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma)n_{xx} = \frac{-0,12}{0,109} + (1 - 0,50) \times 0,00 = -1,10 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma)n_{yy} = \frac{-0,52}{0,109} + (1 - 0,50) \times 6,15 = -1,69 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma)n_{xy} = \frac{0,24}{0,109} + (1 - 0,50) \times -2,89 = 0,79 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 0,79 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

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

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

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,12}{0,109} + 0,50 \times 0,00 = 1,11 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,52}{0,109} + 0,50 \times 6,15 = 7,84 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,24}{0,109} + 0,50 \times -2,89 = -3,67 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,67 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 1,11 + 3,67 = 4,78 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 7,84 + 3,67 = 11,51 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{4,78 \times 10^3}{17} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,\text{eff},y} = A_s / A_{c,\text{eff}} = 17 / 36300 = 0,000462 \quad \dots(7.10)$$

$$s_{r,\text{max},y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},y} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000462 = 3030 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},y} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},y} = 272 \text{ mm}$$

$$s_{r,\text{max},y} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,\text{max},y} = 142 \text{ mm} \quad \dots(7.14)$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,\text{eff},z} = A_s / A_{c,\text{eff}} = 40 / 36300 = 0,001113 \quad \dots(7.10)$$

$$s_{r,\text{max},z} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},z} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,001113 = 1335 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},z} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},z} = 272 \text{ mm}$$

$$s_{r,\text{max},z} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,\text{max},z} = 142 \text{ mm} \quad \dots(7.14)$$

$$s_{r,\text{max}} = \frac{1}{\frac{\cos\theta}{s_{r,\text{max},y}} + \frac{\sin\theta}{s_{r,\text{max},z}}} = \frac{1}{\frac{0,904}{142} + \frac{0,428}{142}} = 106 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{\text{cm}} = 200000 / 29962 = 6,68$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = \frac{\sigma_s - k_t \frac{f_{ct,\text{eff}}}{\rho_{p,\text{eff}}} (1 + \alpha_e \rho_{p,\text{eff}})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000462} (1 + 6,68 \times 0,000462)}{200000} = -0,008176$$

$$\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{\text{sm}} - \varepsilon_{\text{cm}} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,\text{max}} (\varepsilon_{\text{sm}} - \varepsilon_{\text{cm}}) = 106 \times 0,000855 = 0,091 \text{ mm} < w_{\text{max}} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{\text{syb}}}{A_{\text{syb}}} = \frac{11,51 \times 10^3}{40} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,\text{eff},y} = A_s / A_{c,\text{eff}} = 40 / 36300 = 0,001113 \quad \dots(7.10)$$

$$s_{r,\text{max},y} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff},y} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,001113 = 1335 \text{ mm} \quad \dots(7.11)$$

$$s_{r,\text{max},y} > \max [(50-0,8f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max},y} = 272 \text{ mm}$$

$$s_{r,\text{max},y} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,\text{max},y} = 142 \text{ mm} \quad \dots(7.14)$$

$$h_{\text{eff}} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,\text{eff},z} = A_s / A_{c,\text{eff}} = 17 / 36300 = 0,000462 \quad \dots(7.10)$$

$$s_{r,max,z} = k_3 c + k_1 k_2 k_4 \sigma_{p,eff,z} / \rho_{p,eff,z} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000462 = 3030 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max,z} > \max [(50 - 0,8 f_{c,k}) \sigma_c ; 15 \sigma_c] = 272 \text{ mm} \rightarrow s_{r,max,z} = 272 \text{ mm}$$

$$s_{r,max,z} > 1,3 (h - x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max,z} = 142 \text{ mm} \quad \dots(7.14)$$

$$s_{r,max} = \frac{1}{\frac{\cos \theta}{s_{r,max,y}} + \frac{\sin \theta}{s_{r,max,z}}} = \frac{1}{\frac{0,904}{142} + \frac{0,428}{142}} = 106 \text{ mm} \quad \dots(7.15)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,001113} (1 + 6,68 \times 0,001113)}{200000} = -0,002578$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 106 \times 0,000855 = 0,091 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.29 Knoop 336 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 150 \text{ mm} \quad d_t = 41 \text{ mm} \quad d_b = 41 \text{ mm} \quad d_v = 109 \text{ mm}$$

$$n_{xx} = 0,79 \text{ kN/m} \quad n_{yy} = 11,61 \text{ kN/m} \quad n_{xy} = -3,62 \text{ kN/m}$$

$$m_{xx} = -0,059 \text{ kNm/m} \quad m_{yy} = 0,79 \text{ kNm/m} \quad m_{xy} = -0,23 \text{ kNm/m}$$

$$v_x = -0,14 \text{ kN/m} \quad v_y = -1,33 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-0,14^2 + -1,33^2} = 1,34 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{-1,33}{-0,14} = 9,686 \quad \varphi_0 = 84,1^\circ$$

$$\sin \varphi_0 = 0,995 \quad \cos \varphi_0 = 0,103$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 9 / (1000 \times 117) = 0,000074$$

$$\rho_{ly} = A_{sly} / (b_w d) = 49 / (1000 \times 117) = 0,000417$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000413 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 10,75 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{117}} = 2,307 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -10752 / 150000 = -0,1 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000413 \times 20)^{1/3} + 0,15 \times -0,1] \times 1000 \times 117 \times 10^{-3} = 25,1 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times -0,1) \times 1000 \times 117 \times 10^{-3} = 50,54 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(25,1; 50,54) = 50,54 \text{ kN}$$

$$v_0 < V_{Rd,c} \rightarrow \text{Er is geen dwarskrachtwapening nodig.}$$

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,06}{0,109} + (1 - 0,50) \times 0,79 = 0,93 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,79}{0,109} + (1 - 0,50) \times 11,61 = -1,45 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,23}{0,109} + (1 - 0,50) \times -3,62 = 0,29 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 0,29 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

$$2: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{yyt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Toetsing betondrukkraft

$$n_{ct} = (-n_{yyt}) + \frac{n_{0t}^2}{(-n_{yyt})} = 1,45 + \frac{0,29^2}{1,45} = 1,51 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + \frac{n_{0t}^2}{(-n_{yyt})} = 0,93 + \frac{0,29^2}{1,45} = 0,99 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{0,99 \times 10^{-3}}{435} = 2 \text{ mm}^2/\text{m}$$

Onderschi

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,06}{0,109} + 0,50 \times 0,79 = -0,15 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,79}{0,109} + 0,50 \times 11,61 = 13,06 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,23}{0,109} + 0,50 \times -3,62 = -3,91 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,91 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkraft

$$n_{cb} = 2 n_{0b} = 2 \times 3,91 = 7,83 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = -0,15 + 3,91 = 3,77 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 13,06 + 3,91 = 16,97 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{3,77 \times 10^{-3}}{435} = 9 \text{ mm}^2/\text{m}$$

$$A_{syb,ULS} = \frac{n_{syb}}{f_{yd}} = \frac{16,97 \times 10^{-3}}{435} = 39 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 3 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 49 \text{ mm}^2/\text{m}$$

2.4.30 Knoop 336 - BGT Combinatie: 5 Permanent

$$h = 150 \text{ mm}$$

$$d_t = 41 \text{ mm}$$

$$d_b = 41 \text{ mm}$$

$$d_v = 109 \text{ mm}$$

$$n_{xx} = 0,65 \text{ kN/m}$$

$$n_{yy} = 9,51 \text{ kN/m}$$

$$n_{xy} = -2,97 \text{ kN/m}$$

$$m_{xx} = -0,048 \text{ kNm/m}$$

$$m_{yy} = 0,65 \text{ kNm/m}$$

$$m_{xy} = -0,19 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{0,05}{0,109} + (1 - 0,50) \times 0,65 = 0,77 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{-0,65}{0,109} + (1 - 0,50) \times 9,51 = -1,19 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,19}{0,109} + (1 - 0,50) \times -2,97 = 0,24 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 0,24 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

$$2: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{yyt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + \frac{n_{0t}^2}{(-n_{yyt})} = 0,77 + \frac{0,24^2}{1,19} = 0,81 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{0,81 \times 10^3}{3} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 3 / 36300 = 0,000079 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000079 = 17398 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{\tau_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000079} (1 + 6,68 \times 0,000079)}{200000} = -0,054883$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{-0,05}{0,109} + 0,50 \times 0,65 = -0,12 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{0,65}{0,109} + 0,50 \times 9,51 = 10,70 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,19}{0,109} + 0,50 \times -2,97 = -3,21 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,21 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = -0,12 + 3,21 = 3,09 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 10,70 + 3,21 = 13,91 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{3,09 \times 10^{-3}}{9} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 9 / 82500 = 0,000105 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000105 = 13036 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h - x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000239} (1 + 6,68 \times 0,000239)}{200000} = -0,016771$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001069 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,001069 = 0,151 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{13,91 \times 10^{-3}}{49} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 49 / 36300 = 0,001344 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,001344 = 1124 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,001344} (1 + 6,68 \times 0,001344)}{200000} = -0,001893$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.31 Knoop 368 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 150 \text{ mm} \quad d_t = 41 \text{ mm} \quad d_b = 41 \text{ mm} \quad d_v = 109 \text{ mm}$$

$$n_{xx} = 2,00 \text{ kN/m} \quad n_{yy} = 1,54 \text{ kN/m} \quad n_{xy} = 9,50 \text{ kN/m}$$

$$m_{xx} = 0,034 \text{ kNm/m} \quad m_{yy} = -0,06 \text{ kNm/m} \quad m_{xy} = -0,17 \text{ kNm/m}$$

$$v_x = 0,87 \text{ kN/m} \quad v_y = 0,22 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{0,87^2 + 0,22^2} = 0,90 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,22}{0,87} = 0,248 \quad \varphi_0 = 13,9^\circ$$

$$\sin \varphi_0 = 0,240 \quad \cos \varphi_0 = 0,971$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 16 / (1000 \times 117) = 0,000137$$

$$\rho_{ly} = A_{sly} / (b_w d) = 22 / (1000 \times 117) = 0,000186$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,00014 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = 6,41 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{117}} = 2,307 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = -6410 / 150000 = 0 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,00014 \times 20)^{1/3} + 0,15 \times 0] \times 1000 \times 117 \times 10^{-3} = 17,61 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0) \times 1000 \times 117 \times 10^{-3} = 51,048 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(17,61; 51,05) = 51,05 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,03}{0,109} + (1 - 0,50) \times 2,00 = 0,69 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,06}{0,109} + (1 - 0,50) \times 1,54 = 1,29 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,17}{0,109} + (1 - 0,50) \times 9,50 = 6,28 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 6,28 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja $\rightarrow$ Geval 1 wapening in x- en y-richting

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

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

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

Toetsing betondrukkracht

$$n_{ct} = 2 n_{0t} = 2 \times 6,28 = 12,56 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxt} = n_{xxt} + n_{0t} = 0,69 + 6,28 = 6,97 \text{ kN/m}$$

$$n_{syx} = n_{yyt} + n_{0t} = 1,29 + 6,28 = 7,57 \text{ kN/m}$$

$$A_{sxt,ULS} = \frac{n_{sxt}}{f_{yd}} = \frac{6,97 \times 10^{-3}}{435} = 16 \text{ mm}^2/\text{m}$$

$$A_{syx,ULS} = \frac{n_{syx}}{f_{yd}} = \frac{7,57 \times 10^{-3}}{435} = 17 \text{ mm}^2/\text{m}$$

Onderschl

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,03}{0,109} + 0,50 \times 2,00 = 1,31 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,06}{0,109} + 0,50 \times 1,54 = 0,26 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,17}{0,109} + 0,50 \times 9,50 = 3,22 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,22 \text{ kN/m}$$

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

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

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

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

Toetsing betondrukkracht

$$n_{cb} = 2 n_{0b} = 2 \times 3,22 = 6,43 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + n_{0b} = 1,31 + 3,22 = 4,53 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,26 + 3,22 = 3,47 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{4,53 \times 10^{-3}}{435} = 10 \text{ mm}^2/\text{m}$$

$$A_{\text{syb,ULS}} = \frac{n_{\text{syb}}}{f_{\text{yd}}} = \frac{3,47 \times 10^3}{435} = 8 \text{ mm}^2/\text{m}$$

$$A_{\text{sxt,min}} = 0 \text{ mm}^2/\text{m}$$

$$A_{\text{syt,min}} = 22 \text{ mm}^2/\text{m}$$

$$A_{\text{sxb,min}} = 0 \text{ mm}^2/\text{m}$$

$$A_{\text{syb,min}} = 10 \text{ mm}^2/\text{m}$$

2.4.32 Knoop 368 - BGT Combinatie: 5 Permanent

$$h = 150 \text{ mm}$$

$$d_t = 41 \text{ mm}$$

$$d_b = 41 \text{ mm}$$

$$d_v = 109 \text{ mm}$$

$$n_{xx} = 1,64 \text{ kN/m}$$

$$n_{yy} = 1,27 \text{ kN/m}$$

$$n_{xy} = 7,77 \text{ kN/m}$$

$$m_{xx} = 0,028 \text{ kNm/m}$$

$$m_{yy} = -0,05 \text{ kNm/m}$$

$$m_{xy} = -0,14 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,03}{0,109} + (1 - 0,50) \times 1,64 = 0,57 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,05}{0,109} + (1 - 0,50) \times 1,27 = 1,06 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{0,14}{0,109} + (1 - 0,50) \times 7,77 = 5,14 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 5,14 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t}$$

$$n_{yyt} > -n_{0t}$$

ja → Geval 1 wapening in x- en y-richting

$$2: n_{xxt} n_{yyt} < n_{0t}^2$$

$$n_{yyt} < -n_{0t}$$

nee

$$3: n_{xxt} n_{yyt} < n_{0t}^2$$

$$n_{xxt} < -n_{0t}$$

nee

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

$$n_{xxt} < 0 \quad n_{yyt} < 0$$

nee

Berekening van scheurwijdte

$$n_{sxt} = n_{xxt} + n_{0t} = 0,57 + 5,14 = 5,71 \text{ kN/m}$$

$$n_{synt} = n_{yyt} + n_{0t} = 1,06 + 5,14 = 6,20 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxt}}{A_{sxt}} = \frac{5,71 \times 10^3}{16} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{\text{nom}}}; 2 \right) = \min \left(\frac{25}{15}; 2 \right) = 1,67$$

$$w_{\text{max}} = w_{\text{max}} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{\text{eff}} = \min [2,5 (h-d); h/2] = \min [2,5 \times (150 - 117); 150/2] = 75 \text{ mm}$$

$$\rho_{p,\text{eff}} = A_s / A_{c,\text{eff}} = 16 / 75000 = 0,000214$$

...(7.10)

$$s_{r,\text{max}} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,\text{eff}} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000214 = 6446 \text{ mm}$$

...(7.11)

$$s_{r,\text{max}} > \max [(50 - 0,8 f_{c,k}) \emptyset; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,\text{max}} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000442} (1 + 6,68 \times 0,000442)}{200000} = -0,008258$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001068 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,001068 = 0,151 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syf}}{A_{syf}} = \frac{6,20 \times 10^3}{22} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (150 - 117) ; 150 / 2] = 75 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 22 / 75000 = 0,00029 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,00029 = 4801 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000599} (1 + 6,68 \times 0,000599)}{200000} = -0,005982$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,03}{0,109} + 0,50 \times 1,64 = 1,08 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,05}{0,109} + 0,50 \times 1,27 = 0,21 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{-0,14}{0,109} + 0,50 \times 7,77 = 2,63 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 2,63 \text{ kN/m}$$

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

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

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + n_{0b} = 1,08 + 2,63 = 3,71 \text{ kN/m}$$

$$n_{syb} = n_{yyb} + n_{0b} = 0,21 + 2,63 = 2,84 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{3,71 \times 10^{-3}}{10} = 356 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (150 - 117) ; 150 / 2] = 75 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 10 / 75000 = 0,000139 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000139 = 9876 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{356 - 0,4 \frac{2,21}{0,000287} (1 + 6,68 \times 0,000287)}{200000} = -0,013653$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{356}{200000} = 0,001068 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,001068 = 0,151 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

$$\sigma_s = \frac{n_{syb}}{A_{syb}} = \frac{2,84 \times 10^{-3}}{10} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; h / 2] = \min [2,5 \times (150 - 117) ; 150 / 2] = 75 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 10 / 75000 = 0,000133 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000133 = 10328 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50-0,8f_{c,k}) \emptyset ; 15\emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000275} (1 + 6,68 \times 0,000275)}{200000} = -0,014679$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000854 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000854 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

2.4.33 Knoop 45 - UGT Combinatie: 1 #a Permanent + Scheefstand 1/200 +X

$$h = 150 \text{ mm} \quad d_t = 41 \text{ mm} \quad d_b = 41 \text{ mm} \quad d_v = 109 \text{ mm}$$

$$n_{xx} = -2,09 \text{ kN/m} \quad n_{yy} = -0,52 \text{ kN/m} \quad n_{xy} = 7,27 \text{ kN/m}$$

$$m_{xx} = 0,202 \text{ kNm/m} \quad m_{yy} = -0,57 \text{ kNm/m} \quad m_{xy} = 0,09 \text{ kNm/m}$$

$$v_x = -0,37 \text{ kN/m} \quad v_y = 0,23 \text{ kN/m} \quad \theta = 22^\circ$$

$$v_0 = \sqrt{v_x^2 + v_y^2} = \sqrt{-0,37^2 + 0,23^2} = 0,44 \text{ kN/m}$$

$$\tan \varphi_0 = \frac{v_y}{v_x} = \frac{0,23}{-0,37} = -0,625 \quad \varphi_0 = -32,0$$

$$\sin \varphi_0 = -0,530 \quad \cos \varphi_0 = 0,848$$

Opneembare dwarskracht

$$\rho_{lx} = A_{slx} / (b_w d) = 0 / (1000 \times 117) = 0$$

$$\rho_{ly} = A_{sly} / (b_w d) = 22 / (1000 \times 117) = 0,00019$$

$$\rho_l = \rho_{lx} \cos^2 \varphi_0 + \rho_{ly} \sin^2 \varphi_0 = 0,000053 \leq 0,02$$

$$n_{nn} = n_{xx} \cos^2 \varphi_0 + n_{yy} \sin^2 \varphi_0 + n_{xy} \sin 2\varphi_0 = -8,19 \text{ kN/m}$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{117}} = 2,307 > 2,0 \rightarrow k = 2,0$$

$$\sigma_{cp} = n_{nn} / A_c = 8187 / 150000 = 0,1 \text{ MPa} < 0,2 f_{cd}$$

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

$$= [0,12 \times 2 \times (100 \times 0,000053 \times 20)^{1/3} + 0,15 \times 0,1] \times 1000 \times 117 \times 10^{-3} = 14,29 \text{ kN}$$

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

$$V_{Rd,c} = (v_{min} + k_1 \sigma_{cp}) b_w d = (0,443 + 0,15 \times 0,1) \times 1000 \times 117 \times 10^{-3} = 52,756 \text{ kN} \dots(6.2.b)$$

$$V_{Rd,c} = \max(V_{Rd,c(6.2.a)}; V_{Rd,c(6.2.b)}) = \max(14,29; 52,76) = 52,76 \text{ kN}$$

$v_0 < V_{Rd,c} \rightarrow$ Er is geen dwarskrachtwapening nodig.

Bovenschild

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,20}{0,109} + (1 - 0,50) \times -2,09 = -2,90 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,57}{0,109} + (1 - 0,50) \times -0,52 = 4,98 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,09}{0,109} + (1 - 0,50) \times 7,27 = 2,83 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,83 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Toetsing betondrukkraft

$$n_{ct} = (-n_{xxt}) + \frac{n_{0t}^2}{(-n_{xxt})} = 2,90 + \frac{2,83^2}{2,90} = 5,66 \text{ kN/m}$$

$$n_{ct} < 1,0 f_{cd} b_w d_t = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{synt} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = 4,98 + \frac{2,83^2}{2,90} = 7,74 \text{ kN/m}$$

$$A_{synt,ULS} = \frac{n_{synt}}{f_{yd}} = \frac{7,74 \times 10^{-3}}{435} = 18 \text{ mm}^2/\text{m}$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,20}{0,109} + 0,50 \times -2,09 = 0,81 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,57}{0,109} + 0,50 \times -0,52 = -5,50 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,09}{0,109} + 0,50 \times 7,27 = 4,44 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 4,44 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

$$2: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{yyb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Toetsing betondrukkraft

$$n_{cb} = (-n_{yyb}) + \frac{n_{0b}^2}{(-n_{yyb})} = 5,50 + \frac{4,44^2}{5,50} = 9,08 \text{ kN/m}$$

$$n_{cb} < 1,0 f_{cd} b_w d_b = 1,0 \times 13,33 \times 1000 \times 41 \times 10^{-3} = 548,00 \text{ kN/m}$$

Berekening wapening

$$n_{sxb} = n_{xxb} + \frac{n_{0b}^2}{(-n_{yyb})} = 0,81 + \frac{4,44^2}{5,50} = 4,39 \text{ kN/m}$$

$$A_{sxb,ULS} = \frac{n_{sxb}}{f_{yd}} = \frac{4,39 \times 10^{-3}}{435} = 10 \text{ mm}^2/\text{m}$$

$$A_{sxt,min} = 0 \text{ mm}^2/\text{m}$$

$$A_{syt,min} = 22 \text{ mm}^2/\text{m}$$

$$A_{sxb,min} = 13 \text{ mm}^2/\text{m}$$

$$A_{syb,min} = 0 \text{ mm}^2/\text{m}$$

2.4.34 Knoop 45 - BGT Combinatie: 5 Permanent

$$h = 150 \text{ mm}$$

$$d_t = 41 \text{ mm}$$

$$d_b = 41 \text{ mm}$$

$$d_v = 109 \text{ mm}$$

$$n_{xx} = -1,71 \text{ kN/m}$$

$$n_{yy} = -0,42 \text{ kN/m}$$

$$n_{xy} = 5,96 \text{ kN/m}$$

$$m_{xx} = 0,166 \text{ kNm/m}$$

$$m_{yy} = -0,47 \text{ kNm/m}$$

$$m_{xy} = 0,07 \text{ kNm/m}$$

Bovenscil

$$n_{xxt} = \frac{-m_{xx}}{d_v} + (1 - \gamma) n_{xx} = \frac{-0,17}{0,109} + (1 - 0,50) \times -1,71 = -2,38 \text{ kN/m}$$

$$n_{yyt} = \frac{-m_{yy}}{d_v} + (1 - \gamma) n_{yy} = \frac{0,47}{0,109} + (1 - 0,50) \times -0,42 = 4,08 \text{ kN/m}$$

$$n_{xyt} = \frac{-m_{xy}}{d_v} + (1 - \gamma) n_{xy} = \frac{-0,07}{0,109} + (1 - 0,50) \times 5,96 = 2,32 \text{ kN/m}$$

$$n_{0t} = |n_{xyt}| = 2,32 \text{ kN/m}$$

$$1: n_{xxt} > -n_{0t} \quad n_{yyt} > -n_{0t} \quad \text{nee}$$

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

$$3: n_{xxt} n_{yyt} < n_{0t}^2 \quad n_{xxt} < -n_{0t} \quad \text{ja} \rightarrow \text{Geval 3 wapening in alleen y-richting}$$

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

Berekening van scheurwijdte

$$n_{synt} = n_{yyt} + \frac{n_{0t}^2}{(-n_{xxt})} = 4,08 + \frac{2,32^2}{2,38} = 6,35 \text{ kN/m}$$

$$\sigma_s = \frac{n_{synt}}{A_{synt}} = \frac{6,35 \times 10^3}{22} = 285 \text{ MPa}$$

$$k_x = \min \left(\frac{c}{c_{nom}} ; 2 \right) = \min \left(\frac{25}{15} ; 2 \right) = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 22 / 36300 = 0,000613 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \emptyset / \rho_{p,eff} = 3,4 \times 33 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000613 = 2330 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \emptyset ; 15 \emptyset] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000613} (1 + 6,68 \times 0,000613)}{200000} = -0,005812$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$

Onderschil

$$n_{xxb} = \frac{m_{xx}}{d_v} + \gamma n_{xx} = \frac{0,17}{0,109} + 0,50 \times -1,71 = 0,67 \text{ kN/m}$$

$$n_{yyb} = \frac{m_{yy}}{d_v} + \gamma n_{yy} = \frac{-0,47}{0,109} + 0,50 \times -0,42 = -4,51 \text{ kN/m}$$

$$n_{xyb} = \frac{m_{xy}}{d_v} + \gamma n_{xy} = \frac{0,07}{0,109} + 0,50 \times 5,96 = 3,64 \text{ kN/m}$$

$$n_{0b} = |n_{xyb}| = 3,64 \text{ kN/m}$$

$$1: n_{xxb} > -n_{0b} \quad n_{yyb} > -n_{0b} \quad \text{nee}$$

$$2: n_{xxb} n_{yyb} < n_{0b}^2 \quad n_{yyb} < -n_{0b} \quad \text{ja} \rightarrow \text{Geval 2 wapening in alleen x-richting}$$

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

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

Berekening van scheurwijdte

$$n_{sxb} = n_{xxb} + \frac{n_{0b}^2}{(-n_{yyb})} = 0,67 + \frac{3,64^2}{4,51} = 3,60 \text{ kN/m}$$

$$\sigma_s = \frac{n_{sxb}}{A_{sxb}} = \frac{3,60 \times 10^{-3}}{13} = 285 \text{ MPa}$$

$$k_x = \min \left[\frac{c}{c_{nom}} ; 2 \right] = \min \left[\frac{25}{15} ; 2 \right] = 1,67$$

$$w_{max} = w_{max} k_x = 0,4 \times 1,67 = 0,67 \text{ mm}$$

$$h_{eff} = \min [2,5 (h-d) ; (h-x) / 3] = \min [2,5 \times (150 - 117) ; (150 - 41) / 3] = 36 \text{ mm}$$

$$\rho_{p,eff} = A_s / A_{c,eff} = 13 / 36300 = 0,000348 \quad \dots(7.10)$$

$$s_{r,max} = k_3 c + k_1 k_2 k_4 \varnothing / \rho_{p,eff} = 3,4 \times 25 + 0,8 \times 0,5 \times 0,425 \times 8 / 0,000348 = 3992 \text{ mm} \quad \dots(7.11)$$

$$s_{r,max} > \max [(50 - 0,8 f_{c,k}) \varnothing ; 15 \varnothing] = 272 \text{ mm} \rightarrow s_{r,max} = 272 \text{ mm}$$

$$s_{r,max} > 1,3 (h-x) = 1,3 \times (150 - 41) = 142 \text{ mm} \rightarrow s_{r,max} = 142 \text{ mm} \quad \dots(7.14)$$

$$\alpha_e = E_s / E_{cm} = 200000 / 29962 = 6,68$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - k_t \frac{f_{ct,eff}}{\rho_{p,eff}} (1 + \alpha_e \rho_{p,eff})}{E_s} = \frac{285 - 0,4 \frac{2,21}{0,000348} (1 + 6,68 \times 0,000348)}{200000} = -0,011306$$

$$\varepsilon_{sm} - \varepsilon_{cm} < 0,6 \frac{\sigma_s}{E_s} \rightarrow \varepsilon_{sm} - \varepsilon_{cm} = 0,6 \frac{\sigma_s}{E_s} = 0,6 \frac{285}{200000} = 0,000855 \quad \dots(7.9)$$

$$w_k = s_{r,max} (\varepsilon_{sm} - \varepsilon_{cm}) = 142 \times 0,000855 = 0,121 \text{ mm} < w_{max} = 0,67 \text{ mm} \quad \dots(7.8)$$