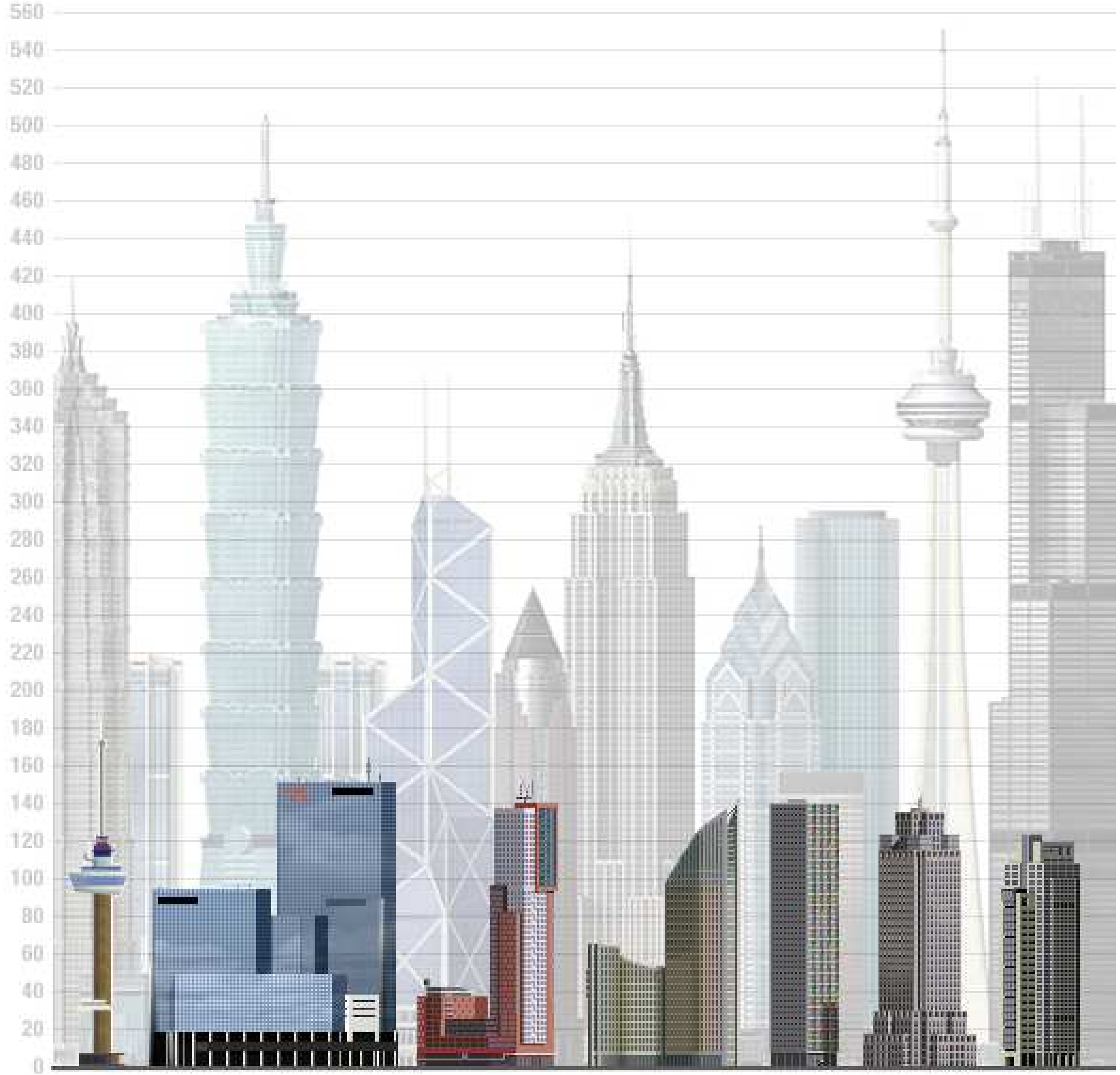
Super high-rise in Rotterdam
Part 3: Appendices



Master's Thesis Report

U.M. Winter

March 2011

Content

Appendices

Appendix A: Reduction of wind induced vibration through openings slots or vents.

The Effect of Open Passage on Reducing Wind Response of Tall Buildings

Experiment and Results

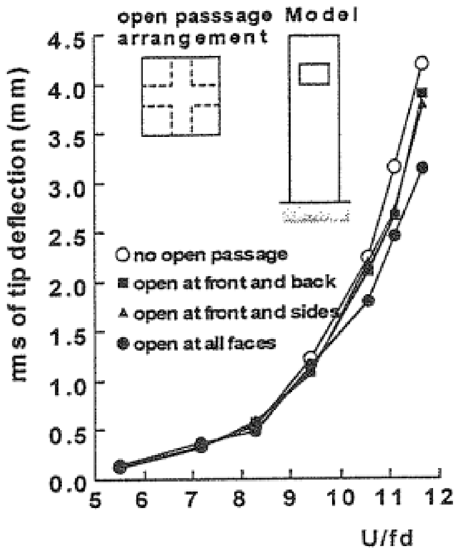


Figure 1 Model dynamic deflection with a damping coefficient 0.38%

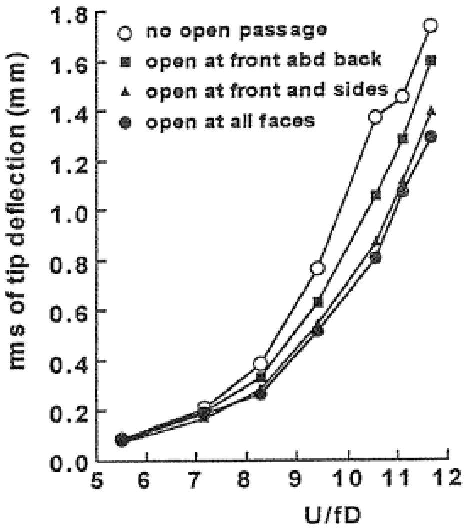


Figure 2 Model dynamic deflection with a damping coefficient 2.6%

- Aspect ratio 8:1
- Opening ratio 1,5 %
- Square cross-section
- Location open passage at 80% of the building height

Conclusions

1.) The open passage configuration results in a significant reduction of the dynamic response of the building model in the across wind direction induced by the period vortex shedding on building corners. The model dynamic deflection reduces about 20-25% even for a very small opening ratio 1,5% on all its 4 walls.

2.) The conditions with the open passage on all its 4 walls tends to be the most effective way in reducing the dynamic response of the building model compared to the arrangements of either only the front and side walls or front and back walls have open passage

3.) For the building model used in this test, The strouhal number is about 0,91 . The lock-in phenomenon starts when the wind speed reaches around 8,5 m/s. However this lock-in phenomenon does not disappear even when the wind speed gets to over 15m/s at the model height. There are two possible reasons: a longer lock-in region in a boundary layer flow condition, or galloping happened within the lock-in region.

[58] Okada,H. and Kong,L. ,*The Effect of Open Passage on Reducing Wind Response of Tall Buildings*

Characteristics of aerodynamic response of high-rise buildings with open passage

Experiment

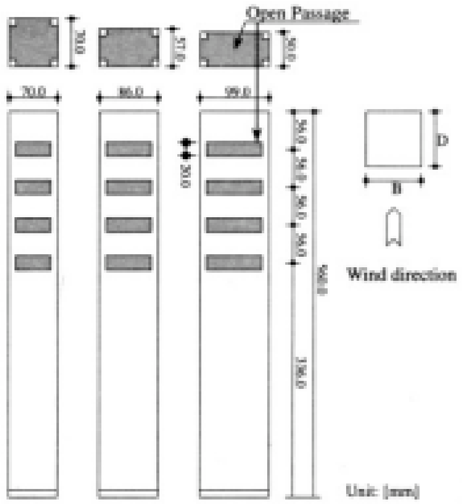


Fig.2 Configuration of Experimental Models

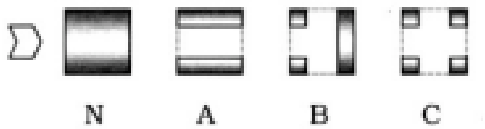
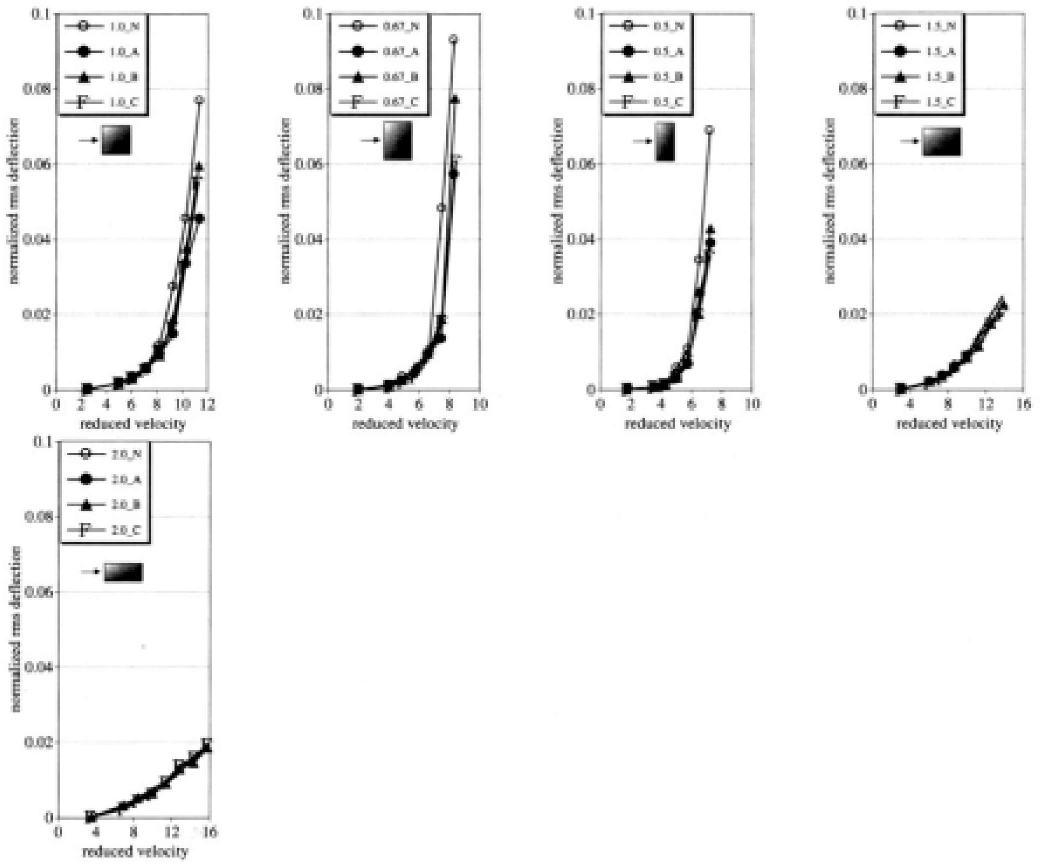


Fig.3 Configuration of Sections

Results



[52] Kikitsu H. , Okada H. (2003) ,*characteristics of aerodynamic response of high-rise buildings with open passage*, Proceedings of CIB-CTBUH international conference on tall buildings Malaysia Ibaraki Japan

Reduction of Tall Buildings Motion By Aerodynamic Treatments

Experiment

A wind model study was carried out at BTWTL to demonstrate how openings or gaps through a building (360 m) can reduce the across-wind response. A square cross-section with an aspect ratio of 9:1 without any changes such as tapering setbacks and changes in cross-section was chosen.
The cross-section had the following aerodynamic modifications:

- Along-wind gaps (width D/6) located through the model centreline in plan.
- Across-wind gaps (width D/6) located through the model centreline in plan.

Results

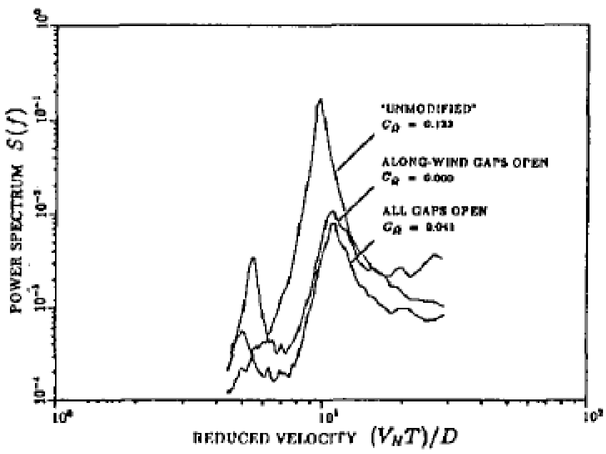


Fig. 1 Across-Wind Base Bending Moment Spectra From Balance Tests

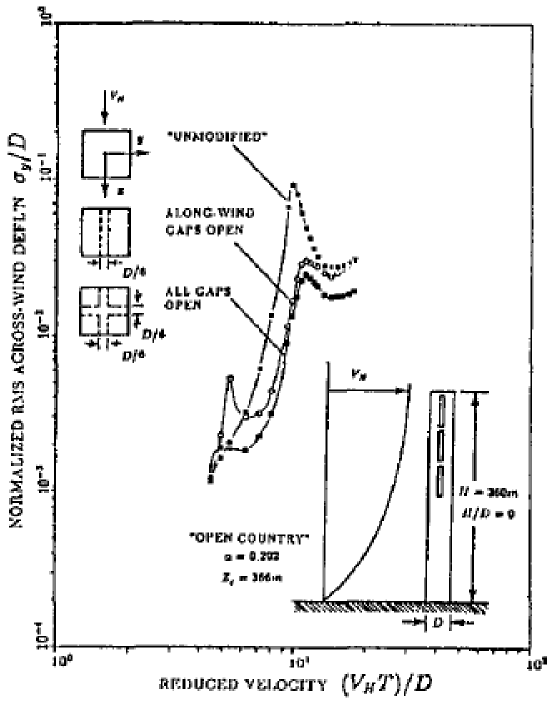


Fig. 2 Across-Wind RMS Tip Deflections From Force Balance Tests

The effects of these modifications can be summarized as follows;

- Introducing gaps results in a pronounced reduction of the vortex shedding induced forces and hence the across wind dynamic deflection of the building

- A major reduction in the excitation and response occurs in the presence of the along-wind gaps which vent the wake to the positive pressure on the building's front face. The addition of identical gaps in the across-wind direction results in a further smaller response. Results indicated that across-wind gaps, if used alone, are not as effective as comparable along-wind gaps.

- Introducing the gaps shifts the spectral peak to a somewhat higher reduced velocity. This implies that the vortex shedding frequency is reduced below that of the unmodified geometry and resonant vibrations of the building are postponed to a somewhat higher wind speed.

- The strouhal number, based on the gross width, changes from S=0,10 for the unmodified geometry, to 0,09 for the along wind gaps and all gaps open cases. For these cases there is alos a second spectral peak located at S=0,18

Conclusions

1) Through-buildings gaps can be effective in reducing the across-wind excitation of tall buildings

2) The observed reduction in the excitation is due to a disruption of the organized or narrow-band vortex vortex shedding process. The evidenceof this is seen from the reduction of the force correlation on the sides of the body ,and a large drop in magnitude of the specrtral peak at the vortex shedding frequency

3) The level of disruption varies with gap width as small as d/D = 4%. A slight recovery of excitation is observed between d/D 10-> 15%. The reason for this recovery is at present unclear however it is suspected to be related to pressure fluctuations induced by the gap.

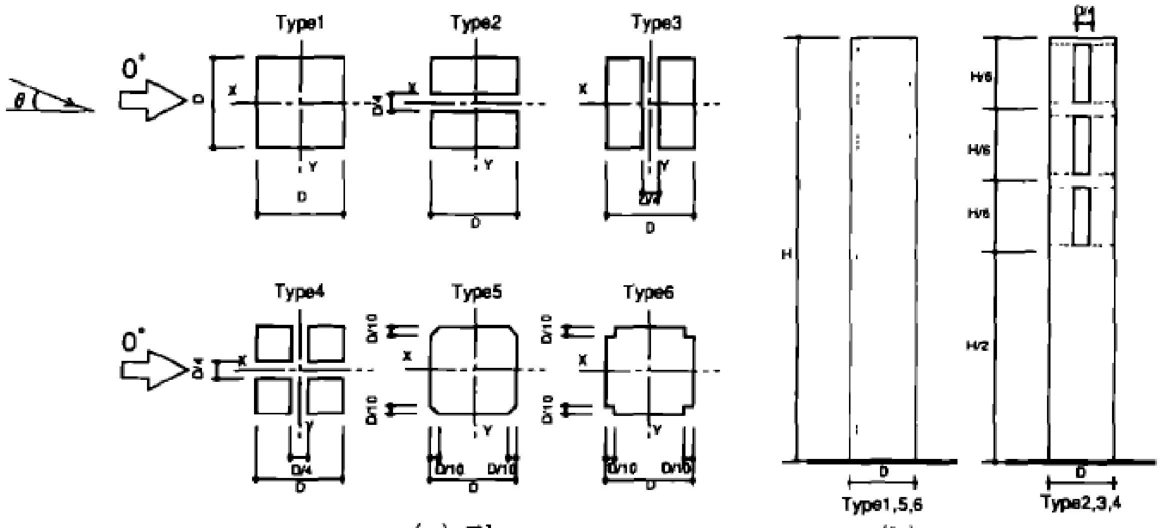
4) A detailed study of the effects of different gap widths in turbulent flow is now underway. It is suspected that the benefits of the gap may not occur at as narrow a gap width as found in smooth flow.

5) Consistent with the findings of other researchers m the mean bas pressure coefficient is a godd indicator of the overall aerodynamic of the body including the vortex shedding excitation . As a result ,It may be possible to gauge the effectiveness of an aerodynamic treatment on the across-wind response from its influence on the base pressure.

[34] Dutton,R. and Isyumov,N. (1990), *Reduction of tall building motions by aerodynamic treatments*, journal of Wind Engineering and industrial aerodynamics, p36

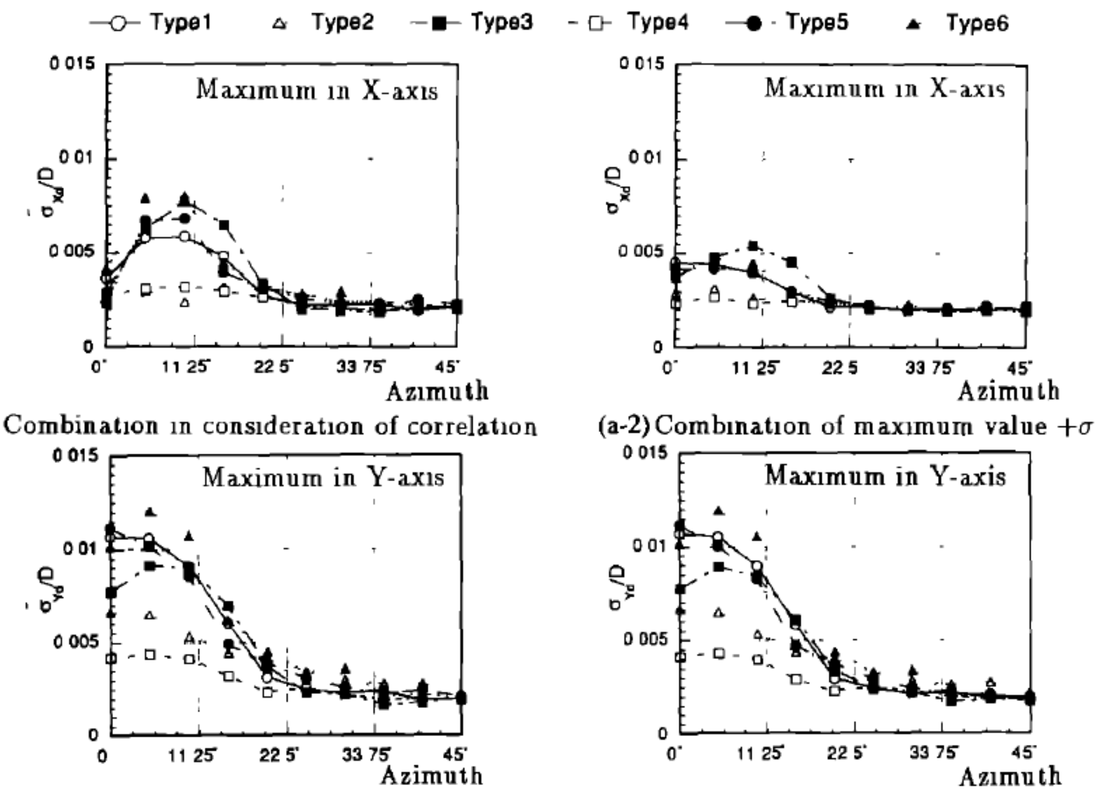
Wind induced response of high-rise buildings, Effects of corner Cuts or openings in square buildings

Experiment



(a) Plane (b) Elevation

Results



(a-1) Combination in consideration of correlation (a-2) Combination of maximum value $+\sigma$

(b-1) Combination in consideration of correlation (b-2) Combination of maximum value $+\sigma$

Conclusions

The conclusions are that:

- It is evident that the presence of the gap reduces the across-wind response by disrupting the regularity of the vortex shedding process.

- For sectional configuration with along wind open passage the across wind response is surpressed since incoming air flow through open passage controls negative pressure region near the leeward wall

- For sectional configuration with across-wind open passage the across wind aerodynamic response is less than without open passage but the aerodynamic damping effect tends to be weakened since air flow from the side wall prevents separated flow from reattaching and the width of the wake is widened

[57] Miyashita et al, *Wind-induced response of high-rise buildings : Effects of Corner Cuts or Openings in Square Buildings,* Journal of Wind Engineering and Industrial Aerodynamics, 50 (1993) 319-328 Elsevier

Appendix B: Building Codes

Introduction

A building code, or building control, consist of rules and guidelines which specify the minimum acceptable level of safety for constructed objects such as buildings and non-building structures. Its purpose is protecting the health, safety and general welfare of the inhabitants during the construction and occupancy of structures. Our building however has an exceptional height and thus the existing code will in some cases be insufficient.

The building will be designed according to the following building codes:

- Bouwbesluit 2003
- Eurocode
- NEN 6720

The codes from the hoogbouwconvenant are also used. Hoogbouwconvenant is a covenant of different parties which are involved in high-rise project. Their aim is to provide rules and guidelines for high-rise specific problems.

Classification

In accordance with NEN-EN 1990 § 2.3 the building will be classified as a monumental building which has a design working life of 100 years.
The building is classified into consequence class CC3 for high-rise taller than 70 meters.

Design working life category	Indicative design working life	examples
4	100	Monumental buildings

Table 1 Design working life

Consequence class	description	Examples
CC3	Large consequences, loss of life and or large economical social consequences for the environment.	High-rise (h > 70 m)

Table 2 definition consequence classes

Loads

In general the variable loads for buildings in NEN-EN 1991 are based on a design working life of 50 years. In case a different design working life is used the extreme values should be adjusted.

Rules are shown in: NEN-EN 1991-4 4.2 remark 4

If no rules are given like in the case of floor loads. The extreme loads can be determined with the formula:

$$F_t = F_{t_0} \frac{\{1+1-\psi_1\}}{9} \ln\left(\frac{t}{t_0}\right)$$

Prescribed loads in buildings Category	φ_0	φ_1	φ_2
Category A residential areas	0,4	0,5	0,3
Category B offices areas	0,5	0,5	0,3
Category C congregation areas	0,25	0,7	0,6
Category D shopping areas	0,4	0,7	0,6
Category E storage area	1	0,9	0,8
Category F traffic area vehicle weight <30 kN	0,7	0,7	0,6
Category G traffic area 30 kN<vehicle weight< 160 kN	0,7	0,5	0,3
Category H roofs	0	0	0
Snow loads	0	0,2	0
Wind loads	0	0,2	0
Temperature (not fire)	0	0,5	0

Table 3 φ factor values for buildings

Vertical loads

Permanent loads

- Reinforced concrete: $\gamma = 25{,}0$ kN/m³
- Structural Steel: $\gamma = 78{,}5$ kN/m³

Variable loads on floors

NEN-EN1991-1-1:2002 in accordance with “ bouwbesluit 2003 “ has been used to determine the variable loads. The loads follow from table 6.2. NB:2007.

Category of the loaded area	q_k (kN/m²)	Q_k (kN)
Category A – Residential area	1,75 + 0,50 = 2,25	3,00
Category A – Stairs	2,00	3,00
Category A – Corridor area	2,00	3,00
Category B – Office areas	2.50 + 0.50 = 3,00	3,00
Category D2 –department store area	4,00	7,00
Category E2 –Technical rooms	10,00	10,00

Table 4 variable loads

Residential areas

The usage function of the penthouses, hotel and apartments is that of a residential area and are classified as category A as mentioned in the Dutch national annex NEN EN 1991-1-1/NB:2007.

Technical rooms

For the technical rooms a variable load of $q_k = 10$ kN/m^2 is considered.

Offices

The usage functions of offices and flexible areas is that of an office area and are classified as category B as mentioned in the Dutch national annex NEN EN 1991-1-1/NB: 2007.

Function	Cat	Load q_k (kN/m^2)	Q_k (kN)
Penthouses	A	2,25	3
Flexible	A/B	3,00	3
Residential	A	2,25	3
Offices	B	3,00	3
Hotel	A	2,25	3
Commercial	C5	4,00	7
Mechanical	E2	10,00	10

Table 5 Live loads

All the live loads are loads for a reference period of 50 years. Since our building has a longer reference period we have to adjust the values in table 5-7 with a reduction factor Ft.

$$F_t = F_{t_0} \frac{\{1+1-\psi_1\}}{9} \ln\left(\frac{t}{t_0}\right)$$

Where
T =100 years
t_0 =50 years
φ_1 is the “momentaan“ factor found in table 1.2

Function	Ft	kN/m^2
Penthouse	1,116	2,511
Residential	1,116	2,511
Flexible	1,116	3,348
Office	1,116	3,348
Commercial	1,100	4,4
Mechanical	------	10
Basement	------	3,5

Table 6 adjusted values live loads

Horizontal loads

Wind loads

In general and especially for irregular geometries the force coefficient is determined with the help of a wind tunnel.
The Rijnhaven Tower uses a aerodynamic design which includes slots. Because of its shape the wind can flow through the building resulting in a reduction of the wind load. This reduction is taken into account by first considering the tower as a conventional closed structure and then applying a reduction of a factor 3. This value is found in the reference project Nakheel Tower (see part1 paragraph 3.6 and [21])

The wind load is determined using NEN-EN199 1-1-4 expression 5.3(2), table 0-7 and the following factors

$$F_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot A_{ref}$$

$$Q_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot B_{ref}$$

CsCd = 1.9 (Appendix C)
C_f = 0.84 (NTA hoogbouw convenant table 03-A.2)
B_{ref} = 100 (width of the building)

Determination of the peak velocity pressure

Values for the extreme windpressure up to 300 meters are taken from

- NEN-EN 1991-1-4 and NEN-EN 1991-1-4/NB: 2007
- Convenanthoogbouw NTA Hoogbouw (03-A) table 03-A.1

Because the structure has a reference period of 100 years we need to adjust the wind loads for this reference period since a longer reference period means a bigger chance of extreme wind conditions.

The way to adjust the wind load is found in NEN-EN 1991-4 4.2 remark 4;

Here the factor c_{prob} is given

$$c_{prob} = \left(\frac{1 - K \cdot \ln(-\ln(1-p))}{1 - K \cdot \ln(-\ln(0{,}98))} \right)^n$$

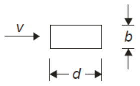
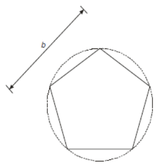
$$K = 0{,}234$$

$$p = 1/R = 1/100 = 0{,}01$$

$$n = 0{,}5$$

$$c_{prob} = 1{,}042$$

Tabel 03-A.2 — krachtcoefficienten voor gebouwen met h/b < 7

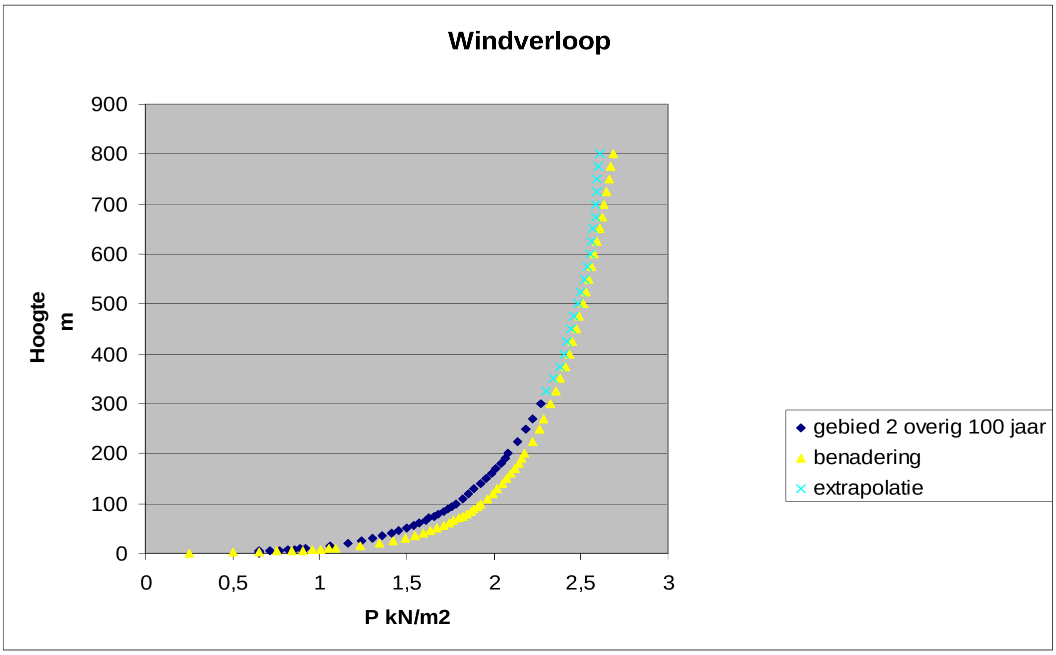
Gebouwvorm [a]		c_f
Rechthoek, d/b < 0,2		1,40
Rechthoek, d/b = 0,7		1,68
Rechthoek, d/b = 1		1,47
Rechthoek, d/b = 2		1,15
Rechthoek, d/b = 5		0,70
Rechthoek, d/b > 10		0,63
[a] Voor tussenliggende waarden van d / b kan c_f door lineaire interpolatie worden bepaald.		
Cirkel		0,84
Hexadeca (16 hoeken)		0,84
dodeca (12 hoeken)		0,91
deca (10 hoeken)		0,91
octa (8 hoeken)		1,02
hexa (6 hoeken)		1,12
penta (5 hoeken)		1,26

Voor rechthoekige gebouwplattegronden met afgeronde hoeken kan een reductiefactor worden toegepast, die afhangt van de verhouding afrondingsstraal – gebouwbreedte. De totale krachtcoefficient wordt met Ψ_r vermenigvuldigd, zoals geïllustreerd in figuur 03-A.1

Figure 1 Force coefficients for buildings h/b<7

Extreme winddruk Gebied 2 referentie tijd 100 jaar					
h meter	P.rep	h meter	P.rep	h meter	P.rep
1	0,651208	70	1,628021	325	2,3
2	0,651208	75	1,660581	350	2,34
3	0,651208	80	1,682288	375	2,38
4	0,651208	85	1,714849	400	2,4
5	0,716329	90	1,736556	425	2,42
6	0,770597	95	1,758263	450	2,44
7	0,81401	100	1,779969	475	2,46
8	0,857424	110	1,823383	500	2,48
9	0,889985	120	1,855944	525	2,5
10	0,922545	130	1,888504	550	2,52
15	1,06364	140	1,921065	575	2,54
20	1,161322	150	1,953625	600	2,55
25	1,237296	160	1,986185	625	2,56
30	1,302417	170	2,007892	650	2,57
35	1,356684	180	2,040453	675	2,58
40	1,410951	190	2,06216	700	2,585
45	1,454365	200	2,083867	725	2,59
50	1,497779	225	2,138134	750	2,595
55	1,541193	250	2,181548	775	2,6
60	1,573753	270	2,224962	800	2,605
65	1,606314	300	2,268376		

Table 7 adjusted and extrapolation of the extreme windpressure



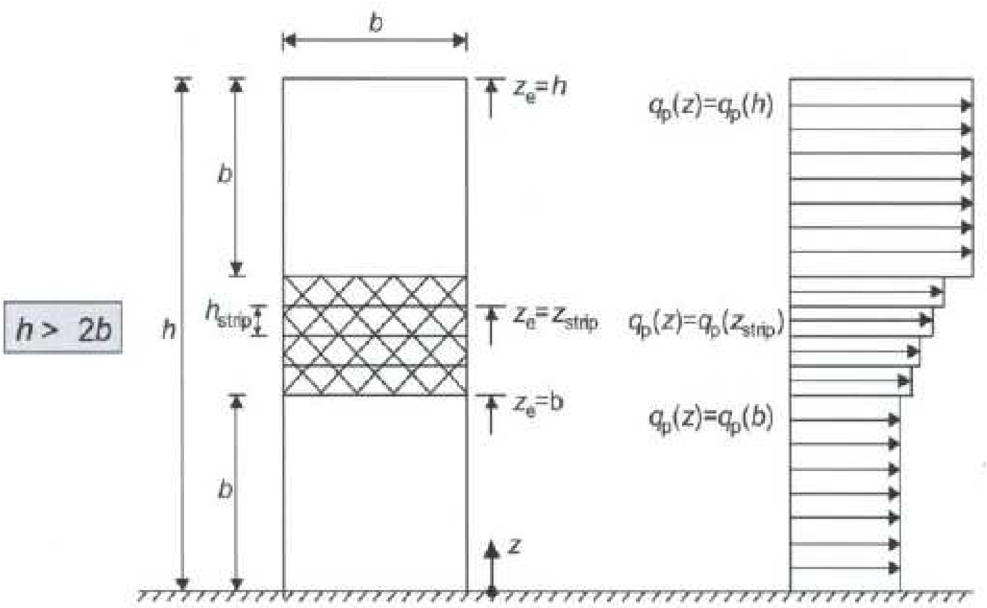


Figure 2 Wind load on building according to NEN-EN 1991-4

This results in the following values for the wind load on the tower

0 < Z < 100	q = 95	kN/m
100 < Z < 700	q = 95 – 140	kN/m
700 < Z < 800	q = 143	kN/m

Fire safety

According to Table 2.91 found in Bouwbesluit 2003, the fire resistance corresponding to the failure of the load-bearing structure should be at least 120 minutes.

Load-bearing structure	**Fire resistance until collapse in minutes**
If a floor with a usage function is located more than 13 m above ground level	120

Table 8 fire resistance

Building should remain standing long enough to let inhabitants escape. The larger the building gets the more difficult this becomes. In this case additional expertise is necessary because the code is insufficient.

Deformations

The deformation of the structure or a structural element should be limited in such a way that the use or functioning of the building is not endangered.

The lateral horizontal deflections have to be restricted for serviceability purposes according to EC 3 to

h/300 for the interstorey drift
h/500 for the building as a whole

	Damping Ratio β	
Form of Construction	Service	Ultimate
RC core, cantilever floor, light weight cladding	0.016	0.022
RC columns, slab floors, few internal walls	0.030	0.070
RC frame, few internal walls	0.030	0.070
RC frame, shear walls	0.030	0.080
RC shear core and columns, some internal walls	0.040	0.120
RC frame, some internal walls	0.040	0.120
RC all forms, many internal walls	0.050	0.160
Steel frame, no internal walls	0.005	0.007
Steel frame, few internal walls	0.025	0.060
Steel frame, many internal walls	0.040	0.150

Figure 3 damping ratio NBCC

Load combinations

The fundamental and characteristics combinations have been determined according to NEN EN 1990:2002

Ultimate limit state

The load combinations in the ultimate limit state have been determined according to NEN EN 1990:2002 §6.4 and the national annex NEN EN 1990:2002:NB 2006 A.1.

Fundamental combinations

The fundamental combinations are defined by 6.10 a and b from NEN-EN 1990:2002 §6.4.3.2:

6.10a: $$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}\psi_{0,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \qquad ()$$

6.10b: $$\sum_{j\geq 1}\xi_j\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}Q_{k,1}+\sum_{i>1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \qquad ()$$

Accidental loads

The combinations of actions for accidental design situations are defined by 6.11 b from NEN-EN 1990:2002 §6.4.3.3

6.11b: $$\sum_{j\geq 1}G_{k,j}+"P"+"A_d"+(\Psi_{1,1} or \Psi_{2,1_{Q,1}})Q_{k,1}+\sum_{i>1}\psi_{2,i}Q_{k,i} \qquad ()$$

Serviceability limit state

The load combinations in the ultimate limit state have been determined according to NEN EN 1990:2002 §6.5 and the national annex NEN-EN 1990:2002:NB 2006 A.1.
Deformations shall be verified according to NEN 6702:2007 chapter 10.

Characteristic combinations

Characteristic combination are defined by 6.14b from NEN-EN 1990:2002 §6.5.3

6.14b: $$\sum_{j\geq 1}G_{k,j}+P+Q_{k,1}+\sum_{i>1}\psi_{0,i}Q_{k,i} \qquad ()$$

They are divided into an immediate deflection (6.14b1) and additional deflection (6.14b2).

Appendix C: CsCd

$$c_s c_d = \frac{1 + 2 \cdot k_p \cdot l_v(z_s) \cdot \sqrt{B^2 + R^2}}{1 + 7 \cdot l_v(z_s)}$$

z_s reference height of the structural factor = 0,6*h
k_p peak factor (3) because v= 0,08 NEN-EN1991-1-4:2005 B2 (4)
l_v turbulence intensity
B^2 “achtergronds respons” factor which is 1
R^2 resonance response factor which is 13,5

$$l_v(z_s) = \frac{\sigma_v}{v_m(z)} = \frac{k_l}{c_o \cdot \ln(z / z_0)}$$

$$l_v(z_s) = l_v(z_{\min})$$

Kl is the turbulence factor = 1,0
C_0 is 1
Z_0 is 0,5 bebouwd gebied (Table 9)

Tabel 4.1 -Terreincategorieën en terreinparameters

Terreincategorie		z_0 m	z_{min} m
0	Zee of kustgebied aan zee	0,005	1
II	Onbebouwd gebied	0,2	4
III	Bebouwd gebied	0,5	7

Table 9 Terrain category

$$l_v(z_s) = 0,087$$

$$l_v(z_{\min}) = 0,189$$

$$R^2 = \frac{\pi^2}{2 \cdot \delta} S_L(z_s, n_{1,x}) \cdot K_s(n_{1,x})$$

δ is given in table F.2 (NEN-EN1991-1-4:2005)
Sl(z_s,n_1) = 6,8 * fl/(1+10.2*$fl^{5/3}$)= 0.22 (figure B.1 NEN-EN1991-1-4:2005)
Fl (z_s,n_1) = (n_1 x l)/v_m(z_s)
N_1 = 46/h = 0.0575 Hz
Ks =1 (size reduction and is not taken into account)

These values give

C_sC_d= 1,86 ≈ 1,9

Appendix D: Floorsystem

Floorsystem superstructure

ComFlor 210 Overspanningstabellen - Lichtbeton[1] (2.000 kg/m^3)

	Brandwerendheid [minuten]	Overspanning Staalplaat-betonvloer	Vloerdikte [mm]	Maximale overspanning [m] 1.00 mm Totale nuttige belasting [kN/m^2] 3.5	1.00 mm 5.0	1.00 mm 10.0	1.25 mm 3.5	1.25 mm 5.0	1.25 mm 10.0
Ongestempeld	30 min	Enkelvelds	280	4,80	4,80	4,80	5,85	5,85	5,85
			300	4,65	4,65	4,65	5,60	5,60	5,60
			320	4,55	4,55	4,55	5,40	5,40	5,40
		Meervelds	280	4,80	4,80	4,80	5,85	5,85	5,85*)
			300	4,65	4,65	4,65	5,60	5,60	5,60*)
			320	4,55	4,55	4,55	5,40	5,40	5,40
	60 min	Enkelvelds	280	4,80	4,80	4,80	5,85	5,85	5,85
			300	4,65	4,65	4,65	5,60	5,60	5,60
			320	4,55	4,55	4,55	5,40	5,40	5,40
		Meervelds	280	4,80	4,80	4,80	5,85	5,85	5,85*)
			300	4,65	4,65	4,65	5,60	5,60	5,60*)
			320	4,55	4,55	4,55	5,40	5,40	5,40
	90 min	Enkelvelds	300	4,65	4,65	4,65	5,60	5,60	5,60
			320	4,55	4,55	4,55	5,40	5,40	5,40
		Meervelds	300	4,65	4,65	4,65	[illegible]	[illegible]	[illegible]
			320	4,55	4,55	4,55	5,40	5,40	5,40
Gestempeld – 1 stempelrij	30 min	Enkelvelds	280	7,00	7,00	5,80	7,00	7,00	5,95
			300	7,50	7,30	6,20	7,50	7,45	6,35
			320	7,35	7,35	6,60	8,00	7,75	6,75
		Meervelds	280	7,55*)	7,55*)	6,40*)	7,70*)	7,70*)	6,55*)
			300	7,55	7,55*)	6,85*)	8,05*)	8,05*)	7,00*)
			320	7,35	7,35*)	7,20*)	8,05	8,05*)	7,30*)
	60 min	Enkelvelds	280	7,00	7,00	5,80	7,00	7,00	5,95
			300	7,50	7,30	6,20	7,50	7,45	6,35
			320	7,35	7,35	6,60	8,00	7,75	6,75
		Meervelds	280	7,55*)	7,55*)	6,40*)	7,70*)	7,70*)	6,55*)
			300	7,55	7,55*)	6,85*)	8,05*)	8,05*)	7,00*)
			320	7,35	7,35*)	7,20*)	8,05	8,05*)	7,30*)
	90 min	Enkelvelds	300	7,50	7,15	5,85	7,50	7,10	5,85
			320	7,35	7,20	6,00	7,70	7,20	6,00
		Meervelds	300	7,55	7,55*)	6,85*)	8,05*)	8,05*)	7,00*)
			320	7,35	7,35*)	7,20*)	8,05*)	8,05*)	7,30*)
Gestempeld – 2 stempelrijen	30 min	Enkelvelds	300	7,55	7,35	6,20	-	-	-
			320	7,55	7,55	6,60	-	-	-
		Meervelds	300	7,55	7,55*)	6,85*)	-	-	-
			320	7,55	7,55*)	7,20*)	-	-	-
	60 min	Enkelvelds	300	7,55	7,35	6,20	-	-	-
			320	7,55	7,55	6,60	-	-	-
		Meervelds	300	7,55	7,55*)	6,85*)	-	-	-
			320	7,55	7,55*)	7,20*)	-	-	-
	90 min	Enkelvelds	300	7,55	7,15	5,85	-	-	-
			320	7,55	7,20	6,00	-	-	-
		Meervelds	300	7,55	7,55*)	6,85*)	-	-	-
			320	7,55	7,55*)	7,20*)	-	-	-

Doorsnedegrootheden ASB-liggers										
	Gewicht	Hoogte	Breedte		Flensdikte	Lijfdikte	Straal	Afstand tussen flenzen	Traagheids-moment	Plastisch Weerstands-moment
			Bovenflens	Onderflens						
	G	H	b_t	b_b	t_1+t_2	t_3	r	D	I_{xx}	$W_{p;xx}$
	kg/m	mm	mm	mm	mm	mm	mm	mm	cm^4	cm^3
280ASB74	73.6	272	175	285	14	10	24	244	12.191	978
280ASB100	100.3	276	184	294	16	19	24	244	15.506	1.294
280ASB105	104.7	288	176	286	22	11	24	244	19.249	1.440
280ASB124	123.9	296	178	288	26	13	24	244	23.453	1.729
280ASB136	136.4	288	190	300	22	25	24	244	22.216	1.805
300ASB153	152.8	310	190	300	24	27	27	262	28.398	2.159
300ASB155	155.4	326	179	289	32	16	27	262	34.514	2.361
300ASB185	184.6	320	195	305	29	32	27	262	35.657	2.658
300ASB196	195.5	342	183	293	40	20	27	262	45.871	3.055
300ASB249	249.2	342	203	313	40	40	27	262	52.920	3.760

Ontwerptabel Slimdek® vloersysteem					
		Overspanning ASB-ligger			
	Overspanning ComFlor 210/SD225	5.4 m Detail 1	7.2 m Detail 1	9.0 m Detail 1	9.0 m Detail 2
Geen brandwerendheidseis of onderflens beschermd	5.4 m	280ASB74 Vloerdikte 300 mm Betondekking 42 mm	280ASB105 Vloerdikte 310 mm Betondekking 44 mm	300ASB153 + zeeg Vloerdikte 325 mm Betondekking 39 mm	300ASB155 + zeeg Vloerdikte 294 mm Betondekking 0 mm
	6.0 m	280ASB74 Vloerdikte 300 mm Betondekking 42 mm	280ASB124 Vloerdikte 310 mm Betondekking 40 mm	300ASB155 + zeeg Vloerdikte 335 mm Betondekking 41 mm	300ASB155 + zeeg Vloerdikte 294 mm Betondekking 0 mm
	7.2 m	280ASB74 Vloerdikte 300 mm Betondekking 42 mm	280ASB105 + zeeg Vloerdikte 310 mm Betondekking 44 mm	300ASB196 + zeeg Vloerdikte 340 mm Betondekking 38 mm	300ASB196 + zeeg Vloerdikte 302 mm Betondekking 0 mm
	8.4 m	280ASB74 Vloerdikte 320 mm Betondekking 62 mm	280ASB124 + zeeg Vloerdikte 320 mm Betondekking 50 mm		
ASB-liggers 60 minuten brandwerend	5.4 m	280ASB74 Vloerdikte 300 mm Betondekking 42 mm	280ASB124 Vloerdikte 310 mm Betondekking 40 mm	300ASB153 + zeeg Vloerdikte 325 mm Betondekking 39 mm	300ASB185 + zeeg Vloerdikte 291 mm Betondekking 0 mm
	6.0 m	280ASB100 Vloerdikte 300 mm Betondekking 40 mm	280ASB136 Vloerdikte 310 mm Betondekking 44 mm	300ASB185 + zeeg Vloerdikte 330 mm Betondekking 39 mm	300ASB185 + zeeg Vloerdikte 291 mm Betondekking 0 mm
	7.2 m	280ASB100 Vloerdikte 300 mm Betondekking 40 mm	280ASB136 + zeeg Vloerdikte 310 mm Betondekking 40 mm	300ASB249 + zeeg Vloerdikte 340 mm Betondekking 38 mm	300ASB249 + zeeg Vloerdikte 302 mm Betondekking 0 mm
	8.4 m	280ASB100 Vloerdikte 320 mm Betondekking 60 mm	300ASB153 + zeeg Vloerdikte 325 mm Betondekking 39 m		
ASB-liggers 90 minuten brandwerend	5.4 m	280ASB136 Vloerdikte 310 mm Betondekking 44 mm	300ASB153 Vloerdikte 325 mm Betondekking 39 mm	300ASB249 Vloerdikte 340 mm Betondekking 38 mm	300ASB185 + zeeg Vloerdikte 291 mm Betondekking 0 mm
	6.0 m	280ASB136 Vloerdikte 310 mm Betondekking 44 mm	300ASB185 Vloerdikte 330 mm Betondekking 39 mm	300ASB249 + zeeg Vloerdikte 340 mm Betondekking 38 mm	300ASB249 + zeeg Vloerdikte 302 mm Betondekking 0 mm
	7.2 m	300ASB153 Vloerdikte 325 mm Betondekking 39 mm			
	8.4 m	300ASB185 Vloerdikte 330 mm Betondekking 39 mm			

Floor-system basement

TT-platen

Overspanning
van 8,00 tot 16,00 m'

Standaardbreedte
2488 mm'

Werkende breedte
2500 mm'

Hoogte
standaard 550 en 770 mm' (parkeergarages)

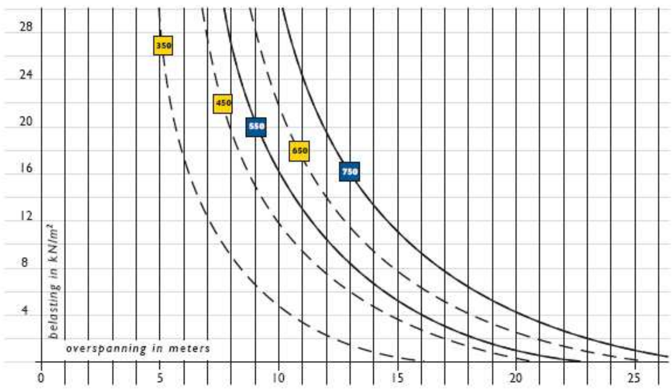
Flensdikte
standaard 80 mm' (parkeergarages)
variabel van 60 mm' tot 100 mm'
60 mm' bij toepassing van druklaag

Tandhoogte
standaard 190 mm' (parkeergarages)
advies overige hoogtes: 0,5 x TT-hoogte

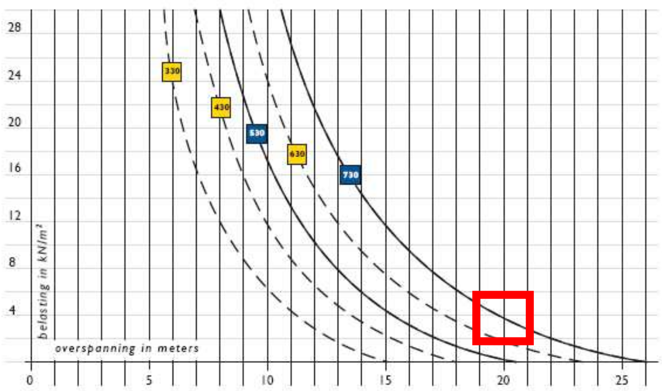
TT-geknikt
(TTG)
standaard hoogte 550 en 770 mm' (parkeergarages)

Vorm
rechthoekig (standaard)
schegvormig: breedte min. 1500 mm' max. 2700 mm'

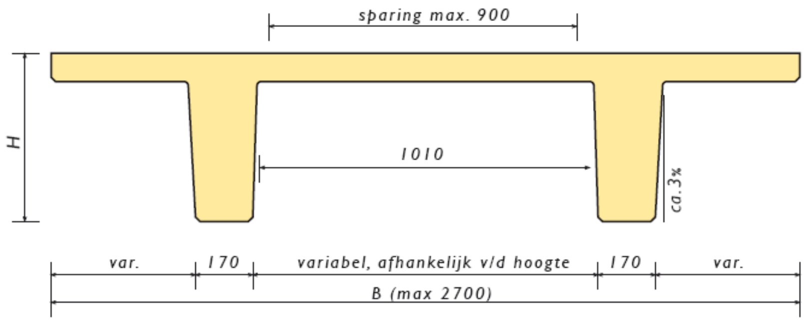
Andere afmetingen op aanvraag

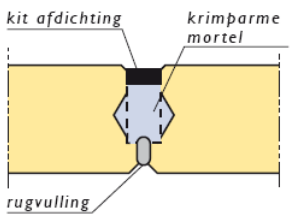


TT-platen flensdikte 80 mm plaatbreedte 2500 mm



TT-platen flensdikte 60 mm plaatbreedte 2500 mm druklaagdikte 50 mm





Profiel TT	B mm'	A 10^5 mm²	v mm'	I 10^9 mm⁴	Q kN/m'
	Element met flensdikte 80 mm'				
770	2390	4,51	501	24,35	11,28

Profiel TTD	B mm'	A 10^5 mm²	H mm'	V mm'	(EI) 10^5 kNm²	Q kN/m'
	Samengesteld profiel, flensdikte 60 mm', druklaag 50 mm'					
730	2390	4,03	780	527	10,60	13,09

floor	function	height	floor	function	height
-7	Basement	-21	43	offices	174,4
-6	Basement	-18	44	offices	178,1
-5	Basement	-15	45	offices	181,8
-4	Basement	-12	46	offices	185,5
-3	Basement	-9	47	offices	189,2
-2	Basement	-6	48	offices	192,9
-1	Basement	-3	49	offices	196,6
0	Lobby	0	50	offices	200,3
1	commercial	15	51	offices	204
2	commercial	19	52	offices	207,7
3	commercial	23	53	offices	211,4
4	commercial	27	54	offices	215,1
5	commercial	31	55	mechanical	218,8
6	commercial	35	56	mechanical	222,8
7	mechanical	39	57	mechanical	226,8
8	offices	44	58	offices	230,8
9	offices	47,7	59	offices	234,5
10	offices	51,4	60	offices	238,2
11	offices	55,1	61	offices	241,9
12	offices	58,8	62	offices	245,6
13	offices	62,5	63	offices	249,3
14	offices	66,2	64	offices	253
15	offices	69,9	65	offices	256,7
16	offices	73,6	66	offices	260,4
17	offices	77,3	67	offices	264,1
18	offices	81	68	offices	267,8
19	offices	84,7	69	Flexible	271,5
20	offices	88,4	70	Flexible	275,2
21	mechanical	92,1	71	Flexible	278,9
22	mechanical	96,1	72	Flexible	282,6
23	mechanical	100,1	73	Flexible	286,3
24	offices	104,1	74	Flexible	290
25	offices	107,8	75	Flexible	293,7
26	offices	111,5	76	Flexible	297,4
27	offices	115,2	77	Flexible	301,1
28	offices	118,9	78	Flexible	304,8
29	offices	122,6	79	Flexible	308,5
30	offices	126,3	80	Flexible	312,2
31	offices	130	81	Flexible	315,9
32	offices	133,7	82	Flexible	319,6
33	offices	137,4	83	Flexible	323,3
34	offices	141,1	84	Flexible	327
35	offices	144,8	85	Flexible	330,7
36	offices	148,5	86	Flexible	334,4
37	offices	152,2	87	Flexible	338,1
38	offices	155,9	88	Flexible	341,8
39	offices	159,6	89	mechanical	345,5
40	offices	163,3	90	mechanical	349,5
41	offices	167	91	mechanical	353,5
42	offices	170,7	92	Flexible	357,5

floor	function	height	floor	function	height
93	Flexible	361,2	143	Residential	547,1
94	Flexible	364,9	144	Residential	550,8
95	Flexible	368,6	145	Residential	554,5
96	Flexible	372,3	146	Residential	558,2
97	Flexible	376	147	Residential	561,9
98	Flexible	379,7	148	Residential	565,6
99	Flexible	383,4	149	Residential	569,3
100	Flexible	387,1	150	Residential	573
101	Flexible	390,8	151	Residential	576,7
102	Flexible	394,5	152	Residential	580,4
103	Flexible	398,2	153	Residential	584,1
104	Flexible	401,9	154	Residential	587,8
105	Flexible	405,6	155	Residential	591,5
106	Flexible	409,3	156	mechanical	595,2
107	Flexible	413	157	mechanical	599,2
108	Flexible	416,7	158	mechanical	603,2
109	Flexible	420,4	159	Residential	607,2
110	Flexible	424,1	160	Residential	610,9
111	Hotel	427,8	161	Residential	614,6
112	Hotel	431,5	162	Residential	618,3
113	Hotel	435,2	163	Residential	622
114	Hotel	438,9	164	Residential	625,7
115	Hotel	442,6	165	Residential	629,4
116	Hotel	446,3	166	Residential	633,1
117	Hotel	450	167	Residential	636,8
118	Hotel	453,7	168	Residential	640,5
119	Hotel	457,4	169	Residential	644,2
120	Hotel	461,1	170	Residential	647,9
121	Hotel	464,8	171	Residential	651,6
122	Hotel	468,5	172	Residential	655,3
123	mechanical	472,2	173	Residential	659
124	mechanical	476,2	174	Residential	662,7
125	mechanical	480,2	175	Residential	666,4
126	Hotel	484,2	176	Residential	670,1
127	Hotel	487,9	177	Residential	673,8
128	Hotel	491,6	178	Residential	677,5
129	Hotel	495,3	179	Residential	681,2
130	Hotel	499	180	Residential	684,9
131	Hotel	502,7	181	Residential	688,6
132	Hotel	506,4	182	Residential	692,3
133	Hotel	510,1	183	Residential	696
134	Hotel	513,8	184	mechanical	699,7
135	Hotel	517,5	185	mechanical	703,7
136	Hotel	521,2	186	mechanical	707,7
137	Hotel	524,9	187	Penthouse	711,7
138	Hotel	528,6	188	Penthouse	715,8
139	Hotel	532,3	189	Penthouse	719,9
140	Hotel	536	190	Penthouse	724
141	Residential	539,7	191	Penthouse	728,1
142	Residential	543,4	192	Penthouse	732,2

floor	function	height
193	Penthouse	736,3
194	Penthouse	740,4
195	Penthouse	744,5
196	Penthouse	748,6
197	Penthouse	752,7
198	Penthouse	756,8
199	Penthouse	760,9
200	Penthouse	765
201	Penthouse	769,1
202	Penthouse	773,2
203	Penthouse	777,3
204	Penthouse	781,4
205	Penthouse	785,5
206	Penthouse	789,6
207	Penthouse	793,7
208	Penthouse	797,8
209		801,9

Appendix E: Loads working on the building

Lateral loads (wind)

The wind load which acts on the building is determined using:

- NEN-EN 1991-1-4 and NEN-EN 1991-1-4/NB: 2007
- Convenanthoogbouw NTA Hoogbouw (03-A) table 03-A.1

Because there are no supertalls (buildings with a height of over 300 meter) in the Netherlands the eurocode only provides values up to a height of 150 meter. The “hoogbouwconvenant” provides values up to 300 meter.These values have been extrapolated to a height 800 meter For more details see appendix B and C

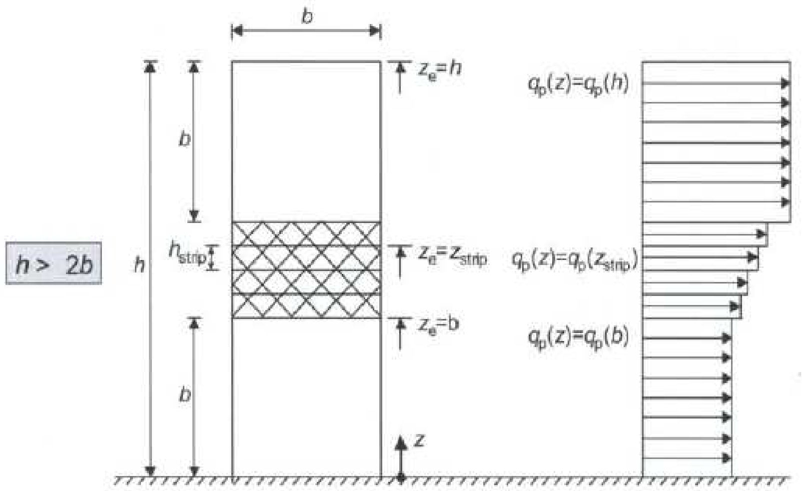


Figure 4 Wind load on building according to NEN-EN 1991-4

0 < Z < 100	q = 95	kN/m
100 < Z < 700	q = 95 – 140	kN/m
700 < Z < 800	q = 143	kN/m

Vertical loads

Self-weight

The self-weight of the following structural elements will be calculated in this paragraph

- Floor
- Installation finishing
- Core
- Column
- Beams
- Foundation raft

Floor + Installations and finishing

Floor system	Dead load (kN/m2)
Floor system	3,94
Beams	0,46

Table 10 floor-system

Columns

For the design of the mega columns see appendix G

Level	Storey	Dimensions	t (mm)	A_{steel} (m^2)	$A_{concrete}$ (m^2)	kN/m per column	kN per column	kN 28 columns
EI 1	0-22	1600x1600	100	0,31	2,25	78,3	7215	202010
EI 2	23-54	1500x1500	100	0,29	1,96	69,8	8844	247640
EI 3	55-88	1300x1300	80	0,2016	1,4884	51,5	6531	182869
EI 4	89-122	1200x1200	70	0,1631	1,2769	43,4	5505	154139
EI 5	123-155	1000x1000	60	0,1164	0,8836	30,3	3732	104504
EI 6	156-183	800x 800	50	0,0775	0,5625	19,6	2047	57302
EI 7	184-208	600x 600	50	0,0575	0,3025	11,8	1062	29736

Table 11 Mega columns loads

- Reinforced concrete: $\gamma = 25,0$ kN/m³
- Structural Steel: $\gamma = 78,5$ kN/m³

Core

Level	Storey	Length (m)	Wall thickness (mm)	kN/m (vertical)
EI 1	0-22	92,1	1000	12120
EI 2	23-54	126,7	900	10908
EI 3	55-88	126,7	850	10302
EI 4	89-122	126,7	800	9696
EI 5	123-155	123	750	9090
EI 6	156-183	104,5	700	8484
EI 7	184-208	102,2	650	7878

Table 12 Core loads

We assume 30 % of the distributed loads are transferred via the perimeter columns and 70 % via the core.

Live loads

Because the chance that all the floors are fully loaded is very small the building code permits the use of the momentaanfactor. This means one floor is fully loaded and the others are multiplied with the momentaan factor.
The mechanical floors however house the electrical sub-stations, water tanks and pumps, air-handling units etc that are essential for the operation of the tower and the comfort of its occupants. "These installations are always present and will therefore not be multiplied with a momentaan factor.
The lobby is also always fully loaded.

Function	Aantal	kN/m^2	kN/m^2		
Mechanical	19	10	1,5*19*10	=	285,00
Penthouse	22	2,511	1,5*22*2,511*0,4	=	33,15
Residential	40	2,511	1,5*49*2,511*0,4	=	73,82
Hotel	27	2,511	1,5*27*2,511*0,4	=	40,68
Flexible	39	3,348	1,5*39*3,348*0,5	=	97,93
Office	55	3,348	1,5*55*3,348*0,5	=	138,11
Commercial	6	4,4	1,5*6*4,4*0,4	=	15,84
Lobby	1	5	1,5*1*5	=	7,50
Basement	7	3,5	1,5*7*3,5*0,7	=	25,73
TOTAL ULS				=	717,76
TOTAL SLS				=	478,51

Table 13 Sum live loads

For the vertical line loads in the structural design (ESA) it is assumed that 30 % of the distributed loads are transferred via the perimeter columns and 70 % via the core.

Live loads: 478 *4291/800 =2563kN/m
Megacolumns: 978200/801,9=1220 kN/m
Diagrid columns 0,336*1003*78,5/11,1=2383 kN/m

$$A_{staal} = \pi\left(0,75^2 - 0,675^2\right) = 0,336m^2$$

Total length columns for 11 meter height

$$A_{staal} = 4 \cdot 12 \cdot 12,5 + 4 \cdot 2 \cdot 13,343 + 4 \cdot 7 \cdot 10,582 = 1003m$$

Core=1828*4291/801,9=9782 kN/m

Floor: 3,94*208*4291/801,9=4385 kN/m
Beams: 0,46*208*4291/801,9=512 kN/m

Appendix F:bending stiffness core

Introduction

In this section the bending stiffness of the core will be calculated using the Steiner theorem found in [hartsuiker 2 toegepaste mechanica] and ESA scia engineer.
The buildings core consists of 4 quadrants which are all subdivided in 7 parts along the buildings height. In each subdivision the building has a different wall thickness. Each quadrant is schematized as having 10 straight walls with a thickness

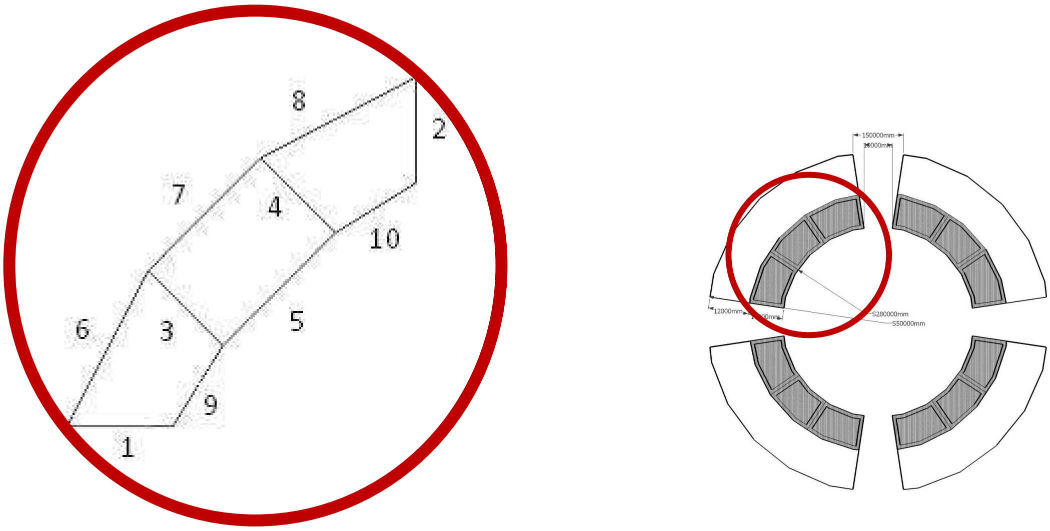


Figure 5 schematization of the core walls

The stiffness of the load-bearing structure in a compound structure depends on the number of couplings. In order to take into account the effect of the coupling of the cores, we first determine the bending stiffness EI of a single quadrant. These quadrants are modeled as rectangular elements in ESA which are then coupled using structural elements which represent the belt trusses which are located at the mechanical floors (see table 2-9 of part 2).. The distance between the rectangular elements in the ESA model is the distance between the centres of gravity of the quadrants.

We will use the formula $w=q*l^4/8*EI$ to derive the average bending stiffness of a tower. The average bending stiffness is used for subdivision 4 which is located at a height of 345,5-472,2 meter. The relation between the bending stiffness of the other subdivisions is then found using the relation between the bending stiffness of an individual quadrant.

The towers footprint is symmetric and we can identify two load cases which are given in the figures below.

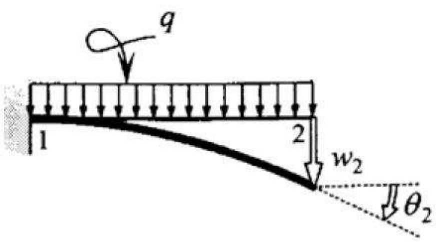
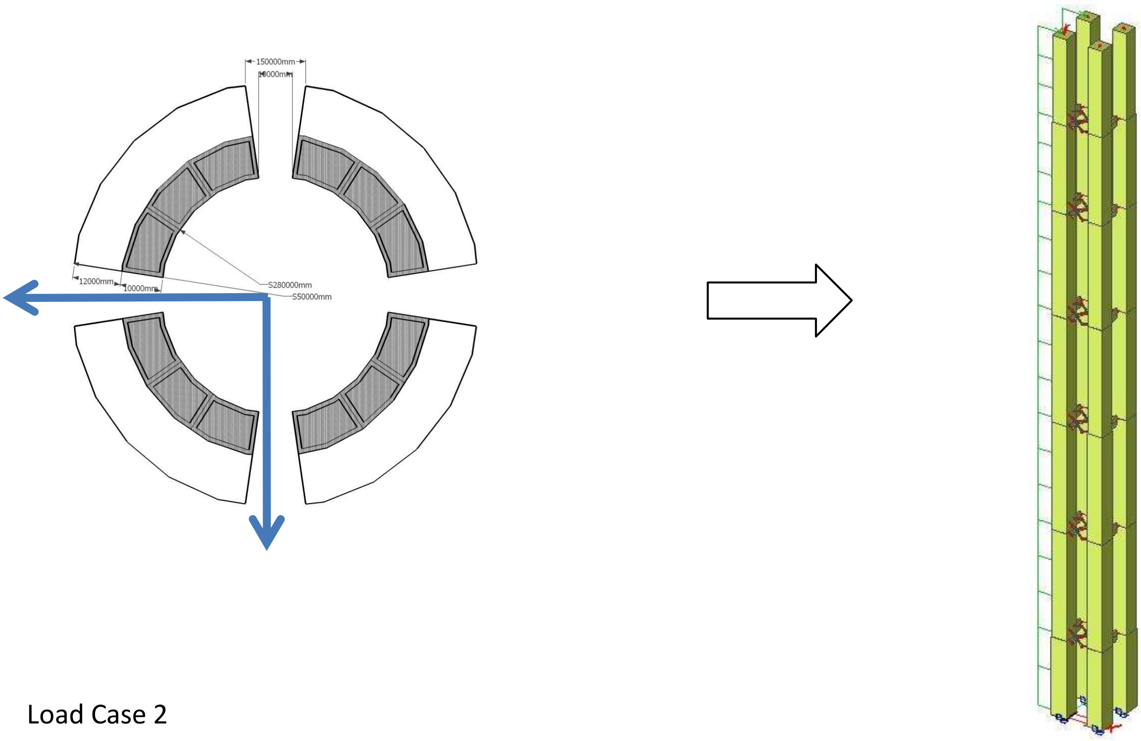
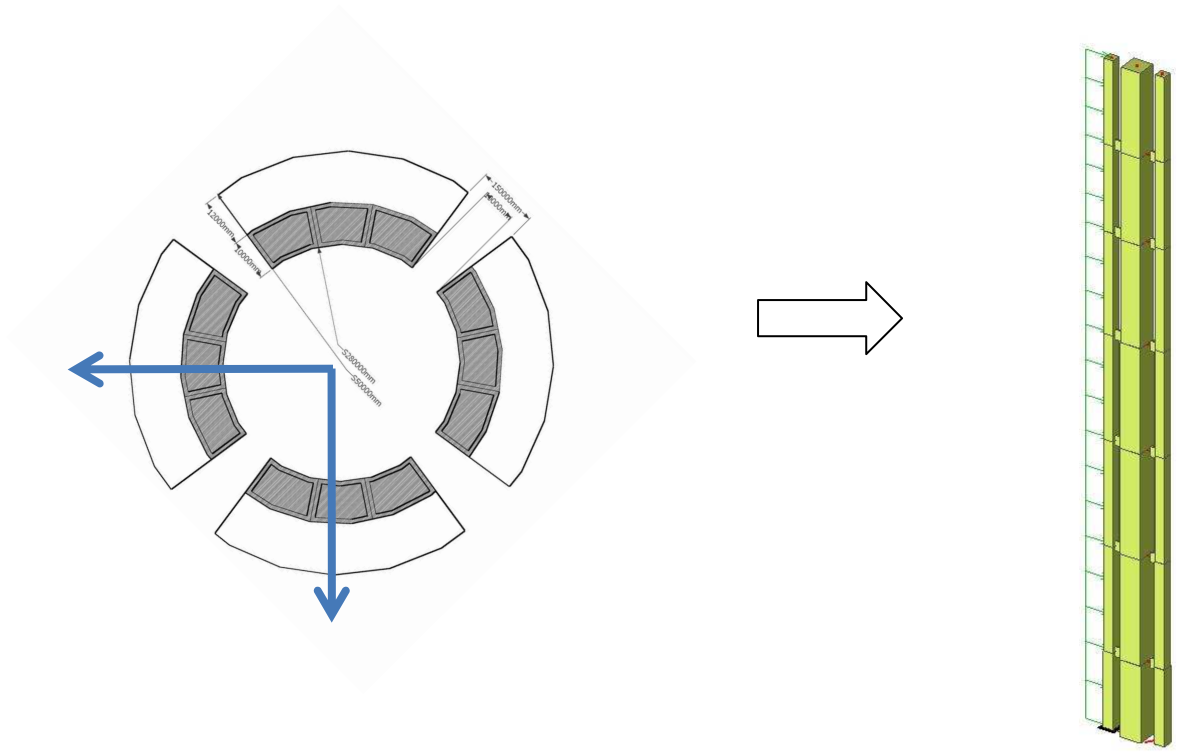


Figure 6 Vergeetmenietje

Load Case 1



Load Case 2



Unit Load

A unit load of 100 kN/m is used to determine the stiffness of the core

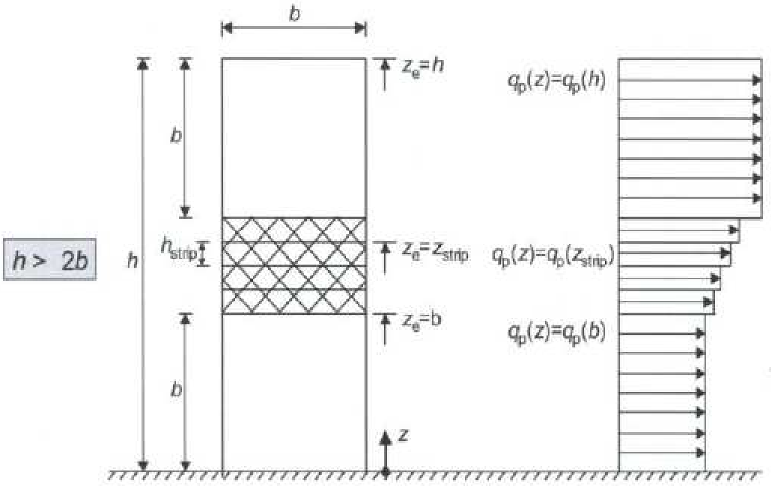


Figure 7

0 < Z < 800 q = 100 kN/m

Load case 1

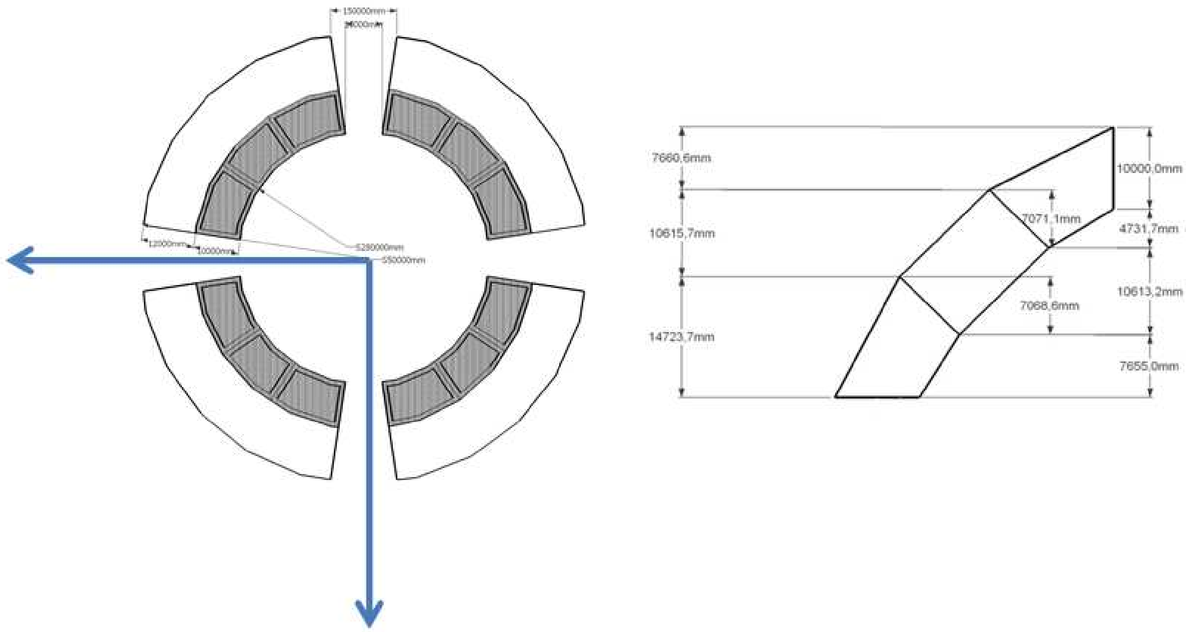
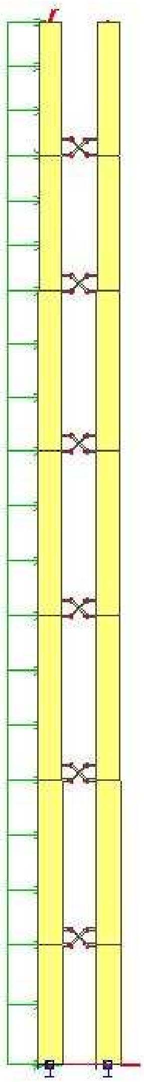


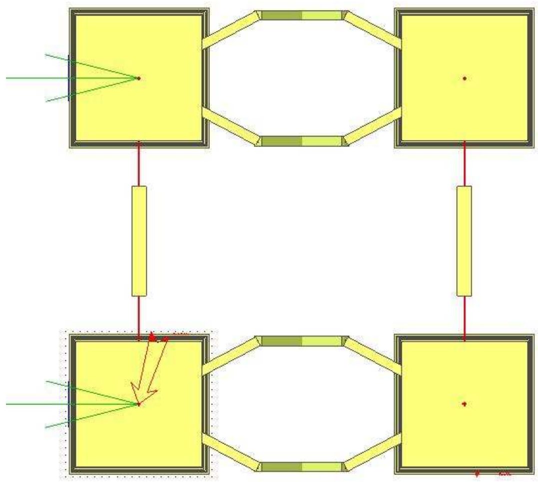
Figure 8 Load case 1

Inertial moment

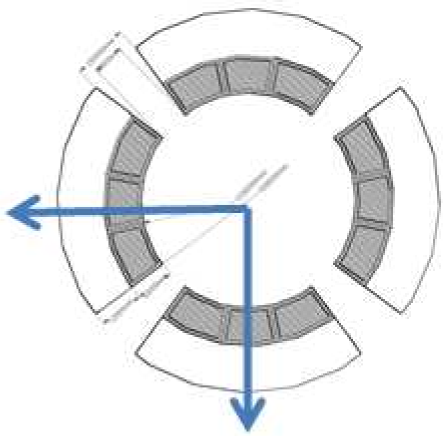
The inertial moment is calculated using steiner theorem and a spreadsheet. The core is subdivided in 7 parts which have a decreasing wall thickness as the building gets higher (See paragraph).
Firstly the centre of gravity of each of the 4 quadrants is determined after which their inertial moment is calculated.
Secondly these inertial moments are used to model the quadrants as rectangular sections in ESA using (1/12 B^4) in which B= the width of the square. The quadrants which are connected through belttrusses perpendicular to the wind direction are modelled as 4 rectangular sections. This centre-to-centre distance between the quadrants is then found using the centres of gravity.

subdivison	Length (m)	Position (m)	$Izz_{quadrant}$	A=bxh (mm^2)
EI 1	92,1	0-92,1	2x1,12867E+16	22814x22814
EI 2	126,7	92,1-218,8	2x 1,01579E+16	22221x22221
EI 3	126,7	218,8-345,5	2x 9,59352E+15	21905x21905
EI 4	126,7	345,5-472,2	2x 9,02914E+15	21576x21576
EI 5	123	472,2-595,2	2x 8,46477E+15	21230x21230
EI 6	104,5	595,2-699,7	2x 7,90041E+15	20867x20867
EI 7	102,2	699,7-801,9	2x 7,33606E+15	20484x20484





Load Case 2



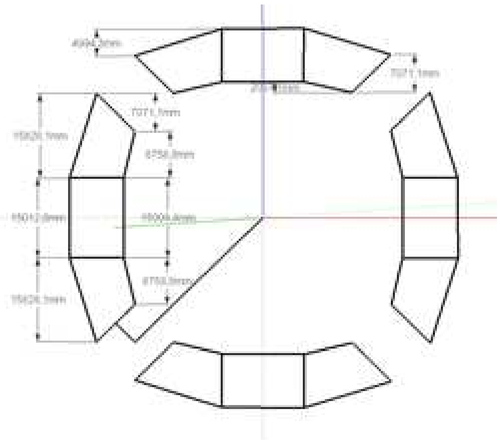


Figure 9 Load case 2

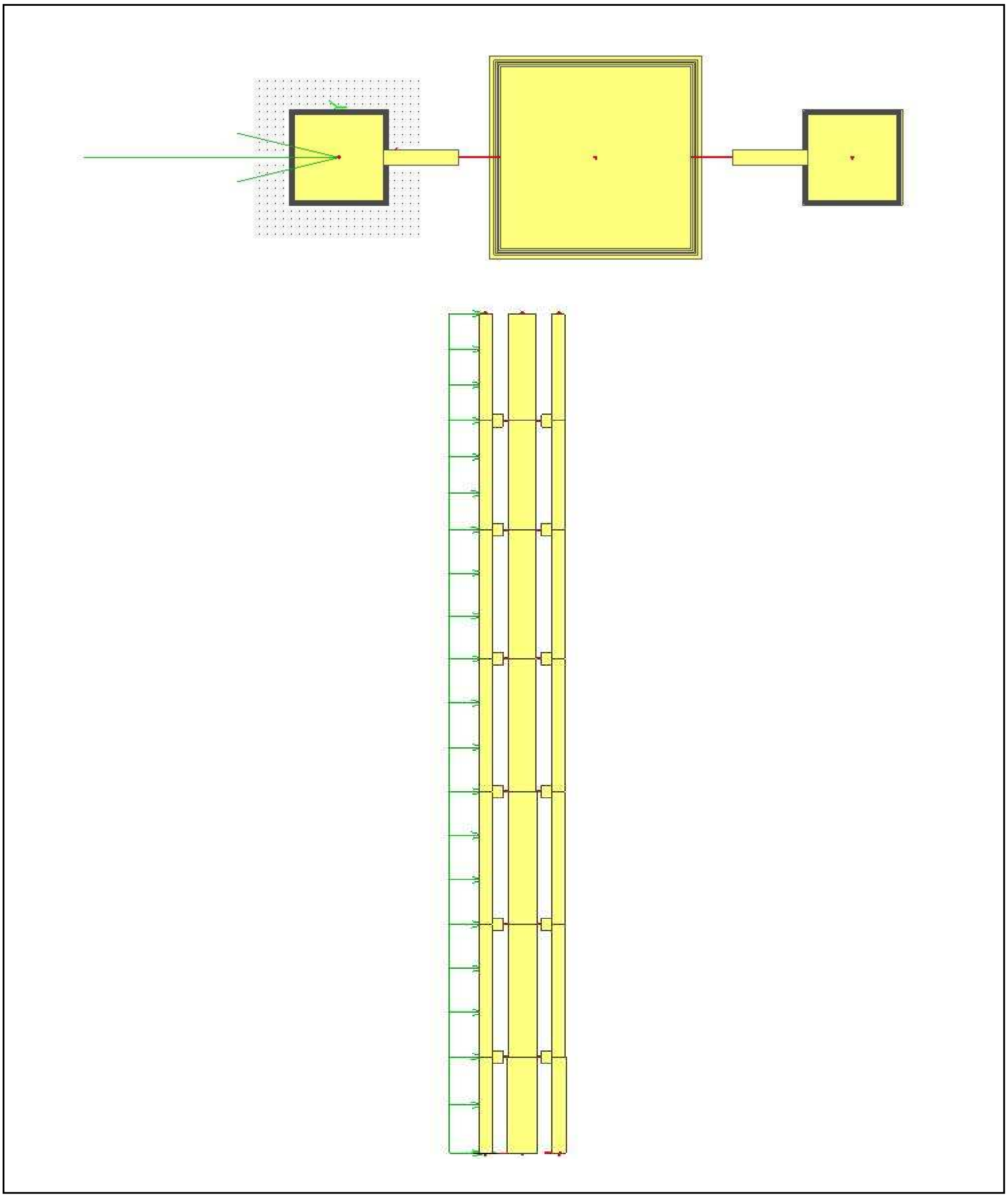
In this configuration the core can be seen as a I-section where A1 is the (web) and A_2 are the flanges. In an I-section the web resists shear forces while the flanges resist most of the bending moment experienced by the beam.

Inertial moment

The inertial moment is calculated using Steiner theorem and using a spreadsheet. The core is subdivided in 7 parts which have a decreasing wall thickness as the building gets higher. (See paragraph)
Firstly the centre of gravity of each of the 4 quadrants is determined after which their inertial moment is calculated.

Secondly these inertial moments are used to model the quadrants as rectangular sections in ESA. The web consist of the two quadrants A_1 (2x A_1) which are connected to the flanges A_2. The centre to centre distance between the quadrants is the found using the centres of gravity which were determined earlier.

subdivison	Length (m)	Position (m)	$Izz_{\text{quadrant 1}}$	$Izz_{\text{quadrant 2}}$ x 2	A_1 (mm^2)	A_2 (mm^2)
EI 1	92,1	0-92,1	2,0795E+16	2x2,03974E+15	26579x26579	12508x12508
EI 2	126,7	92,1-218,8	1,8715E+16	2x1,83548E+15	25888x25888	12182x12182
EI 3	126,7	218,8-345,5	1,76751E+16	2x1,73339E+15	25521x25521	12009x12009
EI 4	126,7	345,5-472,2	1,66352E+16	2x1,63131E+15	25137x25137	11828x11828
EI 5	123	472,2-595,2	1,55954E+16	2x1,52926E+15	24734x24734	11639x11639
EI 6	104,5	595,2-699,7	1,45555E+16	2x1,42722E+15	24311x24311	11440x11440
EI 7	90,2	699,7-801,9	1,35157E+16	2x1,32521E+15	23865x23865	11230x11230



Connections

A very important part of determining the bending stiffness of compound structure core are the structural links between the individual towers. In this paragraph the design and modelling of the belt-trusses

The cores are connected to the each other using belt-trusses. These belt-trusses are located at the mechanical levels). This is the same location as the three storey outriggers which connect the core to the perimeter in the core-outrigger alternative.

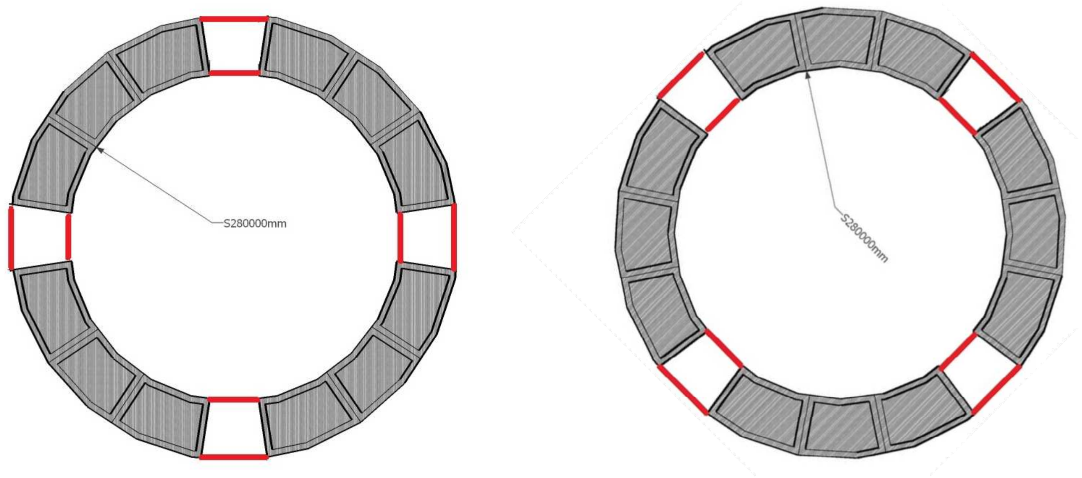


Figure 10 Belt trusses load case 1 (left) and Load case 2 (right)

The structural elements of the belt-truss were designed as followed. Firstly, stiff elements (see table 0-1) are used to connect the 4 towers. The forces working stiff elements are then obtained from ESA table 0-1and applied to a structural model which represents a segment of the belt-truss. .

The forces working on the belt-truss are then applied to a model representing the belttruss.

Height (m)	A (m^2)	E (N/mm^2)
0-92,1	1000x12000	210000
92,1-218,8	1000x12000	210000
218,8-345,5	1000x12000	210000
345,5-472,2	1000x12000	210000
472,2-595,2	1000x12000	210000
595,2-699,7	1000x12000	210000
699,7-801,9	1000x12000	210000

Table 14

N (kN)	V (kN)
14000	73000

Table 15

After which a suitable structural section is chosen. These sections are then added to ESA for the final model. The figures show the ESA model for load case 2 .

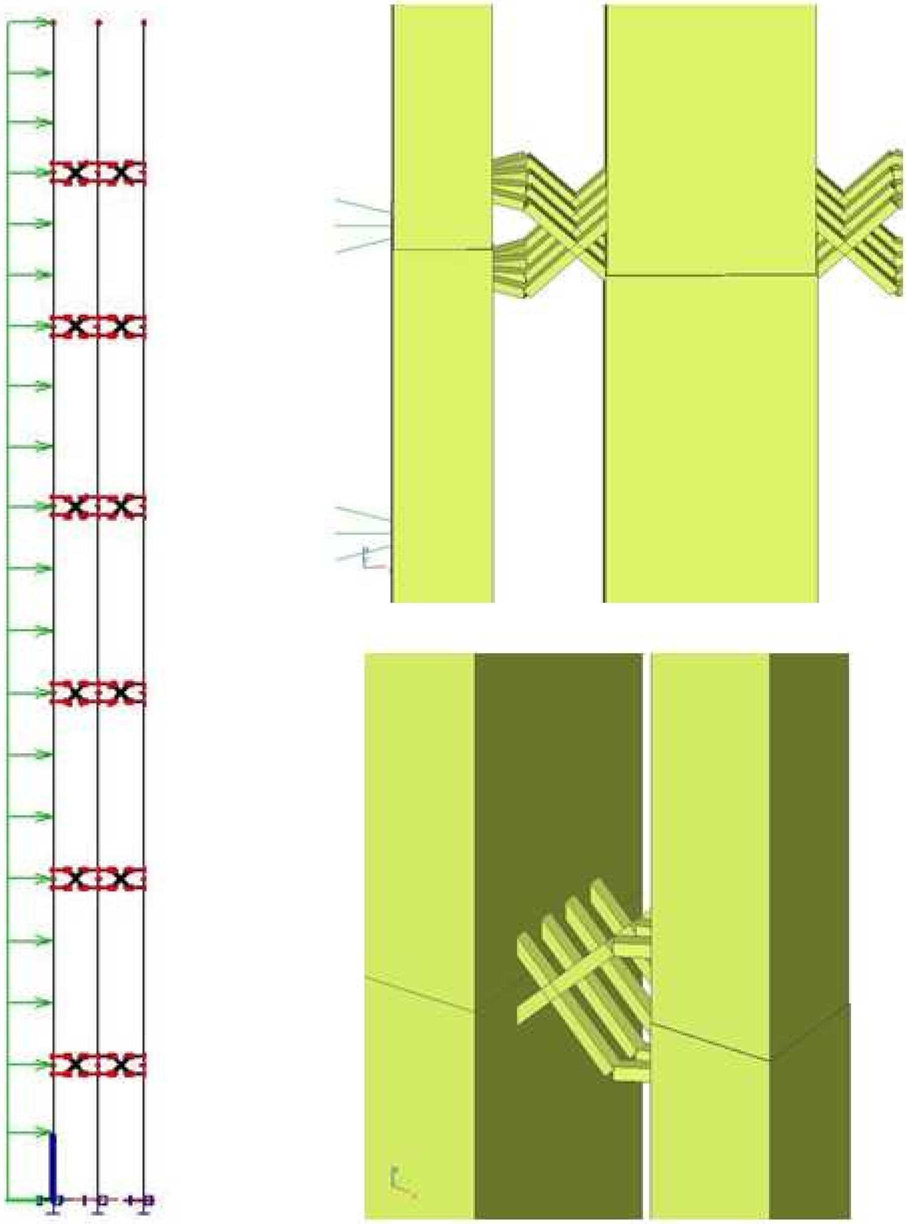


Figure 11 ESA model load case 2

Derivation of the bending stiffness 6 links

Since wind tunnel testing is not available we will use a simplified approach in which we assume that the redcution due to the different configurations is a consequence of the difference in area on which the wind load acts. Friction due to wind is not taken into account

In load case 1 (figure 0-2) the width of the gap is 15 meter which means that the wind load acts on 85 meter. In load case 2 (fgure0-3) wind acts on the entire width of the tower

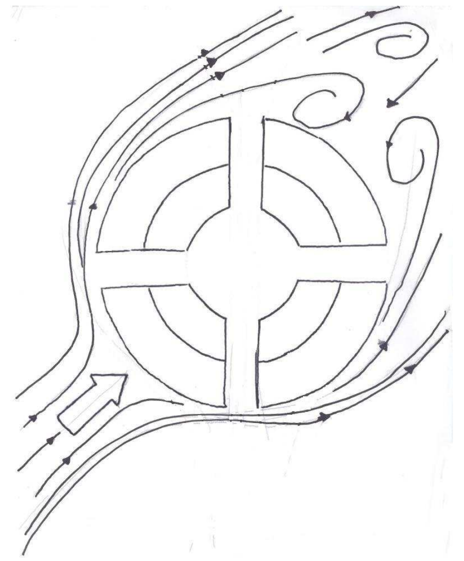


Figure 13

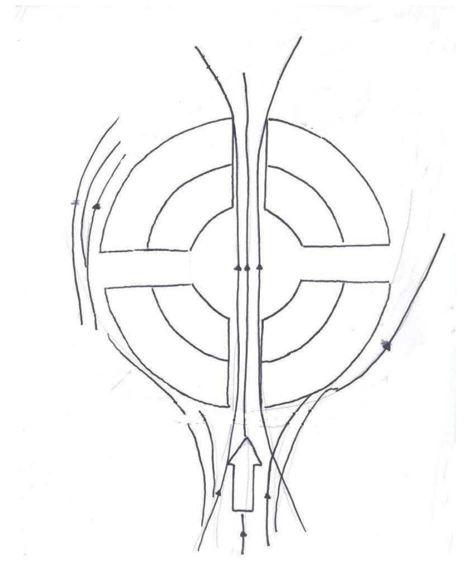


Figure 12

The difference between the windforces is then 85/100 and the difference in stiffness can be approximated calculated Table shows that the tower the has the largest displacement is case of load case 2 Therefore we will design the tower using the stiffness found from load case 2
The results show that wind direction 2 is the weakest configuration since the deformation is larger than in the case of wind coming from direction 2.
Because of the height of the building wind can act on the building in any direction. Therefore we will use the configuration 2 to derive the stiffness of the core.
The deformation due to the unit load of 100 kN/m is calculated using ESA.
The average bending stiffness is calculated using the formula and is given in

$W=(q \cdot l^4/8EI)$

	Length (mm)	**Q (N/mm)**	**W (mm)**	**$EI_{average}$ N/mm^2**
Load case 1	801900	100	336	1,5383E+22
Load case 2	801900	100	478	1,0813E+22

Table 16

subdivison	factor	Position (m)	Izz $_{quadrant\ 1}$
EI 1/ EI 2	1,11	0-92,1	2,0795E+16/1,8715E+16
EI 2/ EI 3	1,069	92,1-218,8	1,8715E+16/ 1,76751E+16
EI 3/ EI 4	1,063	218,8-345,5	1,76751E+16/ 1,66352E+16
EI 4/ EI 5	1,067	345,5-472,2	1,66352E+16/ 1,55954E+16
EI 5/ EI 6	1,116	472,2-595,2	1,55954E+16/ 1,45555E+16
EI 6/ EI 7	1,077	595,2-699,7	1,45555E+16/ 1,35157E+16

Table 17

	windrichting 1	windrichting 2
EI1	1,9403E+22	1,3639E+22
EI2	1,7480E+22	1,2287E+22
EI3	1,6352E+22	1,1494E+22
EI4	1,5383E+22	1,0813E+22
EI5	1,4417E+22	1,0134E+22
EI6	1,2919E+22	9,0807E+21
EI7	1,1995E+22	8,4314E+21

Table 18

dimensions	B=h Load case 1 (mm)	B=h Load case 1 (mm)
Subdivision 1	47962	43916
Subdivision 2	46727	42785
Subdivision 3	45954	42078
Subdivision 4	45258	41440
Subdivision 5	44530	40773
Subdivision 6	43325	39670
Subdivision 7	42529	38941

Table 19

In order to determine in which load case the bending stiffness is the weakest we much take into account how the wind behaves in both load cases. In load case one the wind is allowed to flow through and around the tower where as in load case 2 the wind has to flow around the tower. Therefore the tower is subjected to a larger wind load in load case 2

Effect of number of links along the buildings core on the stiffness

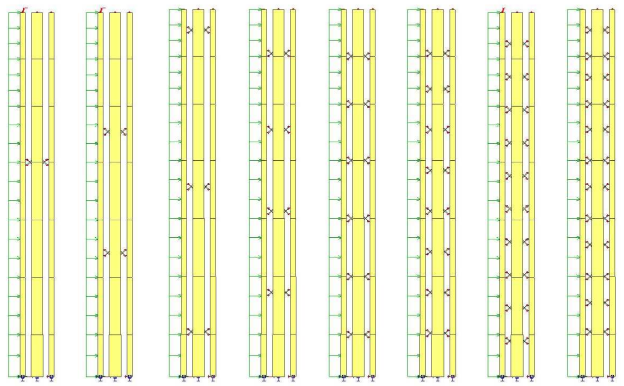


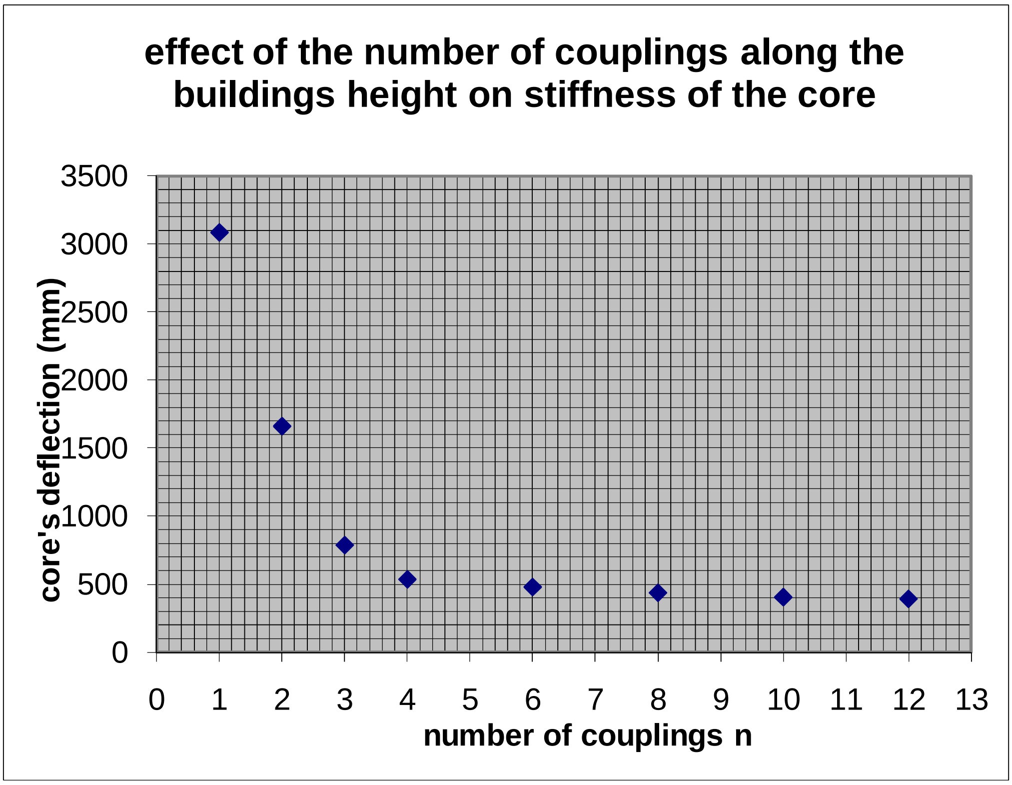
Figure 14 number of couplings along the height of the tower

Figure 0-5 shows several models which were tested to examine the effect the links have on the stiffness of the tower. The results are shown in table 0-3 and the graph

Number of couplings	**1**	**2**	**3**	**4**	**6**	**8**	**10**	**12**
Deformation (mm)	3084	1660	786	535	478	436	404	391
Average bending stiffness EI (N/mm^2)	1.68E+21	3.11E+21	6.58E+21	9.66E+21	1.08E+22	1.19E+22	1.28E+22	1.32E+22

Table 20

Note that the number of bending stiffness of the tower 7 subdivisions are the same for all models.


effect of the number of couplings along the buildings height on stiffness of the core
core's deflection (mm)
3500
3000
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
number of couplings n

Appendix G: Wind (comfort)

TGB 1990 NEN 6702 along-wind accelerations

$$\alpha = 1,6 \cdot \frac{(\rho_2 \cdot p_{w1} \cdot C_t \cdot b_m)}{\rho_l} \qquad (4)$$

Where

ρ_2 factor dependant on the eigenfrequency and damping of the building
$P_{w,1}$ variation in thrust on the building in N/m
C_t summation of the wind factors for thrust and suction 1,2
b_m the average width of the building
ρ_l mass of the building per metre building height

$P_{w,1}$ is given by

$$p_{w1} = 100 \cdot Ln(\frac{h}{0,2}) \qquad (5)$$

H height of the building
ρ_2 is given by equation below

$$\rho_2 = \sqrt{\frac{0,0344 \cdot f_e^{-2/3}}{D(1+0,12 \cdot f_e \cdot h)(1+0,2 \cdot f_e \cdot b_m)}} \qquad (6)$$

Where

f_e eigenfrequency of the building in Hz
D damping factor
H height of the building+
b_m average width of the building

To calculate the natural frequency of the building NEN 6702 gives the following formula

$$f_e = \sqrt{\frac{a}{\delta}} \qquad (7)$$

a =value dependant on the distribution of the mass of the building 0.384 m/s^2

NBCC National building code Canada across-wind accelarations

$$a_w = f_e^2 g_p \sqrt{WD}\left(\frac{a_r}{\rho_B g \sqrt{\beta_W}}\right) \tag{8}$$

Where

f_e = eigenfrequency of the building Hz
g_p= peak factor
W = the average width of the building in m
D = the average Depth of the building in m
ρ = average density in kg/m^3
g =acceleration due to gravity
β=the structural damping

$$a_r = 78,5\cdot 10^{-3}\left(\frac{V_H}{n_w\sqrt{WD}}\right)^{3.3} \tag{9}$$

Where

f_e = eigenfrequency of the building in Hz
W and D= the average width of the building in m
v_h = the mean wind speed at the top of the building

Appendix H: column

Design load

1-208

Function	Number	kN/m^2	kN/m^2
Mechanical	19	10	1,5*19*10 = 285,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*40*2,511*0,4 = 60,27
Hotel	27	2,511	1,5*27*2,511*0,4 = 40,68
Flexible	39	3,348	1,5*39*3,348*0,5 = 97,93
Office	55	3,348	1,5*55*3,348*0,5 = 138,11
Commercial	6	4,4	1,5*6*4,4*0,4 = 15,84
Lobby	1	5	1,5*1*5 = 7,50
TOTAL			= 678,46

Function	Number	kN/m^2	kN/^{m2}
floor	208	3,94	1,2*3,94*208 = 983,42
beams			1,2*30 *208 = 7488 kN
facade		1 (1 meter diep)	1,2*10,6 *208 = 2689 kN

21-208

Function	Number	kN/m^2	kN/m^2
Mechanical	18	10	1,5*18*10 = 270,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*40*2,511*0,4 = 60,27
Hotel	27	2,511	1,5*27*2,511*0,4 = 40,68
Flexible	39	3,348	1,5*39*3,348*0,5 = 97,93
Office	42	3,348	1,5*42*3,348*0,5 = 105,46
TOTAL			= 607,48

Function	Number	kN/m^2	kN/^{m2}
floor	188	3,94	1,2*3,94*188 = 888,86
beams			1,2*30*188 = 6552 kN
facade		1 (1 meter diep)	1,2*10,6*188 = 2391 kN

55-208

Function	Number	kN/m2	kN/m2
Mechanical	15	10	1,5*15*10 = 225,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*40*2,511*0,4 = 60,26
Hotel	27	2,511	1,5*27*2,511*0,4 = 40,68
Flexible	39	3,348	1,5*39*3,348*0,5 = 97,93
Office	11	3,348	1,5*11*3,348*0,5 = 27,62
TOTAL			= 484,64

Function	Number	kN/m2	kN/m2
floor	154	3,94	1,2*3,94*154 = 728,11
beams			1,2*30*154 = 5544 kN
facade		1 (1 meter diep)	1,2*10,6*154 = 1959 kN

89-208

Function	Number	kN/m2	kN/m2
Mechanical	12	10	1,5*12*10 = 180,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*40*2,511*0,4 = 60,26
Hotel	27	2,511	1,5*27*2,511*0,4 = 40,68
Flexible	19	3,348	1,5*19*3,348*0,5 = 47,41
TOTAL			= 361,80

Function	Number	kN/m2	kN/m2
floor	120	3,94	1,2*3,94*120 = 567,36
beams			1,2*30 * 120 = 4320 kN
facade			1,2*10,6 * 120 = 1526 kN

123-208

Function	Number	kN/m2	kN/m2
Mechanical	9	10	1,5*9*10 = 135,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*40*2,511*0,4 = 60,26
Hotel	15	2,511	1,5*15*2,511*0,4 = 22,60
TOTAL			= 251,01

Function	Number	kN/m2	kN/m2
floor	86	3,94	1,2*3,94*86 = 406,61
beams			1,2*30*86 = 3096 kN
facade		1 (1 meter diep)	1,2*10,6*86 = 1115 kN

156-208

Function	Number	kN/m^2	kN/^{m2}
Mechanical	6	10	1,5*6*10 = 90,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	25	2,511	1,5*25*2,511*0,4 = 58,76
TOTAL			= 181,91

Function	Number	kN/m^2	kN/^{m2}
floor	53	3,94	1,2*3,94*53 = 250,58
beams			1,2*30*53 = 1908 kN
facade		1 (1 meter diep)	1,2*10,6*53 = 647 kN

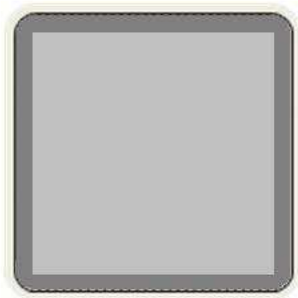
184-208

Function	Number	kN/m^2	kN/^{m2}
Mechanical	3	10	1,5*3*10 = 45,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
TOTAL			= 78,15

Function	Number	kN/m^2	kN/^{m2}
floor	25	3,94	1,2*3,94*57 = 118,2
beams			1,2*30*25 = 900 kN
facade			1,2*10,6*25 = 318 kN

Level	Floors	Design load (kN)	Height (m)	Max. floor-to-floor height	Dimensions (mm)
0-22	208	123117	0-92.1	4	1600x1600 t =50
21-54	188	110679	92.1-218.8	4	1500x1500 t =50
55-88	154	89942	218.8-345.5	4	1300x1300 t = 40
89-122	120	68790	345.5-472.2	4	1200x1200 t =35
123-155	86	48462	472.2-595.2	4	1000x100 t = 30
156-183	53	31244	595.2-699.7	4	800x800 t = 25
184-208	25	13706	699.7-801.9	4,1	600x600 t = 25

Design



Concrete: B85 F_{cd} 70 N/mm^2
$E_{concrete}$: 39300 N/mm^2
Steel: S235 N/mm^2
E_{steel} : 21000 N/mm^2

$$N_{pl} = A_{steel} \cdot 235 + A_{concrete} \cdot F_{cd} \,/ 1,5$$

$$N_{pl;R.K} = A_{steel} \cdot 235 + A_{concrete} \cdot F_{cd}$$

$$EI = E_a I_a + 0,8 \cdot E_d I_c$$

The columns have been calculated using a spreadsheet the results are given in table

	A_{steel}	$A_{concrete}$	I_{steel}	$I_{concrete}$	N_{pl}	$N_{pl \cdot rk}$
Subdivision 1	310000	2250000	1,2426E+11	4,21875E+11	177857,5	230350
Subdivision 2	290000	1960000	1,0174E+11	3,20133E+11	159623,2	205350
Subdivision 3	201600	1488400	5,3397E+10	1,84611E+11	116839,628	151564
Subdivision 4	163100	1276900	3,6927E+10	1,35873E+11	97921,423	127711,5
Subdivision 5	116400	883600	1,8271E+10	65062413333	68591,612	89206
Subdivision 6	77500	562500	7766145833	26367187500	44464,375	57587,5
Subdivision 7	57500	302500	3174479167	7625520833	27630,175	34687,5

Table 21

	EI	Nsd/Npl
Subdivision 1	3,9358E+16	0,69
Subdivision 2	3,1431E+16	0,69
Subdivision 3	1,7018E+16	0,77
Subdivision 4	1,2027E+16	0,70
Subdivision 5	5,8825E+15	0,71
Subdivision 6	2,4599E+15	0,70
Subdivision 7	9,0639E+14	0,50

Table 22

Due to the large dimensions of the columns buckling does not need to be checked.
During the design process the elasticity modulus of the concrete changed because c90/105 was used instead of c70/85. The dimensions of the megacolumns however were kept the same.
The thickness of the steel in the columns is not correct in part 2 of the thesis. This should be

Dimensions (mm)
1600x1600 t =50
1500x1500 t =50
1300x1300 t = 40
1200x1200 t =35
1000x100 t = 30
800x800 t = 25
600x600 t = 25

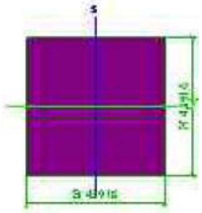
Table 23 correct thickness steel megacolumns

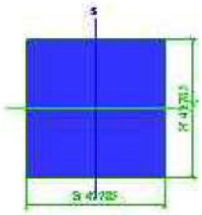
Appendix I: ESA INPUT -OUTPUT

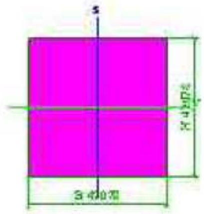
Alternative 1: Core

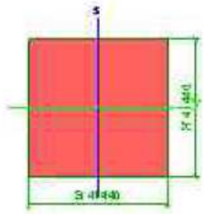
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

1. Doorsneden

Naam	CS3	
Type	Rechthoek	
Uitgebreid	43916; 43916	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,9286e+03	
A y, z [m²]	1,4236e+03	1,4236e+03
I y, z [m⁴]	3,0996e+05	3,0996e+05
I w [m⁶], t [m⁴]	0,0000e+00	2,8493e+05
Wel y, z [m³]	1,4116e+04	1,4116e+04
Wpl y, z [m³]	2,1174e+04	2,1174e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21958	21958
alpha [deg]	0,00	
AL [m²/m]	1,7566e+02	

Naam	CS4	
Type	Rechthoek	
Uitgebreid	42785; 42785	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,8306e+03	
A y, z [m²]	1,5255e+03	1,5255e+03
I y, z [m⁴]	2,7924e+05	2,7924e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,7114e+05
Wel y, z [m³]	1,3053e+04	1,3053e+04
Wpl y, z [m³]	1,9580e+04	1,9580e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21393	21393
alpha [deg]	0,00	
AL [m²/m]	1,7114e+02	

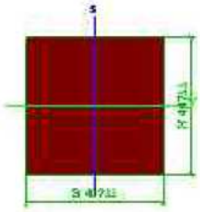
Naam	CS5	
Type	Rechthoek	
Uitgebreid	42078; 42078	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,7706e+03	
A y, z [m²]	1,4755e+03	1,4755e+03
I y, z [m⁴]	2,6124e+05	2,6124e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,4076e+05
Wel y, z [m³]	1,2417e+04	1,2417e+04
Wpl y, z [m³]	1,8625e+04	1,8625e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21039	21039
alpha [deg]	0,00	
AL [m²/m]	1,6831e+02	

Naam	CS6	
Type	Rechthoek	
Uitgebreid	41440; 41440	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,7173e+03	
A y, z [m²]	1,4311e+03	1,4311e+03
I y, z [m⁴]	2,4575e+05	2,4575e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,1463e+05
Wel y, z [m³]	1,1861e+04	1,1861e+04
Wpl y, z [m³]	1,7791e+04	1,7791e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20720	20720
alpha [deg]	0,00	
AL [m²/m]	1,6576e+02	

Naam	CS7	
Type	Rechthoek	
Uitgebreid	40733; 40733	
Onderdeelmateriaal	Emod44000	

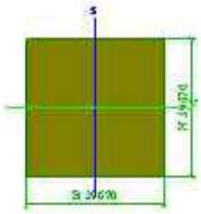
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		



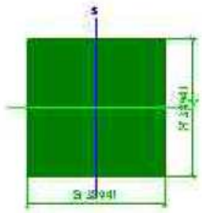
A [m²]	1,6592e+03	
A y, z [m²]	1,3826e+03	1,3826e+03
I y, z [m⁴]	2,2941e+05	2,2941e+05
I w [m⁶], t [m⁴]	0,0000e+00	3,8705e+05
Wel y, z [m³]	1,1264e+04	1,1264e+04
Wpl y, z [m³]	1,6896e+04	1,6896e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20367	20367
alpha [deg]	0,00	
AL [m²/m]	1,6293e+02	

Naam	CS8	
Type	Rechthoek	
Uitgebreid	39670; 39670	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		



A [m²]	1,5737e+03	
A y, z [m²]	1,3114e+03	1,3114e+03
I y, z [m⁴]	2,0638e+05	2,0638e+05
I w [m⁶], t [m⁴]	0,0000e+00	3,4820e+05
Wel y, z [m³]	1,0405e+04	1,0405e+04
Wpl y, z [m³]	1,5607e+04	1,5607e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	19835	19835
alpha [deg]	0,00	
AL [m²/m]	1,5868e+02	

Naam	CS9	
Type	Rechthoek	
Uitgebreid	38941; 38941	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		



A [m²]	1,5164e+03	
A y, z [m²]	1,2637e+03	1,2637e+03
I y, z [m⁴]	1,9162e+05	1,9162e+05
I w [m⁶], t [m⁴]	0,0000e+00	3,2331e+05
Wel y, z [m³]	9,8417e+03	9,8417e+03
Wpl y, z [m³]	1,4763e+04	1,4763e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	19471	19471
alpha [deg]	0,00	
AL [m²/m]	1,5576e+02	

2. Materialen

Naam	S235
Type	Staal
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	7850,00
E-mod [MPa]	2,1000e+05
Poisson - nu	0,3
Onafhankelijke G-modulus	×
G-mod [MPa]	8,0769e+04
Log. decrement	0,025
Therm. exp. (brand) [m/mK]	0,00
Specifieke hitte [J/gK]	6,0000e-01
Thermische geleiding [W/mK]	4,5000e+01
Fu [MPa]	360,0
Fy [MPa]	235,0

Type	Beton
Naam	C53/65
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	2500,00
E-mod [MPa]	3,8500e+04
Poisson - nu	0,2
Onafhankelijke G-modulus	×

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

G-mod [MPa]	1,6042e+04
Karakteristieke kubusdruksterkte (f'ck) [MPa]	65,00
Gemiddelde treksterkte [MPa]	4,30
Cementklasse	32.5
Door gebruiker gedefinieerde treksterkte (fbrep)	×
Representatieve treksterkte (fbrep) [MPa]	3,01
Rekenwaarde van de druksterkte (f'b) [MPa]	39,00
Rekenwaarde van de treksterkte (fb) [MPa]	2,15
Gemiddelde treksterkte (fbm) [MPa]	4,21
Gemeten waarden van gemiddelde druksterkte (invloed van ouderdom)	×

Type	Beton
Naam	Emod44000
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m^3]	2500,00
E-mod [MPa]	4,4000e+04
Poisson - nu	0,2
Onafhankelijke G-modulus	×
G-mod [MPa]	1,8333e+04
Karakteristieke kubusdruksterkte (f'ck) [MPa]	105,00
Gemiddelde treksterkte [MPa]	4,30
Cementklasse	32.5
Door gebruiker gedefinieerde treksterkte (fbrep)	✓
Representatieve treksterkte (fbrep) [MPa]	0,00
Rekenwaarde van de druksterkte (f'b) [MPa]	63,00
Rekenwaarde van de treksterkte (fb) [MPa]	0,00
Gemiddelde treksterkte (fbm) [MPa]	0,00
Gemeten waarden van gemiddelde druksterkte (invloed van ouderdom)	×

3. Belastinggevallen

Naam	Omschrijving	Actie type	Lastgroep	Belastingtype	Spec	Duur	'Master' belastinggeval
BG3	wind	Variabel	LG2	Statisch	Standaard	Kort	Geen
BG1	self weight	Permanent	LG1	Standaard			
BG2	imposed loads	Variabel	LG2	Statisch	Standaard	Lang	Geen

4. Lastgroepen

Naam	Last	Relatie	Coëff.
LG1	Permanent		

Naam	Last	Relatie	Coëff.
LG2	Variabel	Standaard	0,5

5. Combinaties

Naam	Type	Belastinggevallen	Coëff. [-]
Combi2	Lineair - UGT	BG3 - wind	1,50
		BG1 - self weight	1,20
		BG2 - imposed loads	1,50
Combi3	Lineair - BGT	BG3 - wind	1,00
		BG1 - self weight	1,00
		BG2 - imposed loads	1,00

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

6. Niet-lineaire combinaties

Naam	Omschrijving	Type	Belastinggevallen	Coëff. [-]
combi1	nonlin	Uiterste Grenstoestand	BG3 - wind	1,50
			BG1 - self weight	1,20
			BG2 - imposed loads	1,50
combi2	nonlin	Bruikbaarheidsgrenstoestand	BG3 - wind	1,00
			BG1 - self weight	1,00
			BG2 - imposed loads	1,00

7. Combinatiesleutel

Naam	Omschrijving van de combinaties
1	BG3*1.50 +BG1*1.20 +BG2*1.50

Naam	Omschrijving van de combinaties
2	BG3*1.00 +BG1*1.00 +BG2*1.00

8. Lijnlasten op staven

Naam	Staaf / Belastinggeval	Type / Systeem	Rich / Verdeling	P1 [kN/m] / P2 [kN/m]	x1 / x2	Coör / Loc	Oors
Lijnlast1	S1189	Kracht	Z	-95,00	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		1,000	Lengte	
Lijnlast2	S691	Kracht	Z	-95,00	0,000	Abso	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		7,900	Lengte	
Lijnlast3	S1188	Kracht	Z	-143,00	2,200	Abso	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		102,200	Lengte	
Lijnlast4	S691	Kracht	Z	-95,00	7,900	Abso	Vanaf begin
	BG3 - wind	LCS	Trapez	-103,91	126,700	Lengte	
Lijnlast5	S940	Kracht	Z	-103,91	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-113,41	1,000	Lengte	
Lijnlast6	S1101	Kracht	Z	-113,41	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-122,92	1,000	Lengte	
Lijnlast7	S1106	Kracht	Z	-122,92	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-132,40	1,000	Lengte	
Lijnlast8	S1159	Kracht	Z	-132,40	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-139,98	1,000	Lengte	
Lijnlast9	S1188	Kracht	Z	-139,98	0,000	Abso	Vanaf begin
	BG3 - wind	LCS	Trapez	-140,00	2,200	Lengte	
Lijnlast10	S1188	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast11	S1159	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast12	S1106	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast13	S1101	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast14	S940	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast15	S691	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	
Lijnlast16	S1189	Kracht	Z	-1794,10	0,000	Rela	Vanaf begin
	BG2 - imposed loads	GCS	Trapez	-1794,10	1,000	Lengte	

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Naam	Staaf Belastinggeval	Type Systeem	Rich Verdeling	P1 [kN/m] P2 [kN/m]	x1 x2	Coör Loc	Oors
Lijnlast17	S1188 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast18	S1159 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast19	S1106 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast20	S1101 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast21	S691 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast22	S940 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin
Lijnlast23	S1189 BG1 - self weight	Kracht GCS	Z Trapez	-13207,00 -13207,00	0,000 1,000	Rela Lengte	Vanaf begin

9. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	BG1	0,000	**-10590693,38**	0,00	0,00	0,00	0,00	0,00
S1188	BG1	102,200	**0,00**	0,00	0,00	0,00	0,00	0,00
S691	BG1	0,000	-9374328,83	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

10. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	BG2	0,000	**-1438688,77**	0,00	0,00	0,00	0,00	0,00
S1188	BG2	102,200	**0,00**	0,00	0,00	0,00	0,00	0,00
S691	BG2	0,000	-1273452,16	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

11. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG3

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S691	BG3	0,000	**0,00**	**0,00**	85846,06	**0,00**	-32671692,80	**0,00**
S1188	BG3	102,200	0,00	0,00	**0,00**	0,00	**0,00**	0,00
S1189	BG3	0,000	0,00	0,00	**94595,55**	0,00	**-40981028,86**	0,00

12. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Selectie : Alle
Combinaties : Combi2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	Combi2/1	0,000	**-14866865,15**	0,00	**141893,33**	0,00	**-61471543,30**	0,00
S1188	Combi2/1	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S691	Combi2/1	0,000	-13159372,80	**0,00**	128769,09	**0,00**	-49007538,18	**0,00**

13. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi3

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	Combi3/2	0,000	**-12029382,66**	0,00	**94595,55**	0,00	**-40981028,86**	0,00
S1188	Combi3/2	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S691	Combi3/2	0,000	-10647781,38	**0,00**	85846,06	**0,00**	-32671692,80	**0,00**

14. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi1

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	combi1	0,000	**-14866952,19**	0,00	**143861,15**	**0,00**	**-70408142,85**	**0,00**
S1188	combi1	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S1189	combi1	46,050	-14013174,78	**0,00**	140361,86	0,00	-63859150,85	0,00
S1106	combi1	0,000	-6112373,76	**0,00**	81638,68	0,00	-13882636,29	**-0,10**
S940	combi1	0,000	-10810321,92	0,00	126983,66	**0,00**	-40661549,06	0,00

15. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	combi2	0,000	**-12029441,02**	**0,00**	**96187,52**	**0,00**	**-46647615,49**	**0,00**
S1188	combi2	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S691	combi2	0,000	-10647788,54	**0,00**	93163,84	0,00	-38042128,38	**-0,28**
S940	combi2	0,000	-8747107,33	0,00	84317,09	**0,00**	-26883854,34	-0,20

16. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG1	S1188	102,200	**-54,2**	0,0	0,0	0,0	0,0	0,0
BG1	S1189	0,000	**0,0**	0,0	0,0	0,0	0,0	0,0
BG1	S691	0,000	-10,8	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

17. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG1	S1188	102,200	**-54,2**	0,0	0,0	0,0	0,0	0,0
BG1	S1189	0,000	**0,0**	0,0	0,0	0,0	0,0	0,0
BG1	S691	0,000	-10,8	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

18. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG2	S1188	102,200	**-7,4**	0,0	0,0	0,0	0,0	0,0
BG2	S1189	0,000	**0,0**	0,0	0,0	0,0	0,0	0,0
BG2	S691	0,000	-1,5	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**

19. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG3

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG3	S691	0,000	**0,0**	**0,0**	-12,2	**0,0**	0,2	**0,0**
BG3	S1188	102,200	0,0	0,0	**-550,3**	0,0	**0,9**	0,0
BG3	S1189	0,000	0,0	0,0	**0,0**	0,0	**0,0**	0,0

20. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
Combi2/1	S1188	102,200	**-76,1**	0,0	**-825,5**	0,0	**1,4**	0,0
Combi2/1	S1189	0,000	**0,0**	0,0	**0,0**	0,0	**0,0**	0,0
Combi2/1	S691	0,000	-15,2	**0,0**	-18,3	**0,0**	0,4	**0,0**

21. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi3

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
Combi3/2	S1188	102,200	**-61,6**	0,0	**-550,3**	0,0	**0,9**	0,0
Combi3/2	S1189	0,000	**0,0**	0,0	**0,0**	0,0	**0,0**	0,0
Combi3/2	S691	0,000	-12,3	**0,0**	-12,2	**0,0**	0,2	**0,0**

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

22. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
combi1	S1188	102,200	**-76,0**	0,0	**-979,2**	0,0	**1,7**	0,0
combi1	S1189	0,000	**0,0**	0,0	**0,0**	0,0	**0,0**	0,0
combi1	S691	0,000	-15,2	**0,0**	-21,0	**0,0**	0,4	**0,0**

23. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
combi2	S1188	102,200	**-61,5**	0,0	**-647,6**	0,0	**1,1**	0,0
combi2	S1189	0,000	**0,0**	0,0	**0,0**	0,0	**0,0**	0,0
combi2	S691	0,000	-12,3	**0,0**	-13,9	**0,0**	0,3	**0,0**

24. Reacties

Lineaire berekening, Extreem : Knoop
Selectie : Alle
Klasse : Alle BGT

Steunpunt	BG	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
Sn29/K1	Combi3/2	**-94595,55**	**0,00**	**12029382,66**	**0,00**	**-40981028,86**	**0,00**

25. Resultante

Lineaire berekening, Extreem : Globaal
Selectie : Alle
Belastinggevallen: BG3

BG	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
BG3	**-94595,55**	**0,00**	**0,00**	**0,00**	**-40981028,86**	**0,00**

Centraalpunt:

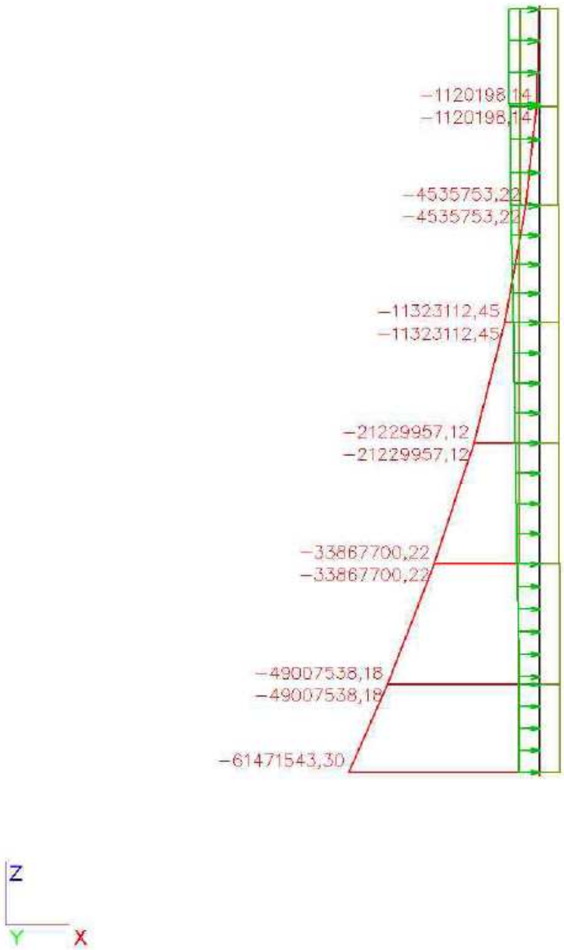
X [m]	Y [m]	Z [m]
0,000	0,000	0,000

26. Eigenfrequenties

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Massacombinatie : CM1				
1	0,05	0,30	0,09	20,74
2	0,05	0,30	0,09	20,74
3	0,27	1,72	2,97	3,65
4	0,27	1,72	2,97	3,65

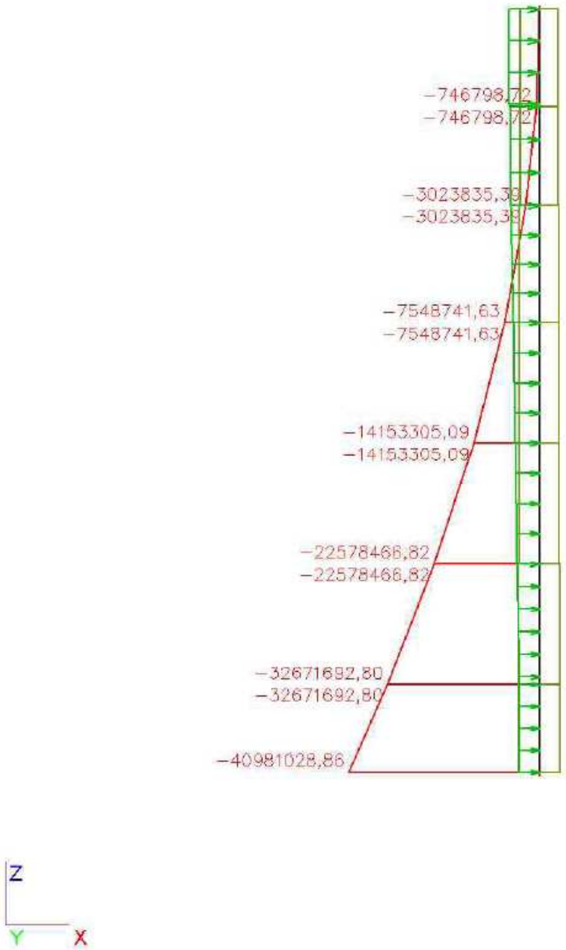
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

27. UGT Linear



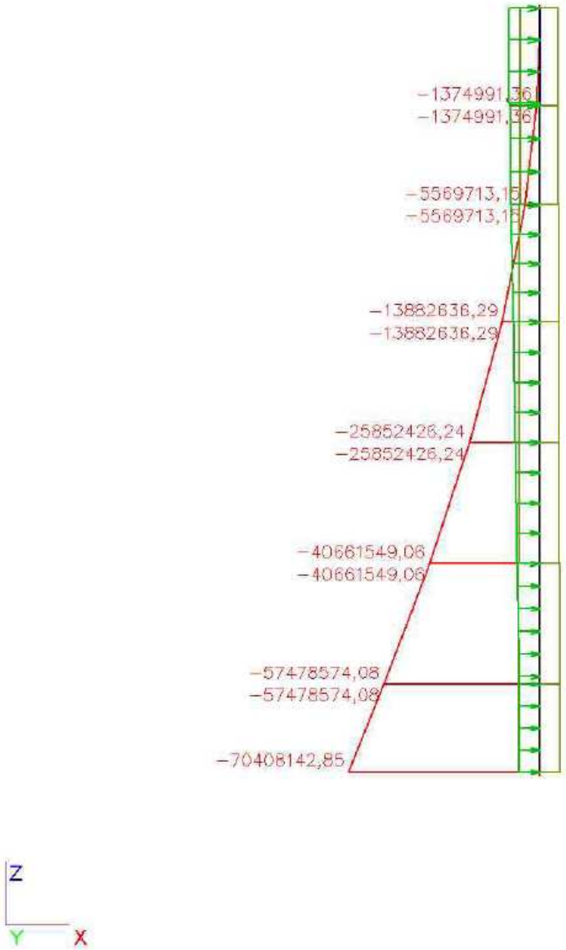
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

28. BGT linear



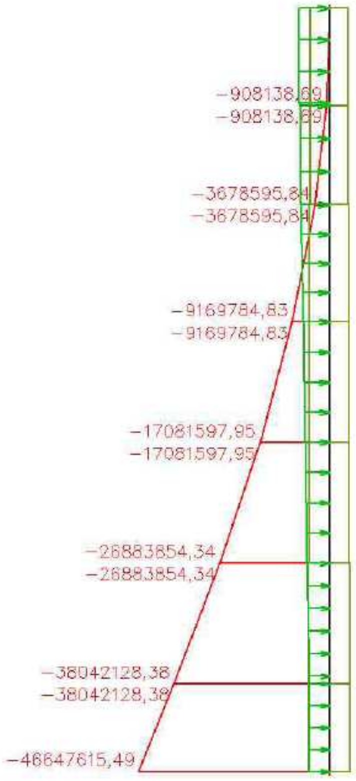
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

29. UGT non linear



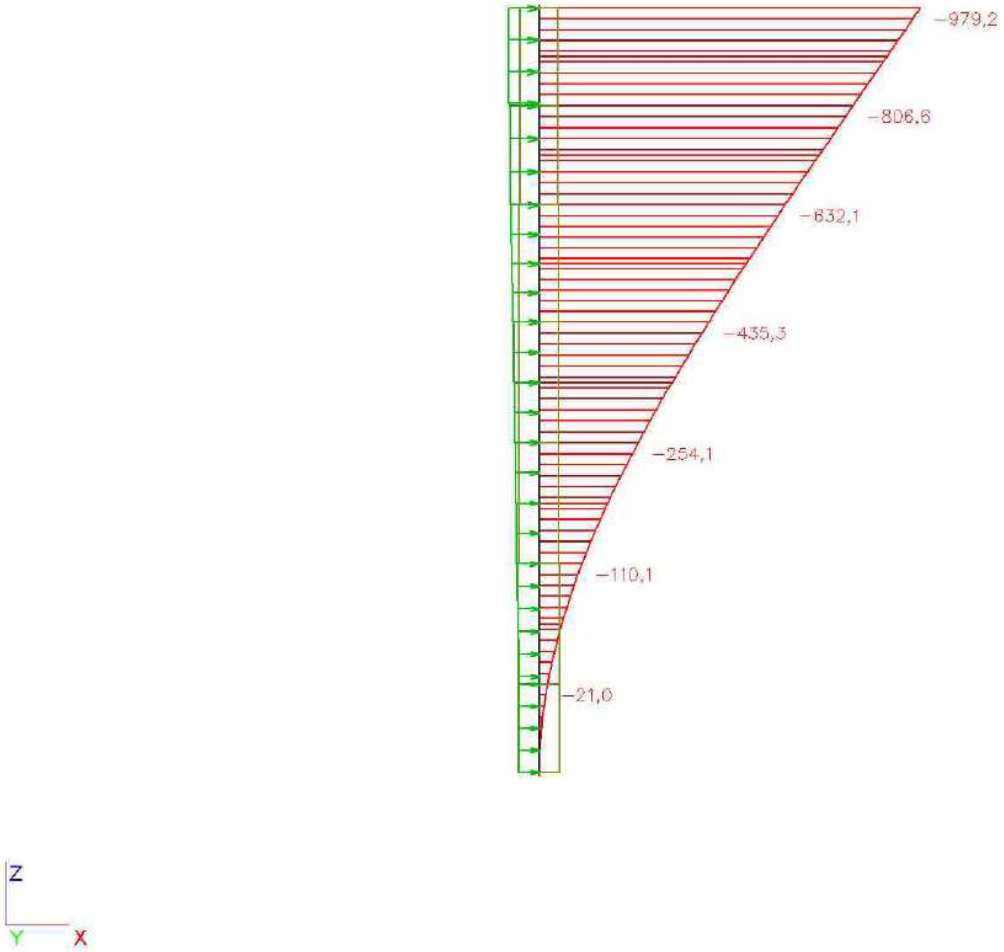
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

30. BGT non linear



Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

31. UGT non linear



32. Spanning

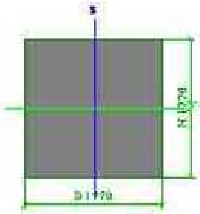
Niet-lineaire berekening
Selectie : S1189
Niet-lineaire combinaties : combi1
Normaalspanning, Schuifspanning, Von Mises

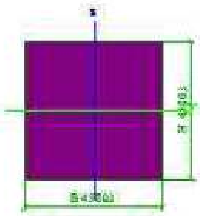
Staaf : S1189, doorsnede : 0.000[m]

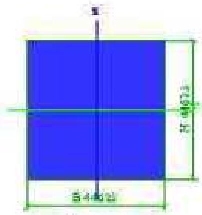
Alternative 2: Core-outrigger

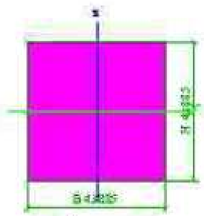
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

1. Doorsneden

Naam	CS1	
Type	Rechthoek	
Uitgebreid	1770; 1770	
Onderdeelmateriaal	Emod44000	
Bouwwijze	beton	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	3,1329e+00	
A y, z [m²]	2,6108e+00	2,6108e+00
I y, z [m⁴]	8,1792e-01	8,1792e-01
I w [m⁶], t [m⁴]	0,0000e+00	1,3800e+00
Wel y, z [m³]	9,2421e-01	9,2421e-01
Wpl y, z [m³]	1,3863e+00	1,3863e+00
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	885	885
alpha [deg]	0,00	
AL [m²/m]	7,0800e+00	

Naam	CS3	
Type	Rechthoek	
Uitgebreid	45803; 45803	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	2,0979e+03	
A y, z [m²]	1,4236e+03	1,4236e+03
I y, z [m⁴]	3,6677e+05	3,6677e+05
I w [m⁶], t [m⁴]	0,0000e+00	2,8493e+05
Wel y, z [m³]	1,6015e+04	1,6015e+04
Wpl y, z [m³]	2,4023e+04	2,4023e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22902	22902
alpha [deg]	0,00	
AL [m²/m]	1,8321e+02	

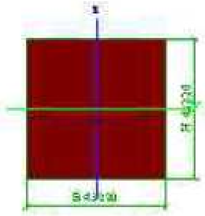
Naam	CS4	
Type	Rechthoek	
Uitgebreid	44623; 44623	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,9912e+03	
A y, z [m²]	1,6593e+03	1,6593e+03
I y, z [m⁴]	3,3041e+05	3,3041e+05
I w [m⁶], t [m⁴]	0,0000e+00	5,5747e+05
Wel y, z [m³]	1,4809e+04	1,4809e+04
Wpl y, z [m³]	2,2213e+04	2,2213e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22312	22312
alpha [deg]	0,00	
AL [m²/m]	1,7849e+02	

Naam	CS5	
Type	Rechthoek	
Uitgebreid	43885; 43885	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,9259e+03	
A y, z [m²]	1,6049e+03	1,6049e+03
I y, z [m⁴]	3,0909e+05	3,0909e+05
I w [m⁶], t [m⁴]	0,0000e+00	5,2149e+05
Wel y, z [m³]	1,4086e+04	1,4086e+04
Wpl y, z [m³]	2,1129e+04	2,1129e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21943	21943
alpha [deg]	0,00	
AL [m²/m]	1,7554e+02	

Naam	CS7
Type	Rechthoek
Uitgebreid	43220; 43220
Onderdeelmateriaal	Emod44000

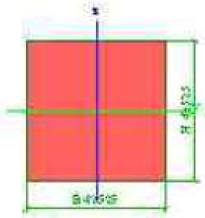
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		



A [m²]	1,8680e+03	
A y, z [m²]	1,5566e+03	1,5566e+03
I y, z [m⁴]	2,9078e+05	2,9078e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,9060e+05
Wel y, z [m³]	1,3456e+04	1,3456e+04
Wpl y, z [m³]	2,0183e+04	2,0183e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21610	21610
alpha [deg]	0,00	
AL [m²/m]	1,7288e+02	

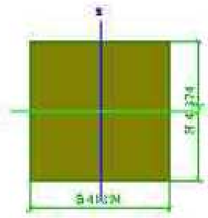
Naam	CS6	
Type	Rechthoek	
Uitgebreid	42525; 42525	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		



A [m²]	1,8084e+03	
A y, z [m²]	1,5070e+03	1,5070e+03
I y, z [m⁴]	2,7252e+05	2,7252e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,5979e+05
Wel y, z [m³]	1,2817e+04	1,2817e+04
Wpl y, z [m³]	1,9225e+04	1,9225e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21263	21263
alpha [deg]	0,00	
AL [m²/m]	1,7010e+02	

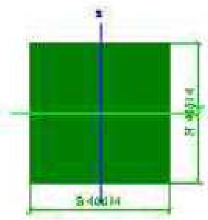
Naam	CS8	
Type	Rechthoek	
Uitgebreid	41374; 41374	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Afbeelding



A [m²]	1,7118e+03	
A y, z [m²]	1,4265e+03	1,4265e+03
I y, z [m⁴]	2,4419e+05	2,4419e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,1200e+05
Wel y, z [m³]	1,1804e+04	1,1804e+04
Wpl y, z [m³]	1,7706e+04	1,7706e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20687	20687
alpha [deg]	0,00	
AL [m²/m]	1,6550e+02	

Naam	CS9	
Type	Rechthoek	
Uitgebreid	40614; 40614	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		

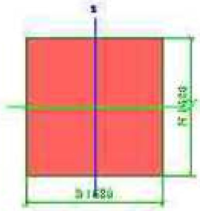


A [m²]	1,6495e+03	
A y, z [m²]	1,3746e+03	1,3746e+03
I y, z [m⁴]	2,2674e+05	2,2674e+05
I w [m⁶], t [m⁴]	0,0000e+00	3,8255e+05
Wel y, z [m³]	1,1165e+04	1,1165e+04
Wpl y, z [m³]	1,6748e+04	1,6748e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20307	20307
alpha [deg]	0,00	
AL [m²/m]	1,6246e+02	

Naam	CS11	
Type	Rechthoek	
Uitgebreid	1680; 1680	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

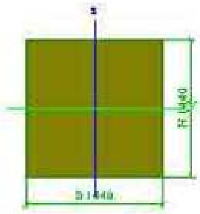
Afbeelding



A [m²]	2,8224e+00	
A y, z [m²]	2,3520e+00	2,3520e+00
I y, z [m⁴]	6,6383e-01	6,6383e-01
I w [m⁶], t [m⁴]	0,0000e+00	1,1200e+00
Wel y, z [m³]	7,9027e-01	7,9027e-01
Wpl y, z [m³]	1,1854e+00	1,1854e+00
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	840	840
alpha [deg]	0,00	
AL [m²/m]	6,7200e+00	

Naam	CS12	
Type	Rechthoek	
Uitgebreid	1440; 1440	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

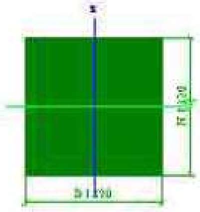
Afbeelding



A [m²]	2,0736e+00	
A y, z [m²]	1,7280e+00	1,7280e+00
I y, z [m⁴]	3,5832e-01	3,5832e-01
I w [m⁶], t [m⁴]	0,0000e+00	6,0455e-01
Wel y, z [m³]	4,9766e-01	4,9766e-01
Wpl y, z [m³]	7,4650e-01	7,4650e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	720	720
alpha [deg]	0,00	
AL [m²/m]	5,7600e+00	

Naam	CS13	
Type	Rechthoek	
Uitgebreid	1320; 1320	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

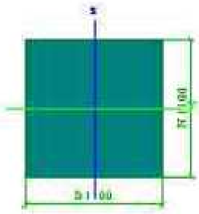
Afbeelding



A [m²]	1,7424e+00	
A y, z [m²]	1,4520e+00	1,4520e+00
I y, z [m⁴]	2,5300e-01	2,5300e-01
I w [m⁶], t [m⁴]	0,0000e+00	4,2686e-01
Wel y, z [m³]	3,8333e-01	3,8333e-01
Wpl y, z [m³]	5,7499e-01	5,7499e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	660	660
alpha [deg]	0,00	
AL [m²/m]	5,2800e+00	

Naam	CS14	
Type	Rechthoek	
Uitgebreid	1100; 1100	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Afbeelding

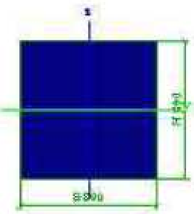


A [m²]	1,2100e+00	
A y, z [m²]	1,0083e+00	1,0083e+00
I y, z [m⁴]	1,2201e-01	1,2201e-01
I w [m⁶], t [m⁴]	0,0000e+00	2,0585e-01
Wel y, z [m³]	2,2183e-01	2,2183e-01
Wpl y, z [m³]	3,3275e-01	3,3275e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	550	550
alpha [deg]	0,00	
AL [m²/m]	4,4000e+00	

Naam	CS15	
Type	Rechthoek	
Uitgebreid	890; 890	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Afbeelding

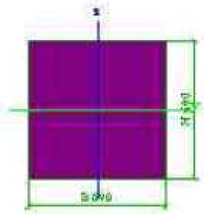


A [m²]	7,9210e-01	
A y, z [m²]	6,6008e-01	6,6008e-01
I y, z [m⁴]	5,2285e-02	5,2285e-02
I w [m⁶], t [m⁴]	0,0000e+00	8,8216e-02
Wel y, z [m³]	1,1749e-01	1,1749e-01
Wpl y, z [m³]	1,7624e-01	1,7624e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	445	445
alpha [deg]	0,00	
AL [m²/m]	3,5600e+00	

Naam	CS16
Type	Rechthoek
Uitgebreid	690; 690
Onderdeelmateriaal	Emod44000

Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Afbeelding



A [m²]	4,7610e-01	
A y, z [m²]	3,9675e-01	3,9675e-01
I y, z [m⁴]	1,8889e-02	1,8889e-02
I w [m⁶], t [m⁴]	0,0000e+00	3,1870e-02
Wel y, z [m³]	5,4752e-02	5,4752e-02
Wpl y, z [m³]	8,2127e-02	8,2127e-02
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	345	345
alpha [deg]	0,00	
AL [m²/m]	2,7600e+00	

2. Materialen

Naam	S235
Type	Staal
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	7850,00
E-mod [MPa]	2,1000e+05
Poisson - nu	0,3
Onafhankelijke G-modulus	×
G-mod [MPa]	8,0769e+04
Log. decrement	0,025
Therm. exp. (brand) [m/mK]	0,00
Specifieke hitte [J/gK]	6,0000e-01
Thermische geleiding [W/mK]	4,5000e+01
Fu [MPa]	360,0
Fy [MPa]	235,0

Naam	S355

Type	Staal
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	7850,00
E-mod [MPa]	2,1000e+05
Poisson - nu	0,3
Onafhankelijke G-modulus	×
G-mod [MPa]	8,0769e+04
Log. decrement	0,025
Therm. exp. (brand) [m/mK]	0,00
Specifieke hitte [J/gK]	6,0000e-01
Thermische geleiding [W/mK]	4,5000e+01
Fu [MPa]	510,0
Fy [MPa]	355,0

Type	Beton
Naam	Emod44000
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	2500,00
E-mod [MPa]	4,4000e+04
Poisson - nu	0,2
Onafhankelijke G-modulus	×
G-mod [MPa]	1,8333e+04
Karakteristieke kubusdruksterkte (f'ck) [MPa]	105,00
Gemiddelde treksterkte [MPa]	4,30
Cementklasse	32.5
Door gebruiker gedefinieerde treksterkte (fbrep)	×

NEMETSCHEK Scia

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Representatieve treksterkte (fbrep) [MPa]	4,41
Rekenwaarde van de druksterkte (f'b) [MPa]	63,00
Rekenwaarde van de treksterkte (fb) [MPa]	3,15
Gemiddelde treksterkte (fbm) [MPa]	6,17
Gemeten waarden van gemiddelde druksterkte (invloed van ouderdom)	×

3. Belastinggevallen

Naam	Omschrijving	Actie type	Lastgroep	Belastingtype	Spec	Duur	'Master' belastinggeval
BG1	self weight	Permanent	LG3	Standaard			
BG2	imposed loads	Variabel	LG4	Statisch	Standaard	Lang	Geen
BG3	wind	Variabel	LG2	Statisch	Standaard	Kort	Geen

4. Combinaties

Naam	Type	Belastinggevallen	Coëff. [-]
UGT	Lineair - UGT	BG1 - self weight	1,20
		BG2 - imposed loads	1,50
		BG3 - wind	1,50
BGT	Lineair - BGT	BG1 - self weight	1,00
		BG2 - imposed loads	1,00
		BG3 - wind	1,00

5. Niet-lineaire combinaties

Naam	Omschrijving	Type	Belastinggevallen	Coëff. [-]
NLCombi1		Uiterste Grenstoestand	BG1 - self weight	1,20
			BG2 - imposed loads	1,50
			BG3 - wind	1,50
NLCombi2		Bruikbaarheidsgrenstoestand	BG1 - self weight	1,00
			BG2 - imposed loads	1,00
			BG3 - wind	1,00

6. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	BG1	0,000	**-11856037,89**	-0,65	0,51	19,98	-116,70	70,05
S1850	BG1	0,000	**12044,13**	5,85	-60,46	34,85	726,47	-67,09
S1870	BG1	0,000	1661,00	**-185,96**	38,82	56,32	-217,10	975,99
S1871	BG1	0,000	1661,31	**185,88**	-38,74	-56,23	192,17	-984,79
S2023	BG1	0,000	773,62	149,16	**-87,36**	**-95,97**	462,27	-825,38
S1997	BG1	0,000	773,61	-149,16	**87,36**	**95,97**	-458,90	747,49
S1455	BG1	0,000	0,12	0,00	11,73	9,78	**-502,74**	0,05

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1851	BG1	0,000	-12308,99	5,94	-60,29	-34,70	**727,40**	-68,31
S1870	BG1	10,545	1661,00	-185,96	38,82	56,32	192,24	**-984,91**
S1864	BG1	0,000	1661,62	-185,88	-38,71	56,21	191,96	**984,79**

7. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	BG2	0,000	**-1689936,90**	-0,20	0,15	5,62	-33,75	20,55
S1850	BG2	0,000	**4586,47**	2,17	-22,94	13,00	277,00	-24,91
S1997	BG2	0,000	341,65	**-61,53**	33,05	**38,49**	-174,62	310,07
S2023	BG2	0,000	341,65	**61,53**	-33,05	**-38,49**	173,90	-338,73
S1064	BG2	0,000	-895,67	11,22	**-33,44**	6,03	168,72	-71,34
S1058	BG2	0,000	-895,67	-11,22	**33,44**	-6,03	-184,54	47,23
S1455	BG2	0,000	0,04	0,00	4,45	3,67	**-190,55**	0,02
S1852	BG2	0,000	4586,47	-2,17	-22,94	-13,00	**277,00**	24,91
S1997	BG2	10,545	341,65	-61,53	33,05	38,49	173,90	**-338,73**
S2004	BG2	0,000	341,65	-61,53	-33,05	38,49	173,90	**338,72**

8. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG3

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S372	BG3	0,000	**-9115,53**	0,00	0,00	0,00	0,00	0,00
S387	BG3	0,000	**9115,53**	0,00	0,00	0,00	0,00	0,00
S769	BG3	0,000	-466,74	**-53,86**	-15,36	-19,55	92,47	280,15
S776	BG3	0,000	466,89	**53,89**	15,37	19,55	-92,61	-280,11
S777	BG3	0,000	575,06	-49,73	**-23,19**	-13,75	123,00	254,86
S1189	BG3	0,000	0,40	-0,01	**94599,63**	16,56	**-34762690,56**	-3,52
S1554	BG3	0,000	320,52	53,11	-3,26	**-67,24**	32,64	**-355,13**
S1562	BG3	0,000	320,19	-53,32	-3,29	**67,63**	32,75	356,43
S1566	BG3	0,000	1570,06	-2,57	-19,19	9,47	**208,02**	2,60
S1561	BG3	0,000	-320,28	-53,43	3,27	67,06	-32,71	**357,30**

9. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : UGT

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	UGT/1	0,000	**-16762150,91**	-1,09	**141900,29**	57,26	**-52144226,30**	109,60
S1850	UGT/1	0,000	**22263,82**	11,15	-112,83	60,18	**1348,05**	-120,39
S1885	UGT/1	0,000	1013,31	**-352,14**	129,22	178,15	-688,92	1865,70
S1912	UGT/1	0,000	1013,23	**352,20**	-129,19	-178,09	673,64	-1847,66
S1049	UGT/1	0,000	-588,88	-190,43	**-162,93**	-129,43	873,84	1075,02
S1939	UGT/1	0,000	587,31	320,71	-152,79	**-206,41**	814,12	-1760,89

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1933	UGT/1	0,000	587,25	-320,73	152,79	**206,42**	-797,06	1621,10
S1911	UGT/1	0,000	786,12	340,35	-127,38	-189,70	671,68	**-1850,80**
S1912	UGT/1	10,545	1013,23	352,20	-129,19	-178,09	-688,63	**1866,29**

10. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : BGT

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	BGT/2	0,000	**-13545974,78**	-0,86	**94600,28**	42,17	**-34762838,02**	87,07
S1850	BGT/2	0,000	**17251,37**	8,60	-87,31	47,09	**1043,99**	-93,68
S1885	BGT/2	0,000	950,53	**-268,49**	99,10	135,22	-529,73	1418,28
S1912	BGT/2	0,000	950,53	**268,53**	-99,08	-135,17	515,22	-1412,98
S1049	BGT/2	0,000	-470,58	-146,79	**-126,08**	-100,36	676,01	829,24
S1939	BGT/2	0,000	600,53	243,98	-117,76	**-156,16**	625,45	-1338,37
S1933	BGT/2	0,000	600,44	-243,99	117,76	**156,17**	-616,33	1234,45
S1911	BGT/2	0,000	799,10	260,63	-97,87	-142,92	513,92	**-1415,12**
S1912	BGT/2	10,545	950,53	268,53	-99,08	-135,17	-529,52	**1418,62**

11. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : NLCombi1

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	NLCombi1	0,000	**-16762135,55**	-1,09	**143605,06**	65,21	**-54362574,85**	110,54
S1850	NLCombi1	0,000	**22316,16**	10,99	-113,26	60,05	**1352,18**	-118,27
S1885	NLCombi1	0,000	949,72	**-353,87**	133,63	177,21	-710,60	1877,15
S1912	NLCombi1	0,000	949,76	**353,91**	-133,60	-177,15	698,41	-1854,38
S2024	NLCombi1	0,000	1220,05	294,47	**-164,63**	-177,37	874,67	-1616,04
S1939	NLCombi1	0,000	526,18	320,42	-150,67	**-205,21**	804,92	-1761,58
S1933	NLCombi1	0,000	525,98	-320,44	150,67	**205,22**	-783,89	1617,25
S1911	NLCombi1	0,000	710,88	341,08	-125,88	-189,95	665,27	**-1856,84**
S1912	NLCombi1	10,545	949,76	353,91	-133,60	-177,15	-710,34	**1877,52**

12. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : NLCombi2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1189	NLCombi2	0,000	**-13545964,54**	-0,86	**95976,95**	48,38	**-36548837,38**	87,80
S1850	NLCombi2	0,000	**17293,75**	8,48	-87,65	46,99	**1047,30**	-92,02
S1885	NLCombi2	0,000	899,80	**-269,98**	102,52	134,61	-546,58	1427,95
S1912	NLCombi2	0,000	899,89	**270,00**	-102,50	-134,56	534,48	-1418,93
S2024	NLCombi2	0,000	966,77	226,02	**-127,65**	-136,92	678,01	-1241,72
S1939	NLCombi2	0,000	551,67	243,88	-116,18	**-155,34**	618,68	-1339,61
S1933	NLCombi2	0,000	551,48	-243,90	116,18	**155,36**	-606,44	1232,11
S1911	NLCombi2	0,000	739,00	261,34	-96,77	-143,23	509,27	**-1420,56**

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1912	NLCombi2	10,545	899,89	270,00	-102,50	-134,56	-546,40	**1428,14**

13. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG1	S1181	102,200	**-91,7**	0,0	0,0	0,0	0,2	0,2
BG1	S2360	0,000	**57,9**	-3,1	-51,3	0,3	0,0	0,3
BG1	S1073	55,013	-61,4	**-7,0**	-7,0	0,0	0,0	0,0
BG1	S1080	55,013	-61,4	**7,0**	-7,0	0,0	0,0	0,0
BG1	S1475	10,545	0,0	0,0	**-91,7**	**-0,9**	0,1	0,0
BG1	S1087	55,013	-61,4	7,0	**7,0**	0,0	0,0	0,0
BG1	S1487	0,000	0,0	0,0	-91,7	**0,9**	-0,1	0,0
BG1	S1468	6,248	0,0	0,0	-85,1	-0,1	**-1,0**	0,0
BG1	S1474	6,248	0,0	0,0	-85,1	-0,1	**1,0**	0,0
BG1	S1181	0,000	-77,1	1,8	-1,8	0,0	-0,4	**-0,4**
BG1	S1174	0,000	-77,1	-1,8	-1,8	0,0	-0,4	**0,4**

14. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG2	S1181	102,200	**-22,3**	0,0	0,0	0,0	0,1	0,1
BG2	S2360	0,000	**12,8**	-1,2	-11,4	0,1	0,0	0,1
BG2	S1181	46,692	-20,4	**-2,6**	**2,6**	0,0	0,0	0,0
BG2	S1174	46,692	-20,4	**2,6**	2,6	0,0	0,0	0,0
BG2	S1475	10,545	0,0	0,0	**-22,3**	**-0,4**	0,0	0,0
BG2	S1486	10,545	0,0	0,0	-22,3	**0,4**	0,0	0,0
BG2	S1468	6,248	0,0	0,0	-19,8	0,0	**-0,4**	0,0
BG2	S1474	6,248	0,0	0,0	-19,8	0,0	**0,4**	0,0
BG2	S1181	0,000	-17,0	0,6	-0,6	0,0	-0,1	**-0,1**
BG2	S1174	0,000	-17,0	-0,6	-0,6	0,0	-0,1	**0,1**

15. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG3

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG3	S1481	0,000	**-377,8**	0,0	-4,6	0,0	-0,6	0,0
BG3	S1463	0,000	**377,8**	0,0	4,6	0,0	0,6	0,0
BG3	S1472	7,500	0,0	**-377,8**	30,5	0,6	0,0	0,0
BG3	S1460	0,000	-57,2	**373,4**	0,0	**-0,6**	-0,1	0,0
BG3	S1163	102,200	-30,4	0,0	**-377,8**	0,0	0,6	0,0
BG3	S1845	17,250	-205,9	-48,4	**241,7**	0,1	-0,6	-0,1
BG3	S1445	0,000	57,2	-373,4	0,0	**0,6**	0,1	0,0

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG3	S1453	0,000	-373,4	-57,2	0,0	0,1	-0,6	0,0
BG3	S1124	123,000	20,5	0,2	-245,9	0,0	0,7	0,0
BG3	S2321	15,988	29,7	-309,7	-79,7	0,4	0,2	-0,5
BG3	S2326	0,000	-29,7	-309,7	-79,7	0,4	-0,2	0,5

16. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : UGT

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
UGT/1	S1481	0,000	-566,6	0,0	-145,2	-1,5	-1,3	0,0
UGT/1	S1463	15,000	566,6	0,0	-145,2	-1,5	1,3	0,0
UGT/1	S1472	7,500	0,0	-566,6	-91,1	-0,6	0,0	0,0
UGT/1	S1461	29,742	85,7	560,1	-111,4	-1,0	1,6	0,0
UGT/1	S1167	102,200	-176,2	0,0	-566,6	0,0	0,7	-0,3
UGT/1	S2307	0,000	380,7	116,4	282,0	0,1	0,7	0,1
UGT/1	S1496	0,000	240,3	513,2	-181,2	-2,5	0,1	0,0
UGT/1	S1490	0,000	140,8	-548,9	-183,9	2,5	-0,1	0,0
UGT/1	S1830	17,250	-236,4	-70,9	-420,9	0,1	-1,9	0,1
UGT/1	S1493	6,196	560,1	85,7	-168,5	0,0	2,5	0,0
UGT/1	S2329	15,975	-312,1	-378,1	126,3	0,9	-0,5	-1,1
UGT/1	S2317	0,000	312,0	-378,1	126,3	0,9	0,5	1,1

17. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : BGT

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BGT/2	S1481	0,000	-377,8	0,0	-114,6	-1,2	-0,9	0,0
BGT/2	S1463	15,000	377,8	0,0	-114,6	-1,2	0,9	0,0
BGT/2	S1472	7,500	0,0	-377,8	-78,3	-0,6	0,0	0,0
BGT/2	S1461	29,742	57,2	373,4	-88,5	-0,7	1,2	0,0
BGT/2	S1167	102,200	-135,8	0,0	-377,8	0,0	0,4	-0,2
BGT/2	S2307	0,000	265,1	77,3	177,9	0,1	0,4	0,1
BGT/2	S1496	0,000	160,2	342,1	-139,0	-1,8	0,0	0,0
BGT/2	S1489	0,000	160,2	-342,1	-139,0	1,8	0,0	0,0
BGT/2	S1830	17,250	-148,0	-47,3	-290,5	0,1	-1,3	0,1
BGT/2	S1493	6,196	373,4	57,2	-129,0	0,0	1,9	0,0
BGT/2	S2329	15,975	-219,6	-252,7	74,0	0,7	-0,3	-0,8
BGT/2	S2317	0,000	219,6	-252,7	74,0	0,7	0,3	0,8

18. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : NLCombi1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
NLCombi1	S1481	0,000	-597,9	0,0	-145,6	-1,5	-1,4	0,0

Diagrid

NEMETSCHEK Scia	Project	Outrigger Stijfheid
	Onderdeel	-
	Omschrijving	-
	Auteur	wtu

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
NLCombi1	S1463	15,000	**598,0**	0,0	-145,6	-1,5	1,4	0,0
NLCombi1	S1472	0,000	0,0	**-597,9**	-90,4	-0,5	-0,4	0,0
NLCombi1	S1460	29,742	-90,5	**591,0**	-103,1	-0,9	1,3	0,0
NLCombi1	S1167	81,385	-175,8	6,4	**-605,0**	0,0	0,0	-0,3
NLCombi1	S2307	0,000	396,8	123,0	**301,7**	0,1	0,7	0,1
NLCombi1	S1496	0,000	253,6	541,4	-183,7	**-2,5**	0,1	0,0
NLCombi1	S1490	0,000	148,6	-579,1	-186,7	**2,5**	-0,1	0,0
NLCombi1	S1830	17,250	-253,3	-74,7	-440,0	0,1	**-1,9**	0,1
NLCombi1	S1492	6,196	591,0	-90,4	-170,7	0,0	**2,6**	0,0
NLCombi1	S2329	15,975	-324,3	-398,7	137,3	1,0	-0,5	**-1,1**
NLCombi1	S2317	0,000	324,3	-398,7	137,3	1,0	0,5	**1,1**

19. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : NLCombi2

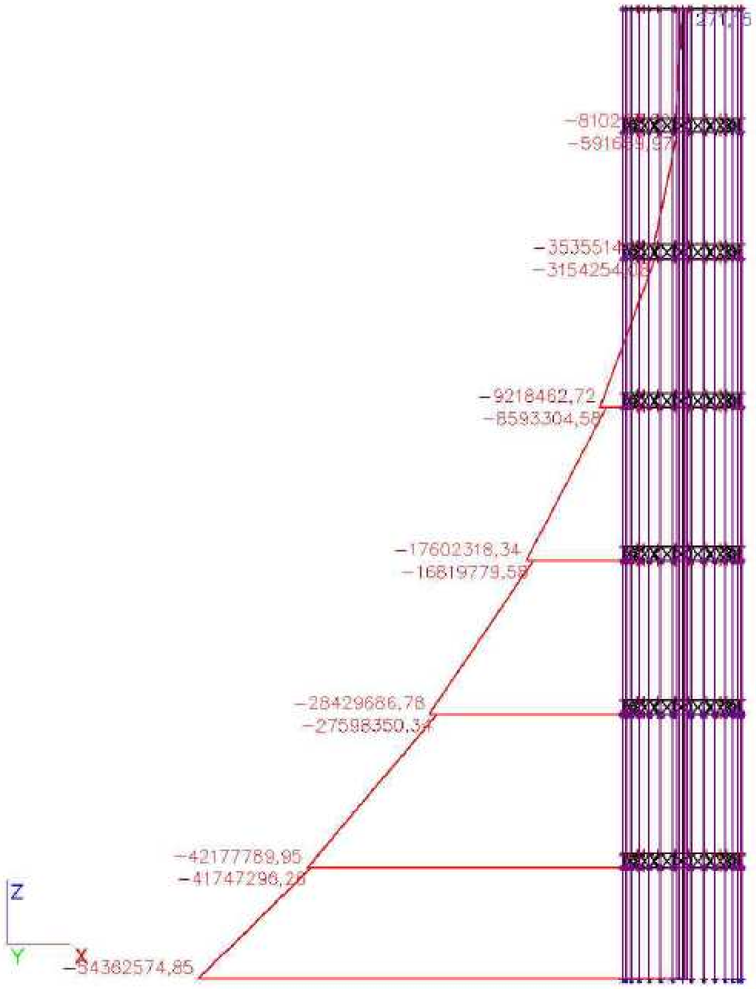
BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
NLCombi2	S1481	0,000	**-403,0**	0,0	-114,8	-1,2	-1,0	0,0
NLCombi2	S1463	15,000	**403,0**	0,0	-114,8	-1,2	1,0	0,0
NLCombi2	S1472	0,000	0,0	**-402,9**	-77,7	-0,5	-0,3	0,0
NLCombi2	S1460	29,742	-61,0	**398,3**	-82,9	-0,6	1,0	0,0
NLCombi2	S1167	81,385	-135,5	5,0	**-410,5**	0,0	-0,1	-0,2
NLCombi2	S2307	0,000	278,0	82,6	**193,8**	0,1	0,5	0,1
NLCombi2	S1496	0,000	170,9	364,8	-141,0	**-1,9**	0,0	0,0
NLCombi2	S1490	0,000	100,1	-390,3	-142,8	**1,9**	-0,1	0,0
NLCombi2	S1831	17,250	-161,6	50,3	-305,8	-0,1	**-1,4**	-0,1
NLCombi2	S1492	6,196	398,3	-60,9	-130,8	0,0	**1,9**	0,0
NLCombi2	S2329	15,975	-229,5	-269,2	82,8	0,7	-0,4	**-0,8**
NLCombi2	S2317	0,000	229,5	-269,2	82,8	0,7	0,4	**0,8**

20. Eigenfrequenties

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Massacombinatie : CM1				
1	0,05	0,34	0,12	18,30
2	0,05	0,34	0,12	18,30
3	0,19	1,18	1,39	5,32
4	0,30	1,85	3,44	3,39

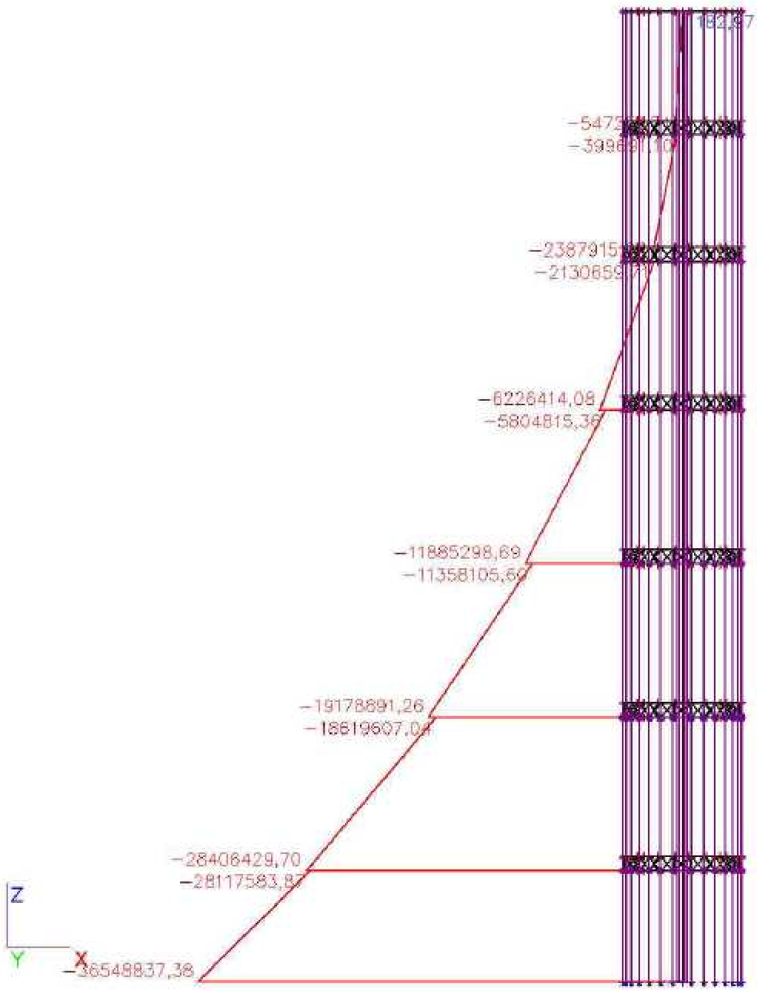
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

21. Interne krachten in staaf



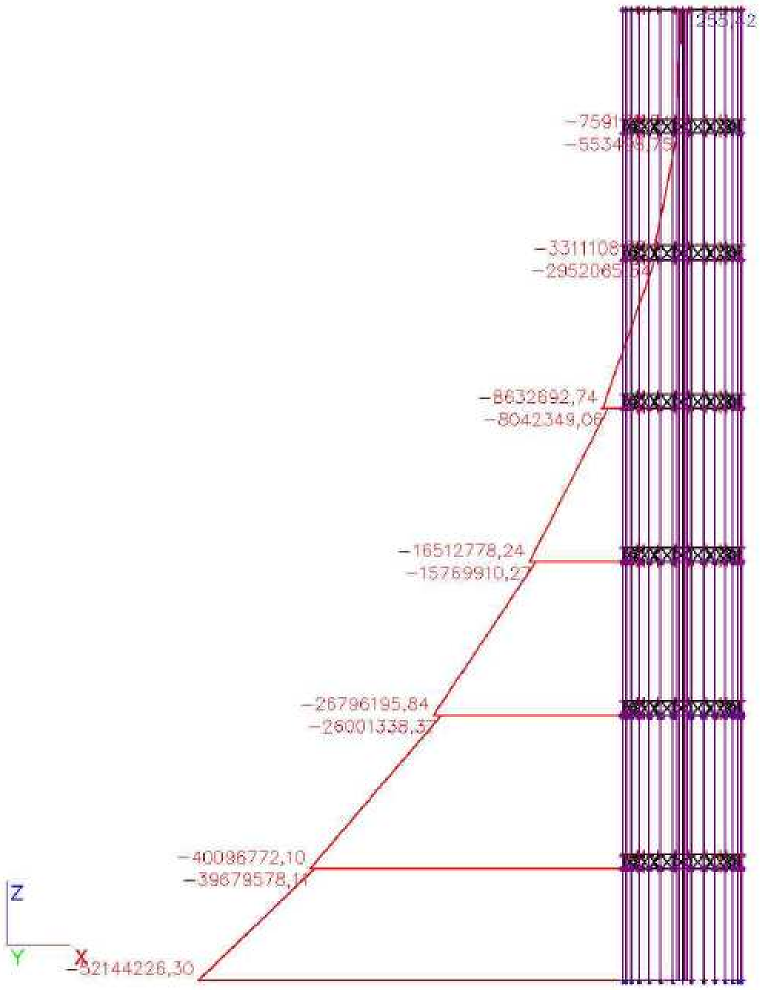
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

22. Interne krachten in staaf



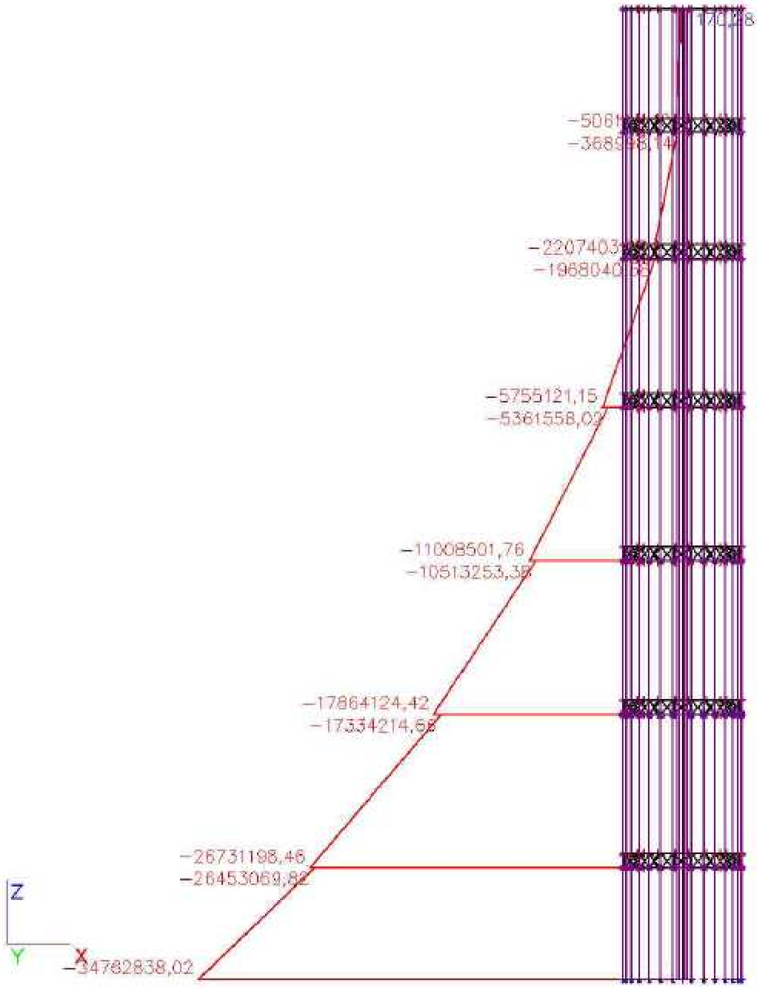
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

23. Interne krachten in staaf



Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

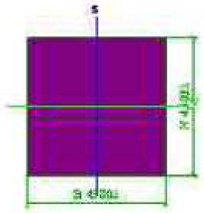
24. Interne krachten in staaf

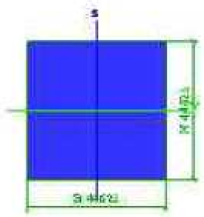


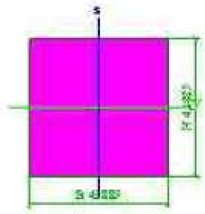
Alternative 3: Diagrid

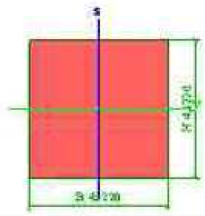
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

1. Doorsneden

Naam	CS3	
Type	Rechthoek	
Uitgebreid	45803; 45803	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	2,0979e+03	
A y, z [m²]	1,4236e+03	1,4236e+03
I y, z [m⁴]	3,6677e+05	3,6677e+05
I w [m⁶], t [m⁴]	0,0000e+00	2,8493e+05
Wel y, z [m³]	1,6015e+04	1,6015e+04
Wpl y, z [m³]	2,4023e+04	2,4023e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22902	22902
alpha [deg]	0,00	
AL [m²/m]	1,8321e+02	

Naam	CS4	
Type	Rechthoek	
Uitgebreid	44623; 44623	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,9912e+03	
A y, z [m²]	1,6593e+03	1,6593e+03
I y, z [m⁴]	3,3041e+05	3,3041e+05
I w [m⁶], t [m⁴]	0,0000e+00	5,5747e+05
Wel y, z [m³]	1,4809e+04	1,4809e+04
Wpl y, z [m³]	2,2213e+04	2,2213e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22312	22312
alpha [deg]	0,00	
AL [m²/m]	1,7849e+02	

Naam	CS5	
Type	Rechthoek	
Uitgebreid	43885; 43885	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,9259e+03	
A y, z [m²]	1,6049e+03	1,6049e+03
I y, z [m⁴]	3,0909e+05	3,0909e+05
I w [m⁶], t [m⁴]	0,0000e+00	5,2149e+05
Wel y, z [m³]	1,4086e+04	1,4086e+04
Wpl y, z [m³]	2,1129e+04	2,1129e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21943	21943
alpha [deg]	0,00	
AL [m²/m]	1,7554e+02	

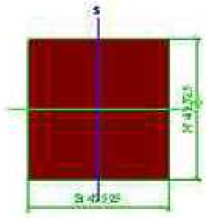
Naam	CS6	
Type	Rechthoek	
Uitgebreid	43220; 43220	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	
Afbeelding		
A [m²]	1,8680e+03	
A y, z [m²]	1,5566e+03	1,5566e+03
I y, z [m⁴]	2,9078e+05	2,9078e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,9060e+05
Wel y, z [m³]	1,3456e+04	1,3456e+04
Wpl y, z [m³]	2,0183e+04	2,0183e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21610	21610
alpha [deg]	0,00	
AL [m²/m]	1,7288e+02	

Naam	CS7
Type	Rechthoek
Uitgebreid	42525; 42525
Onderdeelmateriaal	Emod44000

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

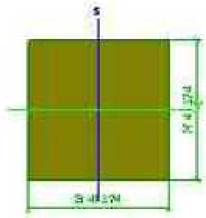
Afbeelding



A [m²]	1,8084e+03	
A y, z [m²]	1,5070e+03	1,5070e+03
I y, z [m⁴]	2,7252e+05	2,7252e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,5979e+05
Wel y, z [m³]	1,2817e+04	1,2817e+04
Wpl y, z [m³]	1,9225e+04	1,9225e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21263	21263
alpha [deg]	0,00	
AL [m²/m]	1,7010e+02	

Naam	CS8	
Type	Rechthoek	
Uitgebreid	41374; 41374	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

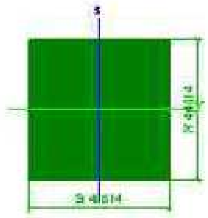
Afbeelding



A [m²]	1,7118e+03	
A y, z [m²]	1,4265e+03	1,4265e+03
I y, z [m⁴]	2,4419e+05	2,4419e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,1200e+05
Wel y, z [m³]	1,1804e+04	1,1804e+04
Wpl y, z [m³]	1,7706e+04	1,7706e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20687	20687
alpha [deg]	0,00	
AL [m²/m]	1,6550e+02	

Naam	CS9	
Type	Rechthoek	
Uitgebreid	40614; 40614	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

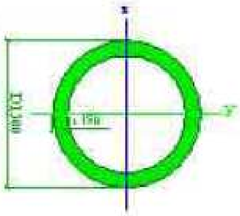
Afbeelding



A [m²]	1,6495e+03	
A y, z [m²]	1,3746e+03	1,3746e+03
I y, z [m⁴]	2,2674e+05	2,2674e+05
I w [m⁶], t [m⁴]	0,0000e+00	3,8255e+05
Wel y, z [m³]	1,1165e+04	1,1165e+04
Wpl y, z [m³]	1,6748e+04	1,6748e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20307	20307
alpha [deg]	0,00	
AL [m²/m]	1,6246e+02	

Naam	CS11	
Type	Buis	
Uitgebreid	1500; 150	
Onderdeelmateriaal	S235	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Afbeelding

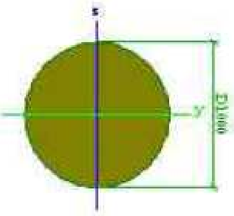


A [m²]	6,3604e-01	
A y, z [m²]	4,0492e-01	4,0492e-01
I y, z [m⁴]	1,4666e-01	1,4666e-01
I w [m⁶], t [m⁴]	0,0000e+00	2,8986e-01
Wel y, z [m³]	1,9554e-01	1,9554e-01
Wpl y, z [m³]	2,7442e-01	2,7442e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	0	0
alpha [deg]	0,00	
AL [m²/m]	4,7121e+00	

Naam	CS13	
Type	Cirkel	
Uitgebreid	1000	
Onderdeelmateriaal	Eioneindig	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	×	

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Afbeelding		
A [m²]	7,8524e-01	
A y, z [m²]	6,6745e-01	6,6745e-01



I y, z [m⁴]	4,9067e-02	4,9067e-02
I w [m⁶], t [m⁴]	0,0000e+00	9,8135e-02
Wel y, z [m³]	9,8135e-02	9,8135e-02
Wpl y, z [m³]	1,6662e-01	1,6662e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	0	0
alpha [deg]	0,00	
AL [m²/m]	3,1414e+00	

2. Materialen

Naam	S235	G-mod [MPa]	8,0769e+04
Type	Staal	Log. decrement	0,025
Thermisch uitz. [m/mK]	0,00	Therm. exp. (brand) [m/mK]	0,00
Massa eenheid [kg/m³]	7850,00	Specifieke hitte [J/gK]	6,0000e-01
E-mod [MPa]	2,1000e+05	Thermische geleiding [W/mK]	4,5000e+01
Poisson - nu	0,3	Fu [MPa]	360,0
Onafhankelijke G-modulus	×	Fy [MPa]	235,0

Type	Beton
Naam	C53/65
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	2500,00
E-mod [MPa]	3,8500e+04
Poisson - nu	0,2
Onafhankelijke G-modulus	×
G-mod [MPa]	1,6042e+04
Karakteristieke kubusdruksterkte (f'ck) [MPa]	65,00
Gemiddelde treksterkte [MPa]	4,30
Cementklasse	32.5
Door gebruiker gedefinieerde treksterkte (fbrep)	×
Representatieve treksterkte (fbrep) [MPa]	3,01
Rekenwaarde van de druksterkte (f'b) [MPa]	39,00
Rekenwaarde van de treksterkte (fb) [MPa]	2,15
Gemiddelde treksterkte (fbm) [MPa]	4,21
Gemeten waarden van gemiddelde druksterkte (invloed van ouderdom)	×

Type	Beton
Naam	Emod44000
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m³]	2500,00
E-mod [MPa]	4,4000e+04
Poisson - nu	0,2
Onafhankelijke G-modulus	×
G-mod [MPa]	1,8333e+04
Karakteristieke kubusdruksterkte (f'ck) [MPa]	90,00
Gemiddelde treksterkte [MPa]	5,00
Cementklasse	32.5
Door gebruiker gedefinieerde treksterkte (fbrep)	✓
Representatieve treksterkte (fbrep) [MPa]	0,00
Rekenwaarde van de druksterkte (f'b) [MPa]	54,00
Rekenwaarde van de treksterkte (fb) [MPa]	0,00
Gemiddelde treksterkte (fbm) [MPa]	0,00

NEMETSCHEK Scia

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Gemeten waarden van gemiddelde druksterkte (invloed van ouderdom)	✓
Ouderdom van beton [dag]	7,0
	12,0
	28,0
Gemiddelde kubusdruksterkte [MPa]	5,0
	5,0
	5,0
Karakteristieke kubusdruksterkte (f'ck) [MPa]	5,0
	5,0
	5,0
Gemiddelde treksterkte (fbm) [MPa]	0,0
	0,0
	0,0
E modulus [MPa]	23500,0
	23500,0
	23500,0
Standaarddeviatie [MPa]	0,0
Karakteristieke kubusdruksterkte (28) [MPa]	5,0

Naam	Eioneindig	G-mod [MPa]	8,0769e+04
Type	Staal	Log. decrement	0,025
Thermisch uitz. [m/mK]	0,00	Therm. exp. (brand) [m/mK]	0,00
Massa eenheid [kg/m³]	7850,00	Specifieke hitte [J/gK]	6,0000e-01
E-mod [MPa]	1,0000e+10	Thermische geleiding [W/mK]	4,5000e+01
Poisson - nu	0,3	Fu [MPa]	550,0
Onafhankelijke G-modulus	✓	Fy [MPa]	460,0

3. Belastinggevallen

Naam	Omschrijving	Actie type	Lastgroep	Belastingtype	Spec	Duur	'Master' belastinggeval
BG1	Self weight	Permanent	LG1	Standaard			
BG2	Imposed Loads	Variabel	LG2	Statisch	Standaard	Lang	Geen
BG3	wind	Variabel	LG2	Statisch	Standaard	Kort	Geen

4. Lastgroepen

Naam	Last	Relatie	Coëff.
LG1	Permanent		

Naam	Last	Relatie	Coëff.
LG2	Variabel	Standaard	0,5

5. Combinaties

Naam	Type	Belastinggevallen	Coëff. [-]
Combi2	Lineair - UGT	BG1 - Self weight	1,20
		BG2 - Imposed Loads	1,50
		BG3 - wind	1,50
Combi3	Lineair - BGT	BG1 - Self weight	1,00
		BG2 - Imposed Loads	1,00

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Naam	Type	Belastinggevallen	Coëff. [-]
Combi3	Lineair - BGT	BG3 - wind	1,00

6. Niet-lineaire combinaties

Naam	Omschrijving	Type	Belastinggevallen	Coëff. [-]
combi1	nonlin	Uiterste Grenstoestand	BG1 - Self weight	1,20
			BG2 - Imposed Loads	1,50
			BG3 - wind	1,50
combi2	nonlin	Bruikbaarheidsgrenstoestand	BG1 - Self weight	1,00
			BG2 - Imposed Loads	1,00
			BG3 - wind	1,00

7. Knoopondersteuningen

Naam	Knoop	Systeem	Type	X	Y	Z	Rx	Ry	Rz
Sn29	K1	GCS	Standaard	Vast	Vast	Vast	Vast	Vast	Vast
Sn1	K987	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn2	K948	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn3	K989	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn4	K972	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn5	K952	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn6	K941	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn9	K978	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn30	K1662	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn31	K1663	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn32	K1666	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn33	K1668	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn34	K1673	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn35	K1675	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn36	K1679	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn37	K1683	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn38	K1684	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn39	K1685	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn40	K1690	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn41	K1692	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn42	K1693	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn43	K1701	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn44	K1702	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn45	K1704	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn46	K1709	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn47	K1713	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn48	K1715	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn49	K1717	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij
Sn50	K1720	GCS	Standaard	Vast	Vast	Vast	Vrij	Vrij	Vrij

8. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	BG1	0,000	**-12237877,25**	114,71	-43,16	134,12	90256,50	22851,66
S25409	BG1	0,000	**4007,42**	2,50	-170,99	0,07	-9,94	-135,04
S25518	BG1	0,000	2187,66	**-532,97**	-5,11	4,57	40,60	3416,23
S3	BG1	3,200	-8887180,29	**541,66**	67,01	-768,18	78608,32	-30760,48
S33196	BG1	0,000	107,09	-42,67	**-1142,88**	1,20	199,30	118,41
S25580	BG1	0,000	-14480,45	-1,43	**148,45**	0,53	-921,66	10,41
S2729	BG1	22,200	-11930695,68	216,28	30,17	**-985,78**	88211,23	14493,44
S2729	BG1	11,100	-12086760,45	128,24	15,09	**284,70**	90205,54	27010,26
S33196	BG1	49,571	107,09	-42,67	-1142,88	1,20	**-56453,81**	-1996,79
S2729	BG1	22,200	-11940163,58	128,24	15,09	284,70	**90373,10**	**28433,76**
S3	BG1	25,400	-8544347,14	540,03	67,57	-762,68	78232,85	**-30811,22**

9. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	BG2	0,000	**-1642797,18**	12,57	1,90	14,83	652,91	4461,71
S25409	BG2	0,000	**533,06**	0,41	-21,00	0,01	-1,58	-17,91
S25518	BG2	0,000	290,76	**-71,10**	-0,65	0,63	5,16	455,77
S25619	BG2	0,000	289,04	**67,75**	0,81	-0,56	-4,85	-434,54
S33196	BG2	0,000	13,36	-5,04	**-141,47**	0,15	25,45	15,30
S25580	BG2	0,000	-1930,39	-0,21	**19,76**	0,06	-122,65	1,51
S2729	BG2	22,200	-1601239,55	26,76	7,48	**-128,59**	483,71	3405,96
S2729	BG2	11,100	-1622326,14	15,69	3,60	**33,16**	719,46	4959,58
S33196	BG2	49,571	13,36	-5,04	-141,47	0,15	**-6987,45**	-234,46
S2729	BG2	22,200	-1602411,65	15,69	3,60	33,16	**759,45**	**5133,77**
S3	BG2	25,400	-1146414,46	67,25	10,57	-91,58	-317,25	**-2324,73**

10. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG3

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S25263	BG3	0,000	**-8900,42**	9,30	70,88	-15,85	-445,70	-102,09
S25315	BG3	0,000	**8899,43**	9,28	-70,90	-15,85	445,81	-102,00
S25871	BG3	0,000	59,98	**-496,31**	-30,34	0,11	22,33	-351,34
S25870	BG3	0,000	84,16	**528,32**	-28,78	-0,13	20,47	321,23
S26751	BG3	0,000	376,81	-71,97	**-245,03**	-0,03	121,46	-41,56
S2729	BG3	0,000	-53,42	-25,72	**109365,44**	-9393,78	**-30259060,74**	-937,00
S2729	BG3	11,100	-56,17	-28,53	93079,90	**-12941,29**	-29125464,06	-1323,36
S2	BG3	18,900	-2,96	-2,60	81993,04	**6404,42**	-21849925,63	621,48
S7	BG3	88,400	2,84	-1,83	1589,67	89,62	**17049,83**	81,13
S25871	BG3	49,571	59,98	-496,31	-30,34	0,11	-1481,71	**-24953,67**
S25870	BG3	49,571	84,16	528,32	-28,78	-0,13	-1405,93	**26510,38**

11. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Selectie : Alle
Combinaties : Combi2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	Combi2/1	0,000	**-17149728,77**	117,92	**163999,22**	-13907,46	**-45279305,73**	32709,07
S25414	Combi2/1	0,000	**8487,51**	1,67	-21,52	0,00	-35,44	1,31
S26003	Combi2/1	0,000	4860,08	**-1012,66**	-1078,32	0,32	88,88	3506,44
S25994	Combi2/1	0,000	4917,03	**1079,14**	-1202,03	-0,63	80,31	-4248,24
S26974	Combi2/1	0,000	207,59	49,93	**-1626,90**	0,10	305,19	48,10
S2729	Combi2/1	11,100	-16937686,02	134,64	139643,38	**-19020,55**	-43578875,90	37866,65
S2	Combi2/1	0,000	-15268257,79	623,88	126530,54	**8657,35**	-34512564,22	-19427,92
S7	Combi2/1	77,300	-564478,66	645,52	4460,98	-682,75	**71061,92**	29039,88
S26003	Combi2/1	49,996	4860,08	-1012,66	-1078,32	0,32	-53823,16	**-47122,64**
S25994	Combi2/1	49,996	4917,03	1079,14	-1202,03	-0,63	-60016,60	**49704,62**

12. Interne krachten in staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi3

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	Combi3/2	0,000	**-13880727,55**	101,55	**109324,18**	-9244,82	**-30168150,02**	26376,38
S25414	Combi3/2	0,000	**6441,07**	0,97	-43,54	0,00	-15,16	0,76
S26003	Combi3/2	0,000	3862,92	**-715,04**	-884,72	0,26	81,05	2901,06
S25994	Combi3/2	0,000	3911,43	**762,33**	-985,71	-0,52	73,36	-3511,82
S33196	Combi3/2	0,000	122,01	-36,30	**-1286,50**	1,30	224,75	139,06
S2729	Combi3/2	11,100	-13709143,04	115,41	93098,60	**-12623,43**	-29034539,01	30646,48
S2	Combi3/2	0,000	-12358061,06	506,07	84364,20	**5638,03**	-22991790,08	-16200,48
S7	Combi3/2	77,300	-456909,12	524,81	2968,22	-528,89	**57126,84**	23365,82
S26003	Combi3/2	49,996	3862,92	-715,04	-884,72	0,26	-44151,88	**-32848,33**
S25994	Combi3/2	49,996	3911,43	762,33	-985,71	-0,52	-49208,73	**34601,97**

13. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi1

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	combi1	0,000	**-17149725,70**	116,54	**165382,11**	-14516,78	**-46972977,15**	32740,23
S25414	combi1	0,000	**8608,15**	1,78	-17,83	0,00	-33,57	1,39
S26003	combi1	0,000	4882,10	**-1045,02**	-1077,63	0,32	87,49	3487,13
S25994	combi1	0,000	4938,38	**1113,53**	-1201,26	-0,63	78,92	-4225,84
S26974	combi1	0,000	233,16	55,64	**-1638,03**	0,10	310,92	51,44
S2729	combi1	11,100	-16937681,92	132,91	140458,59	**-19860,09**	-45259124,74	37882,53
S2729	combi1	88,800	-15329419,26	624,34	129611,10	**9053,65**	-36506648,58	-21456,59
S7	combi1	77,300	-564475,78	645,31	4756,71	-685,09	**71711,06**	29040,13
S26003	combi1	49,996	4882,10	-1045,02	-1077,63	0,32	-53790,30	**-48759,97**
S25994	combi1	49,996	4938,38	1113,53	-1201,26	-0,63	-59979,72	**51446,55**

14. Interne krachten in staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Niet-lineaire combinaties : combi2

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S2729	combi2	0,000	-13880726,53	100,44	110443,49	-9737,93	-31539005,44	26402,20
S25414	combi2	0,000	6538,75	1,06	-40,55	0,00	-13,64	0,83
S26003	combi2	0,000	3880,73	-741,23	-884,18	0,26	79,92	2885,43
S25994	combi2	0,000	3928,69	790,16	-985,11	-0,51	72,23	-3493,67
S33196	combi2	0,000	121,86	-35,40	-1286,70	1,30	224,84	139,08
S2729	combi2	11,100	-13709139,97	114,01	93758,43	-13302,84	-30394529,79	30659,96
S2729	combi2	88,800	-12407552,00	506,44	86790,47	5958,64	-24546123,78	-17845,48
S7	combi2	77,300	-456907,20	524,64	3207,59	-530,93	57652,63	23365,99
S26003	combi2	49,996	3880,73	-741,23	-884,18	0,26	-44126,07	-34173,28
S25994	combi2	49,996	3928,69	790,16	-985,11	-0,51	-49179,72	36011,56

15. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG1	S7	102,200	-57,9	-0,2	1,9	0,0	0,0	0,0
BG1	S33150	0,000	54,0	-0,9	-23,8	0,0	0,0	0,0
BG1	S25619	12,714	0,4	-3,1	-4,9	0,0	0,0	0,0
BG1	S25593	0,000	3,8	3,1	-3,1	0,0	0,0	0,0
BG1	S33080	15,000	-1,9	-0,2	-59,1	0,0	0,0	0,0
BG1	S25699	13,434	5,3	-0,3	-3,7	-0,1	0,0	0,1
BG1	S25468	12,235	-5,8	0,3	-2,8	0,1	0,0	0,0
BG1	S25593	6,717	3,2	1,5	-2,5	0,0	-0,1	-0,3
BG1	S25660	6,717	-3,3	0,0	-2,2	0,0	0,1	0,0
BG1	S25619	6,357	0,3	-1,6	-4,8	0,0	0,0	-0,3
BG1	S25518	6,357	-0,3	-1,6	-4,9	0,0	0,0	0,3

16. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Belastinggevallen: BG2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG2	S7	102,200	-7,8	0,0	0,0	0,0	0,0	0,0
BG2	S33035	0,000	7,2	0,0	-3,3	0,0	0,0	0,0
BG2	S25619	12,714	0,1	-0,4	-0,6	0,0	0,0	0,0
BG2	S25593	0,000	0,5	0,4	-0,4	0,0	0,0	0,0
BG2	S33080	15,000	0,0	0,0	-7,9	0,0	0,0	0,0
BG2	S25699	13,434	0,7	0,0	-0,5	0,0	0,0	0,0
BG2	S25468	12,235	-0,8	0,0	-0,4	0,0	0,0	0,0
BG2	S25593	6,717	0,4	0,2	-0,3	0,0	0,0	0,0
BG2	S25660	6,717	-0,4	0,0	-0,3	0,0	0,0	0,0
BG2	S25619	6,357	0,0	-0,2	-0,6	0,0	0,0	0,0
BG2	S25518	6,357	0,0	-0,2	-0,6	0,0	0,0	0,0

17. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Selectie : Alle
Belastinggevallen: BG3

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
BG3	S33094	0,000	**-322,3**	0,0	-4,1	0,0	-0,5	0,0
BG3	S33080	0,000	**322,3**	0,0	4,1	0,0	0,5	0,0
BG3	S33087	0,000	0,0	**-322,3**	-26,9	0,5	0,0	0,0
BG3	S33229	15,000	0,0	**322,3**	26,9	-0,5	0,0	0,0
BG3	S7	102,200	0,0	0,0	**-323,8**	0,0	0,5	0,0
BG3	S33016	12,235	-138,3	38,8	**288,5**	0,0	-0,5	0,1
BG3	S33007	0,000	0,0	310,1	26,8	**-0,5**	0,0	0,0
BG3	S32865	0,000	0,0	-310,1	-26,8	**0,5**	0,0	0,0
BG3	S33101	50,000	-316,2	0,0	0,0	0,0	**-0,5**	0,0
BG3	S7	77,300	0,0	0,0	-310,1	0,0	**0,5**	0,0
BG3	S32767	6,118	9,2	-292,7	43,4	0,2	-0,1	**-0,5**
BG3	S32606	6,118	-9,2	292,7	-43,4	-0,2	0,1	**0,5**

18. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
Combi2/1	S33094	15,000	**-481,2**	0,2	-76,4	0,0	-0,8	0,0
Combi2/1	S33080	0,000	**481,2**	-0,2	-76,6	0,0	0,8	0,0
Combi2/1	S33087	15,000	-0,2	**-481,2**	-122,1	0,8	0,0	0,0
Combi2/1	S33229	15,000	0,2	**481,2**	-42,4	-0,8	0,0	0,0
Combi2/1	S7	102,200	-81,1	-0,2	**-483,4**	0,0	0,8	0,0
Combi2/1	S33052	12,235	-281,3	-57,7	**396,0**	0,0	-0,8	-0,1
Combi2/1	S32785	15,000	0,2	444,9	-42,0	**-0,8**	0,0	0,0
Combi2/1	S32643	15,000	-0,2	-444,9	-121,9	**0,8**	0,0	0,0
Combi2/1	S31019	6,717	-109,6	42,3	-301,7	-0,1	**-0,8**	0,0
Combi2/1	S33080	7,500	481,2	-0,3	-82,8	0,0	**0,8**	0,0
Combi2/1	S32592	12,235	-88,1	-441,7	-99,7	0,3	0,1	**-0,7**
Combi2/1	S32815	12,235	133,1	-441,7	-2,8	0,3	0,1	**0,7**

19. Vervormingen van staaf

Lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Combinaties : Combi3

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
Combi3/2	S33094	15,000	**-320,4**	0,2	-62,7	0,0	-0,5	0,0
Combi3/2	S33080	0,000	**320,4**	-0,2	-62,9	0,0	0,6	0,0
Combi3/2	S33087	15,000	-0,2	**-320,4**	-93,1	0,5	0,0	0,0
Combi3/2	S33229	15,000	0,2	**320,4**	-40,1	-0,5	0,0	0,0
Combi3/2	S7	102,200	-65,6	-0,2	**-321,9**	0,0	0,5	0,0
Combi3/2	S33052	12,235	-198,1	-38,4	**258,7**	0,0	-0,5	-0,1
Combi3/2	S32785	15,000	0,2	296,2	-39,7	**-0,5**	0,0	0,0
Combi3/2	S32643	15,000	-0,1	-296,2	-92,9	**0,5**	0,0	0,0
Combi3/2	S30797	6,717	-58,2	26,8	-196,8	-0,1	**-0,6**	0,1
Combi3/2	S33080	7,500	320,4	-0,2	-67,0	0,0	**0,6**	0,0
Combi3/2	S32592	12,235	-69,4	-294,1	-71,3	0,2	0,1	**-0,5**
Combi3/2	S32815	12,235	99,3	-294,1	-6,9	0,2	0,1	**0,5**

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

20. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi1

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
combi1	S33094	15,000	-504,5	0,2	-76,0	0,0	-0,9	0,0
combi1	S33080	0,000	504,6	-0,2	-76,2	0,0	0,9	0,0
combi1	S33087	15,000	-0,2	-504,5	-124,4	0,9	0,0	0,0
combi1	S33229	15,000	0,2	504,5	-40,6	-0,9	0,0	0,0
combi1	S7	102,200	-81,1	-0,2	-506,8	0,0	0,9	0,0
combi1	S33052	12,235	-291,3	-60,6	416,9	0,0	-0,8	-0,1
combi1	S32785	15,000	0,2	466,4	-40,2	-0,9	0,0	0,0
combi1	S32643	15,000	-0,2	-466,3	-124,1	0,9	0,0	0,0
combi1	S31241	6,717	-127,3	46,7	-330,1	-0,1	-0,9	0,0
combi1	S33080	7,500	504,5	-0,3	-82,8	0,0	0,9	0,0
combi1	S32829	12,235	136,1	463,0	-1,6	-0,4	0,1	-0,8
combi1	S32815	12,235	136,0	-463,0	-1,9	0,4	0,1	0,8

21. Vervormingen van staaf

Niet-lineaire berekening, Extreem : Globaal, Systeem : Hoofd
Selectie : Alle
Niet-lineaire combinaties : combi2

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
combi2	S33094	15,000	-339,3	0,2	-62,4	0,0	-0,6	0,0
combi2	S33080	0,000	339,3	-0,2	-62,6	0,0	0,6	0,0
combi2	S33087	15,000	-0,2	-339,3	-94,9	0,6	0,0	0,0
combi2	S33229	15,000	0,2	339,3	-38,6	-0,6	0,0	0,0
combi2	S7	102,200	-65,6	-0,2	-340,9	0,0	0,6	0,0
combi2	S33052	12,235	-206,2	-40,7	275,7	0,0	-0,6	-0,1
combi2	S32785	15,000	0,2	313,7	-38,3	-0,6	0,0	0,0
combi2	S32643	15,000	-0,1	-313,6	-94,7	0,6	0,0	0,0
combi2	S31019	6,717	-70,6	29,9	-217,1	-0,1	-0,6	0,0
combi2	S33080	7,500	339,3	-0,2	-67,0	0,0	0,6	0,0
combi2	S32829	12,235	101,7	311,4	-5,8	-0,2	0,1	-0,5
combi2	S32815	12,235	101,6	-311,4	-6,0	0,2	0,1	0,5

22. Reacties

Lineaire berekening, Extreem : Knoop
Selectie : Alle
Belastinggevallen: BG3

Steunpunt	BG	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
Sn29/K1	BG3	-109365,44	-25,72	53,42	-937,00	-30259060,74	-9393,78
Sn1/K987	BG3	966,90	326,55	5583,48	0,00	0,00	0,00
Sn2/K948	BG3	673,52	671,70	8615,72	0,00	0,00	0,00
Sn3/K989	BG3	355,56	759,93	11213,05	0,00	0,00	0,00
Sn4/K972	BG3	49,86	688,19	13441,02	0,00	0,00	0,00
Sn5/K952	BG3	253,46	400,07	14870,89	0,00	0,00	0,00
Sn6/K941	BG3	112,30	470,66	13886,11	0,00	0,00	0,00
Sn9/K978	BG3	1322,42	162,85	1980,20	0,00	0,00	0,00
Sn30/K1662	BG3	111,15	-461,64	13888,66	0,00	0,00	0,00
Sn31/K1663	BG3	250,42	-391,87	14879,83	0,00	0,00	0,00

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Steunpunt	BG	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
Sn32/K1666	BG3	43,29	-678,83	13456,78	0,00	0,00	0,00
Sn33/K1668	BG3	344,09	-749,22	11236,71	0,00	0,00	0,00
Sn34/K1673	BG3	1308,04	-160,95	1993,87	0,00	0,00	0,00
Sn35/K1675	BG3	941,76	-316,76	5627,56	0,00	0,00	0,00
Sn36/K1679	BG3	655,50	-660,99	8648,79	0,00	0,00	0,00
Sn37/K1683	BG3	111,94	-467,74	-13889,79	0,00	0,00	0,00
Sn38/K1684	BG3	666,33	-667,45	-8629,64	0,00	0,00	0,00
Sn39/K1685	BG3	252,22	-396,71	-14876,00	0,00	0,00	0,00
Sn40/K1690	BG3	47,03	-684,18	-13448,15	0,00	0,00	0,00
Sn41/K1692	BG3	958,22	-323,14	-5602,20	0,00	0,00	0,00
Sn42/K1693	BG3	350,72	-755,42	-11223,02	0,00	0,00	0,00
Sn43/K1701	BG3	111,48	464,16	-13891,72	0,00	0,00	0,00
Sn44/K1702	BG3	250,90	393,11	-14882,05	0,00	0,00	0,00
Sn45/K1704	BG3	43,75	679,62	-13458,51	0,00	0,00	0,00
Sn46/K1709	BG3	1338,07	-164,94	-1962,89	0,00	0,00	0,00
Sn47/K1713	BG3	344,51	749,70	-11238,18	0,00	0,00	0,00
Sn48/K1715	BG3	1308,05	160,95	-1995,05	0,00	0,00	0,00
Sn49/K1717	BG3	941,97	316,83	-5628,80	0,00	0,00	0,00
Sn50/K1720	BG3	655,83	661,24	-8650,10	0,00	0,00	0,00

23. Resultante

Lineaire berekening, Extreem : Globaal
Selectie : Alle
Belastinggevallen: BG3

BG	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
BG3	-94596,14	0,00	0,01	-0,10	-40981352,45	0,00

Centraalpunt:

X [m]	Y [m]	Z [m]
0,000	0,000	0,000

24. Eigenfrequenties

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Massacombinatie : CM1				
1	0,05	0,34	0,11	18,65
2	0,05	0,34	0,11	18,62
3	0,31	1,95	3,80	3,22
4	0,31	1,95	3,81	3,22

Appendix J: Foundation Calculations

Vertical loads

The vertical loads from the superstructure are transferred to the foundation raft through the concrete walls of the foundation. These walls are an extension of the structural columns and core walls found in the footprint.
The raft is able to distribute to a distance of 7 times its thickness (21m) on both side of the line loads which are transferred from the superstructure. For both the core and perimeter loads the area these areas are calculated.

- Distributed loads Pi*r^2 - Pi*r^2 = Pi*(r^2- r^2) = Pi *(70^2-7^2) = 15240 m^2
- Core loads Pi*r^2 - Pi*r^2 = Pi*(r^2- r^2) = Pi *(59^2-7^2) = 10782 m^2
- Perimeter loads Pi*r^2 - Pi*r^2 = Pi*(r^2- r^2) = Pi *(70^2-29^2)= 12752 m^2

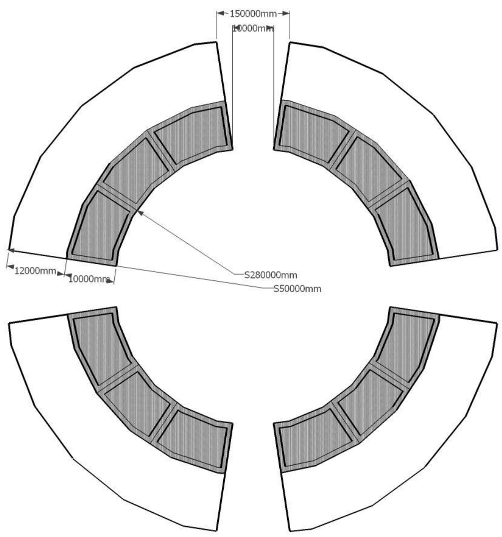


Figure 15 Core

Distributed load

Floor + Installations and finishing

Floor system	Span(m)	Dead load (kN/m^2)
Comflor 320	5,4	3,19
installations and finishing		0,75

Table 24

3,94*208=819,52 kN/m2

Beams

0,45*208=95,69 kN/m2

Raft

3 meters thick 3*25=75 kN/m2

Live loads

Function	number	kN/m^2	kN/m^2
Mechanical	19	10	1,5*19*10 = 285,00
Penthouse	22	2,511	1,5*22*2,511*0,4 = 33,15
Residential	40	2,511	1,5*49*2,511*0,4 = 73,82
Hotel	27	2,511	1,5*27*2,511*0,4 = 40,68
Flexible	39	3,348	1,5*39*3,348*0,5 = 97,93
Office	55	3,348	1,5*55*3,348*0,5 = 138,11
Commercial	6	4,4	1,5*6*4,4*0,4 = 15,84
Lobby	1	5	1,5*1*5 = 7,50
Basement	7	3,5	1,5*7*3,5*0,7 = 25,73
TOTAL ULS			= 717,76
TOTAL SLS			= 478,51

Table 25 Sum live loads

Load	Dead load (kN/m^2)
Floor	820
Beams	96
Raft	75
Live loads	479
Total	1470

Table 26 Distributed loads

Perimeter loads

Columns

Each floor has 28 megacolumns .The selfweight of the megacolumns is calculated as follows kN/m per column = (A_{steel} * 78,5) + ($A_{concrete}$ *25)

Level	Storey	Dimensions	t (mm)	A_{steel} m^2	$A_{concrete}$ m^2	kN/m per column	kN per column	kN 28 columns
EI 1	0-22	1600x1600	100	0,31	2,25	78,3	7215	202010
EI 2	23-54	1500x1500	100	0,29	1,96	69,8	8844	247640
EI 3	55-88	1300x1300	80	0,2016	1,4884	51,5	6531	182869
EI 4	89-122	1200x1200	70	0,1631	1,2769	43,4	5505	154139
EI 5	123-155	1000x1000	60	0,1164	0,8836	30,3	3732	104504
EI 6	156-183	800x 800	50	0,0775	0,5625	19,6	2047	57302
EI 7	184-208	600x 600	50	0,0575	0,3025	11,8	1062	29736

Table 27

Total load in kN as a result of the self-weight of the columns is 978200

Core loads

Core

Level	Storey	Length (m)	Wall thickness (mm)	kN/m (vertical)	kN
EI 1	0-22	92,1	1000	12120	1116252
EI 2	23-54	126,7	900	10908	1382044
EI 3	55-88	126,7	850	10302	1305263
EI 4	89-122	126,7	800	9696	1228483
EI 5	123-155	123	750	9090	1118070
EI 6	156-183	104,5	700	8484	886578
EI 7	184-208	102,2	650	7878	805132
EI 1	-7 - 0	21	1000	12120	254520
Total					8096342

Table 28

Total load in kN as a result of the self-weight of the columns is 8096342

Overall (floor beams live loads)

1470*4291 / 15240= 414 kN/m^2

Core

8095486,42 / 10728= 750,9 kN/m^2

Perimeter (columns)

978200 kN /12752= 76,7 kN/m2

Maximum stress is 414+750,9+76,7=1242 kN/m^2

Load bearing capacity of the foundation

In this paragraph we will determine the load bearing capacity of the raft

According to NEN 6740 -6.2 the foundation is classified as GC3
According to table 3 of NEN 6740 the partial factor or soil characteristics are given in **Fout! Verwijzingsbron niet gevonden.**.

Factor		**Limit states**		
		1A/1B (ultimate)		**2 (serviceability)**
		Favourable	**Unfavourable**	
$\gamma_{m;g}$	Self-weight soil	1,1	1	1
$\gamma_{m;\varphi}$	Tangent friction angle	1,15	1	1
$\gamma_{m;c1}$	Cohesion	1,6	1	1
$\gamma_{m;cu}$	Undrained shear strength	1,35	1	1

Table 29 Partial factors

The following soil layers are classified according to appendix K and NEN 6740

Layer	**Depth**	**γ kN/m3**	**Description**
0	3,5 tm -1	17	Sand / Clay
1	-1 tm -2,5	17	Clay
2	-2,5 tm-9,5	18	Sand
3	-9,5 tm -11,5	10	Peat
4	-11,5 tm -17	17	Clay
5	-17 tm -34	19	Sand
6	-34 tm -35	13	Peat
7	-35 tm -38	20	Sand
8	-38 tm -43	20	Clay
9	-43 tm -47	20	Sand
10	-47 tm -51	20	Peat / Clay
11	-51 tm -53	20	Sand
12	-53 tm -56	21	Clay / Loam
13	-56 tm -63	20	Sand
14	-63 tm -64	20	Peat / Clay
15	-64 tm -71	20	Sand

Table 30 soil layer description

Layer	Depth NAP (m)	γ (kN/m^3)	γ_{sat} (kN/m^3)	φ	C_p	C_s
0	3.5 to -1	17	19	30		
1	-1 to -2,5	17	17	17,5		
2	-2.5 to -9.5	18	20	32,5		
3	-9.5 to -11.5	10	10	15		
4	-11.5 to -17	17	17	17,5		
5	-17 to -34	19	21	35	1000	∞
6	-34 to -35	13	13	15	30	40
7	-35 to -38	20	22	40	1500	∞
8	-38 to -43	20	20	22,5	30	400
9	-43 to -47	20	22	40	1500	∞
10	-47 to -51	20	20	22,5	40	400
11	-51 to -53	20	22	40	1500	∞
12	-53 to -56	21	21	27,5	50	600
13	-56 to -63	18	20	32,5	450	∞
14	-63 to -64	20	20	22,5	50	600
15	-64 to -71	17	19	30	200	∞

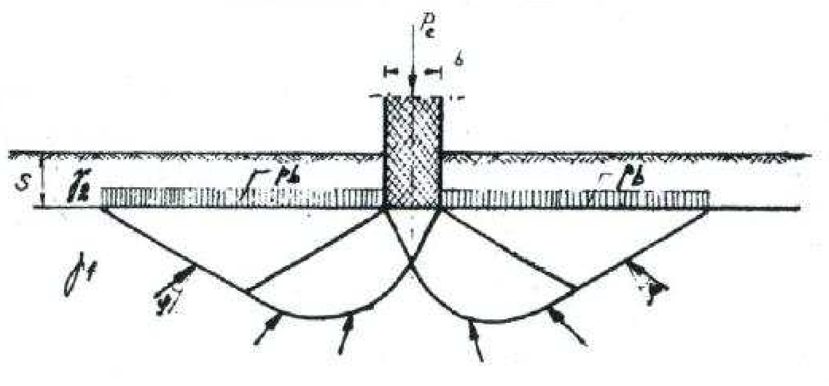
Table 31 Representative soil properties

The values in Table 31 are standardized values. These values have not been converted to the level of the effective vertical soil stresses $\Delta\sigma'_{v;z}$ of 100 kPa.

Layer	Depth NAP (m)	γ (kN/m^3)	γ_{sat} (kN/m^3)	φ	C_p	C_s
0	3.5 to -1	15,5	17,3	26,1		
1	-1 to -2,5	15,5	15,5	15,2		
2	-2.5 to -9.5	16,4	18,2	28,3		
3	-9.5 to -11.5	9,1	9,1	13,0		
4	-11.5 to -17	15,5	15,5	15,2		
5	-17 to -34	17,3	19,3	30,4	1000	∞
6	-34 to -35	11,8	11,8	13,0	30	400
7	-35 to -38	18,2	20	34,8	1500	∞
8	-38 to -43	18,2	18,2	19,6	30	400
9	-43 to -47	18,2	20	34,8	1500	∞
10	-47 to -51	18,2	18,2	19,6	40	400
11	-51 to -53	18,2	20	34,8	1500	∞
12	-53 to -56	19,1	19,1	23,9	50	600
13	-56 to -63	16,4	18,2	28,3	450	∞
14	-63 to -64	18,2	18,2	19,6	60	600
15	-64 to -71	15,5	17,3	26,1	200	∞

Table 32 Design values of soil properties

Raft



According to (Brough, [30]) the load-bearing capacity of a shallow foundation can be determined with:

$$P_e = b(V_b \cdot p_b + V_g \cdot \gamma_1 \cdot b_q)$$
$$p_e = (V_b \cdot p_b + V_g \cdot \gamma_1 \cdot b_q)$$

Where,

$b =$ Width of the foundation [m]
$V_b =$ Coefficient for the (surcharge) depending on φ
$p_b = \gamma_2 \cdot S =$ Surcharge [tf/m^3]
$V_g =$ Coefficient for the (influence of the foundations width depending on φ
$\gamma_1 =$ Weight of the soil (minus upwards water pressure) [tf/m^3]
$\gamma_2 =$ Weight of the soil (minus upwards water pressure) [tf/m^3]

In Table 31 we see that φ = 35 for layer 5 which gives the following values for the coefficients V_b and V_g

φ	V_b	V_g
30	18,4	15,2
35	24,6	22,5

Table 33 Coefficients V_b and V_g

The shape factors υ_b and υ_g are used to take into account the ratio of the width and length of the raft.

Shape factor

$$\upsilon_b = 1 + 0{,}2 \cdot \frac{b}{a} = 1{,}2$$

$$\upsilon_g = 1 - 0{,}2 \cdot \frac{b}{a} = 0{,}8$$

V_b = 1,2
V_g = 0,8

The raft is located at -21 NAP
The surcharge is the weight of the soil layers minus the water pressure.

$P_{b*}S$= 4,5*15,5+1,5*15,5+7*18,2+2*9,1+5,5*15,5+4*19,3- 19*10= 401,05 -190 =211

$\gamma_2 = \gamma_1 = 19{,}3$ -10=9,3 (layer 5 **γ_{sat} $^{kN/m3}$) – γwater)**

This gives a load-bearing capacity of
$p_e = (1{,}2 \cdot 24{,}6 \cdot 21{,}1 + 0{,}8 * 22{,}5 \cdot 0{,}93 \cdot 140)$
$p_e = 2966\_tf / m^2$

A tonne-force is 1000 kilograms-force or 10 kN which means that the foundations system consisting of a raft has a load-bearing capacity of 29660 kPa or 29660 kN/m^2.

Calculation settlements shallow foundation

Primary settlement

$$w_1 = \sum_{j=0}^{j=n} \frac{C_{c;j}}{1+e_j} \cdot h_j \cdot \log \frac{\sigma'_{v;z;0} + \Delta\sigma'_{v;z}}{\sigma'_{v;z;0}}$$

where:

w_1 is the primary settlement in m;

$C_{c;j}$ is the value of the primary compression index of layer j determined according to chapter 8 (NEN–EN 6740);

e_j is the factor related to porosity ;

h_j is the thickness of the layer j in m;

$\sigma'_{v;z;0}$ is the value of the effective vertical stress before loading in the middle of a layer at a depth z determined according to 13.5.2.2;

$\Delta\sigma'_{v;z}$ is the value of the effective vertical stress increase in the middle of a layer at a depth z determined according to 13.5.2.2;

$$w_1 = \sum_{j=0}^{j=n} \frac{1}{C_{p;j}} \cdot h_j \cdot \ln \frac{\sigma'_{v;z;0} + \Delta\sigma'_{v;z}}{\sigma'_{v;z;0}}$$

this formula is generally used in the Netherlands.

where:

w_1 is de primary settlement in m;

$C_{p;j}$ is the value of the compression constant of layer j valid for an increase in loading from the (maximum stress value)) determined according to chapter 8 (for normal consolidated soil the (maximum stress value is equal to de vertical effective stress;

h_j is the thickness of the layer j in m;

$\sigma'_{v;z;0}$ is the value of the effective vertical stress before loading in the middle of a layer at a depth z determined according to 13.5.2.2;

$\Delta\sigma'_{v;z}$ is te value of the effective vertical stress increase in the middle of a layer at a depth z determined according to 13.5.2.2

Secondary settlement

$$w_2 = \sum_{j=0}^{j=n} C_{a;j} \cdot h_j \cdot \log \frac{t_\infty}{t_1}$$

where:

w_2 is the secondary settlement in m;

$C_{a;j}$ is the value of the secondary compression index of layer j determined according to 8.1 (NEN–EN 6740);

h_j is the thickness of the layer j in m;

t_∞ is the end time for the secondary settlement in days after loading. A value of t_∞ 10000 days has to be considered unless the actual loading time is significantly shorter;

t_1 is the begin time in days after loading t1 = 1 day;

$$w_2 = \sum_{j=0}^{j=n} \frac{1}{C'_{s;j}} \cdot h_j \cdot \log \frac{t}{t_0} \cdot \ln \frac{\sigma'_{v;z;0} + \Delta\sigma'_{v;z}}{\sigma'_{v;z;0}}$$ this formula is generally used in the Netherlands.

where:

w_2 is the secondary settlement in m;

$C'_{s;j}$ is the value of the secondary compression index of layer j determined according to 8.1 (NEN–EN 6740);

h_j is the thickness of the layer j in m;

t is time duration in days A value of =10000 days has to be considered;

t_0 is the begin time in days after loading t1 = 1 day;

$\sigma'_{v;z;0}$ is the value of the effective vertical stress before loading in the middle of a layer at a depth z determined according to 13.5.2.2;

$\Delta\sigma'_{v;z}$ is the value of the effective vertical stress increase in the middle of a layer at a depth z determined according to 13.5.2.2;

We will use the Koppejan formulas which are generally used in Holland.

The following table shows the calculation of the effective vertical stress before excavation.

layer	H	Depth centre layer beneath NAP in (m)	$\sigma'_{v;z;0}$ in middle of layer before excavation (kPa)
5	17	25,5	593 -255 = 335
6	2	35	739,5-330 = 409,5
7	2	37	771,5-350 = 421,5
8	5	40,5	843,5-385 = 458,5
9	4	45	937,5-430 = 470,5
10	4	49	1021,5-470 = 507,5
11	2	52	1094,5-500 = 594,5
12	3	54,5	1159-525 = 634
13	7	59,5	1260,5-575 = 685,5
14	1	63,5	1340,5-615 = 725,5
15	7	67,5	1388,5-655 = 733,5

Table 34 vertical stresses before excavation

We use the Sun of Newmark to determine the stress distribution

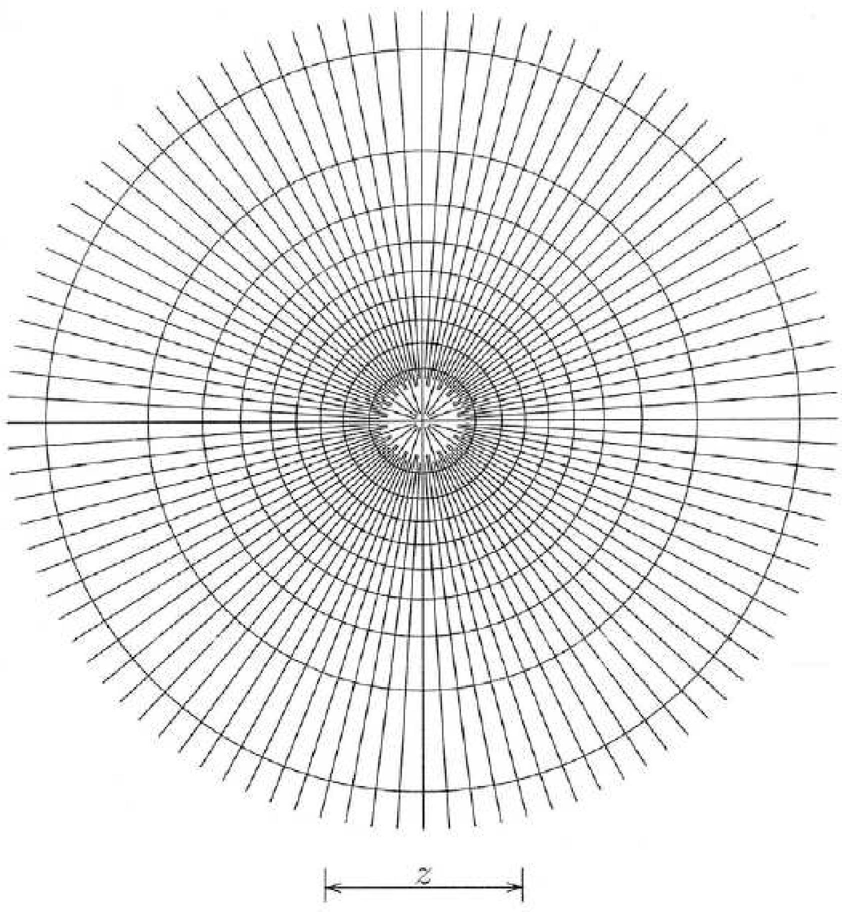


Figure 16 Cirkel of newmark

layer	Depth center layer beneath raft (m)	Newmark	spreidingsfactor
5	6,5	1000	1
6	14	1000	1
7	16	1000	1
8	19,5	1000	1
9	24,5	1000	1
10	28,5	1000	1
11	31,5	960	0,960
12	34	930	0,930
13	39	910	0,910
14	43	875	0,875
15	49	825	0,825

Table 35 Newmark

To determine the settlements we need the vertical stresses in the centre of the layers after excavation and the increase of the stresses after the building is completed.

layer	H	Depth middle layer beneath raft (m)	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)
5	17	6,5	335 -263,5*1 = 71,5	1242*1 = 1242
6	2	14	372,5- 263,5*1 = 109	1242*1 = 1242
7	2	16	384,5 - 263,5*1 = 121	1242*1 = 1242
8	5	19,5	421,5 - 263,5*1 = 157,5	1242*1 = 1242
9	4	24,5	470,5- 263,5*1 = 207	1242*1 = 1242
10	4	28,5	514,5 - 263,5*1 = 251	1242*1 = 1242
11	2	31,5	557,5 - 263,5*1 = 294	1242*0,960 = 1192
12	3	34	597,5 -263,5*0,975 = 340,6	1242*0,930 = 1155
13	7	39	641,5-263,5*0,925 = 397,8	1242*0,910 = 1130
14	1	43	674,5-263,5*0,900 = 437,4	1242*0,875 = 1087
15	7	49	674-263,5*0,825 = 456,6	1242*0,825 = 1025

Table 36 stress increase

The settlements are dependent on the maximum stress value. The maximum stress value can be calculated with the formula (17*z-145)
In which z is the depth? If the maximum stress value has not been reached the ground will act stiffer

All the values necessary to calculate the settlements are given in table Table 37

Layer	Depth middle layer (m)	Absolute depth (m)	Maximum stress value (kPa)	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)	σ'_{eind} (kPa)
5	6,5	31	382	71,5	1242	1313,5
6	14	38,5	509,5	109	1242	1351
7	16	40,5	543,5	121	1242	1363
8	19,5	44	603	157,5	1242	1399,5
9	24,5	49	688	207	1242	1449
10	28,5	53	756	251	1242	1493
11	31,5	56	807	294	1192	1486
12	34	58,5	849,5	340,6	1155	1495,6
13	39	63,5	934,5	397,8	1130	1527,8
14	43	67,5	1002,5	437,4	1087	1524,4
15	49	73,5	1104,5	456,6	1025	1481,6

Table 37 Stress increase and maximum stress value

Laag 5

$$w_1 = \frac{1}{1000} \cdot 17 \cdot \ln \frac{71,5 + 1242 \cdot (\varepsilon = 1,0)}{71,5} = 0{,}0495$$

$$w_2 = 0$$

Laag 6

$$w_1 = \frac{1}{30} \cdot 1 \cdot \ln \frac{109 + 1242 \cdot (\varepsilon = 1,0)}{109} = 0{,}0839$$

$$w_2 = \frac{1}{400} \cdot 1 \cdot \log \frac{10000}{1} \cdot \ln \frac{109 + 1242 \cdot (\varepsilon = 1,0)}{109} = 0{,}0252$$

Laag 7

$$w_1 = \frac{1}{1500} \cdot 3 \cdot \ln \frac{121 + 1242 \cdot (\varepsilon = 1,0)}{121} = 0{,}0048$$

$$w_2 = 0$$

Laag 8

$$w_1 = \frac{1}{30} \cdot 5 \cdot \ln \frac{157,5 + 1242 \cdot (\varepsilon = 1,0)}{157,5} = 0{,}3641$$

$$w_2 = \frac{1}{400} \cdot 5 \cdot \log \frac{10000}{1} \cdot \ln \frac{157,5 + 1242 \cdot (\varepsilon = 1,0)}{157,5} = 0{,}1092$$

Laag 9

$$w_1 = \frac{1}{1500} \cdot 4 \cdot \ln \frac{207 + 1242 \cdot (\varepsilon = 1,0)}{207} = 0{,}0052$$

$$w_2 = 0$$

Laag 10

$$w_1 = \frac{1}{40} \cdot 4 \cdot \ln \frac{251 + 1242 \cdot (\varepsilon = 1,0)}{251} = 0{,}1783$$

$$w_1 = \frac{1}{500} \cdot 4 \cdot \log \frac{10000}{1} \cdot \ln \frac{251 + 1242 \cdot (\varepsilon = 1,0)}{251} = 0{,}0571$$

Laag 11

$$w_1 = \frac{1}{1500} \cdot 2 \cdot \ln \frac{294 + 1242 \cdot (\varepsilon = 0,96)}{294} = 0{,}0022$$

$$w_2 = 0$$

Laag 12

$$w_1 = \frac{1}{50} \cdot 3 \cdot \ln \frac{340,6 + 1242 \cdot (\varepsilon = 0,93)}{340,6} = 0,0888$$

$$w_2 = \frac{1}{600} \cdot 3 \cdot \log \frac{10000}{1} \cdot \ln \frac{340,6 + 1242 \cdot (\varepsilon = 0,93)}{340,6} = 0,0296$$

Laag 13

$$w_1 = \frac{1}{450} \cdot 7 \cdot \ln \frac{397,8 + 1242 \cdot (\varepsilon = 0,91)}{397,8} = 0,0209$$

$$w_2 = 0$$

Laag 14

$$w_1 = \frac{1}{60} \cdot 1 \cdot \ln \frac{437,4 + 1242 \cdot (\varepsilon = 0,875)}{437,4} = 0,0208$$

$$w_2 = \frac{1}{700} \cdot 1 \cdot \log \frac{10000}{1} \cdot \ln \frac{437,4 + 1242 \cdot (\varepsilon = 0,875)}{437,4} = 0,0071$$

Laag 15

$$w_1 = \frac{1}{200} \cdot 7 \cdot \ln \frac{456,6 + 1242 \cdot (\varepsilon = 0,825)}{456,6} = 0,0412$$

$$w_2 = 0$$

layer	C_p	C_s	D (m)	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)	w1 (m)	w2 (m)	W_{end}(m)
5	1000	∞	17	71.5	1242	0,0495	0,0000	
6	30	400	1	109	1242	0,0839	0,0252	
7	1500	∞	3	121	1242	0,0048	0,0000	
8	30	400	5	157.5	1242	0,3641	0,1092	
9	1500	∞	4	207	1242	0,0052	0,0000	
10	40	500	4	251	1242	0,1783	0,0571	
11	1500	∞	2	294	1192	0,0022	0,0000	
12	50	600	3	340.6	1155	0,0888	0,0296	
13	450	∞	7	397.8	1130	0,0209	0,0000	
14	60	700	1	437.4	1087	0,0208	0,0071	
15	200	∞	7	456.6	1025	0,0412	0,0000	
total						0,8597	0,2282	1,0879

Table 38 Soil layer Settlements

Calculation differential settlements shallow foundation

The wind load which acts on the building is determined using .

- NEN-EN 1991-1-4 and NEN-EN 1991-1-4/NB: 2007
- Convenanthoogbouw NTA Hoogbouw (03-A) table 03-A.1

Because there are no supertalls (buildings with a height of over 300 meter) in the Netherlands the eurocode only provides values up to a height of 150 meter. The “hoogbouwconvenant” provides values up to 300 meter. These values have been extrapolated to a height 800 meter For more details see appendix A and C.

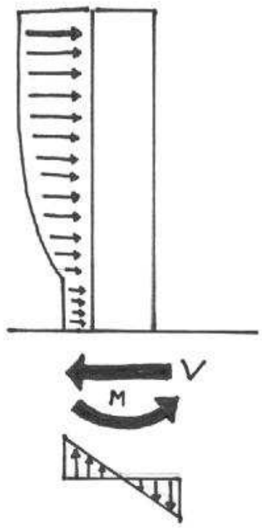


Figure 17

The wind load causes a moment and a horizontal force at the base. This bending moment will cause compression on one side of the building and tension on the other side. When combined with the vertical loads from the superstructure this result in an asymmetric stress pattern at the foundation.
The size of the bending moment and the lateral force at the base has been determined using ESA scia engineer.

The shear force and moment are calculated using an FEM program and are :

M= 36.5 $* 10^6$ kNm
V = 96.017 $* 10^3$ kN

The moment on the raft is the sum of the moment at the base of the building and the shear force times the depth of the raft (-21 NAP).

$36,5*10^6 + 96017 * 21 = 38,5 * 10^6$ kNm

Alternative	Moment (kNm)	Shear force kN	Total moment
Core-outrigger	$36,5* 10^6$	96017	$38,5* 10^6$

Table 39

In order to determine the maximum vertical load at the foundation we need to find the resultants of tensile and compression stresses

$$F_{res} = \frac{1}{2} \cdot \pi \cdot R^2 \cdot \sigma_{\max} \cdot \frac{1}{2}$$

$\sigma_{\max}$ = Maximum stress caused by the moment

The resulting tension and compression forces act on the centre of gravity in both halves. The centre of gravity of stresses will be somewhere between 0.4244*R (circle) and triangle (0.666*R) a value of $\frac{3}{16} \cdot \pi \cdot R = 0,589 \cdot R$ is found in the literature.

F_{res} can be found by dividing the Moment with the lever arm.

$$F_{res} = \frac{38,5,57 \cdot 10^6}{(2 \cdot 0,589 \cdot 70)} = 466893 \text{ kN}$$

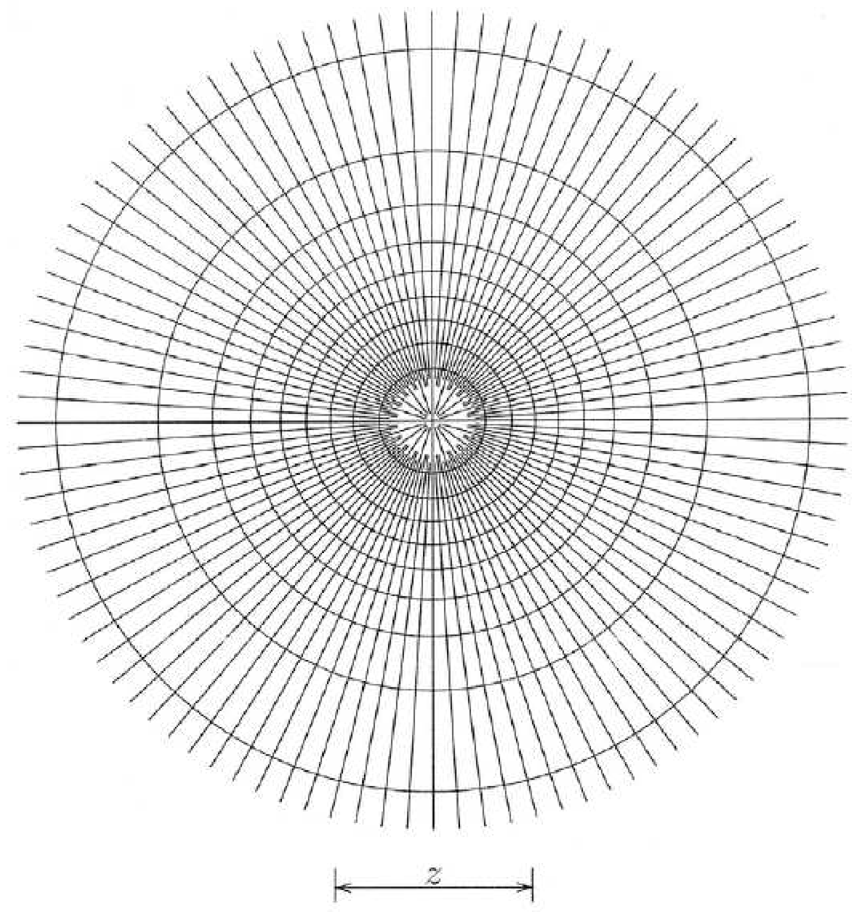
And

$$\sigma_{\max} = \frac{F_{res}}{\frac{1}{4} \cdot \pi \cdot 70} = 121 kN / m^2$$

layer	H	Depth centre layer beneath NAP in (m)	$\sigma'_{v;z;0}$ in middle of layer before excavation (kPa)
5	17	25,5	593 -255 = 335
6	2	35	739,5-330 = 409,5
7	2	37	771,5-350 = 421,5
8	5	40,5	843,5-385 = 458,5
9	4	45	937,5-430 = 470,5
10	4	49	1021,5-470 = 507,5
11	2	52	1094,5-500 = 594,5
12	3	54,5	1159-525 = 634
13	7	59,5	1260,5-575 = 685,5
14	1	63,5	1340,5-615 = 725,5
15	7	67,5	1388,5-655 = 733,5

Table 40 vertical stresses before excavation

We use the Sun of Newmark to determine the stress distribution



The settlements are dependent on the maximum stress value. The maximum stress value can be calculated with the formula (17*z-145) in which z is the depth.

All the values necessary to calculate the settlements are given in Table 41.

Layer	Depth middle layer (m)	Absolute depth (m)	Maximum stress value (kPa)	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)
5	6,5	31	382	1313,5	121
6	14	38,5	509,5	1351	121
7	16	40,5	543,5	1363	121
8	19,5	44	603	1399,5	121
9	24,5	49	688	1449	121
10	28,5	53	756	1493	121
11	31,5	56	807	1486	116
12	34	58,5	849,5	1495,6	113
13	39	63,5	934,5	1527,8	110
14	43	67,5	1002,5	1524,4	106
15	49	73,5	1104,5	1481,6	99,8

Table 41 Stress increase and maximum stress value

Laag 5

$$w_1 = \frac{1}{2000} \cdot 17 \cdot \ln \frac{1313{,}5 + 121 \cdot (\varepsilon = 1,0)}{1313{,}5} = 0{,}00075$$

$$w_1 = \frac{1}{2000} \cdot 17 \cdot \ln \frac{1313{,}5 - 121 \cdot (\varepsilon = 1,0)}{1313{,}5} = -0{,}00082$$

Laag 6

$$w_1 = 0{,}00000$$

$$w_1 = 0{,}00000$$

Laag 7

$$w_1 = \frac{1}{3000} \cdot 3 \cdot \ln \frac{1363 + 121 \cdot (\varepsilon = 1,0)}{1363} = 0{,}00009$$

$$w_1 = \frac{1}{3000} \cdot 3 \cdot \ln \frac{1363 - 121 \cdot (\varepsilon = 1,0)}{1363} = -0{,}00009$$

Laag 8

$$w_1 = 0{,}00000$$

$$w_1 = 0{,}00000$$

Laag 9

$$w_1 = \frac{1}{3000} \cdot 4 \cdot \ln \frac{1449 + 121 \cdot (\varepsilon = 1,0)}{1449} = 0{,}00011$$

$$w_1 = \frac{1}{3000} \cdot 4 \cdot \ln \frac{1449 - 121 \cdot (\varepsilon = 1,0)}{1449} = -0{,}00012$$

Laag 10

$$w_1 = 0{,}00000$$

$$w_1 = 0{,}00000$$

Laag 11

$$w_1 = \frac{1}{3000} \cdot 2 \cdot \ln \frac{1486 + 121 \cdot (\varepsilon = 0,96)}{1486} = 0{,}00005$$

$$w_1 = \frac{1}{3000} \cdot 2 \cdot \ln \frac{1486 - 121 \cdot (\varepsilon = 0,96)}{1486} = \text{-}0{,}00005$$

Laag 12

$$w_1 = 0{,}00000$$

$$w_1 = 0{,}00000$$

Laag 13

$$w_1 = \frac{1}{900} \cdot 7 \cdot \ln \frac{1528 + 121 \cdot (\varepsilon = 0,91)}{1528} = 0,00054$$
$$w_1 = \frac{1}{900} \cdot 7 \cdot \ln \frac{1528 - 121 \cdot (\varepsilon = 0,91)}{1528} = -0,00058$$

Laag 14

$$w_1 = 0,00000$$
$$w_1 = 0,00000$$

Laag 15

$$w_1 = \frac{1}{400} \cdot 7 \cdot \ln \frac{1481,6 + 121 \cdot (\varepsilon = 0,825)}{1481,6} = 0,00114$$
$$w_1 = \frac{1}{400} \cdot 7 \cdot \ln \frac{1481,6 - 121 \cdot (\varepsilon = 0,825)}{1481,6} = -0,00122$$

layer	Cp	d	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)	w1 (m)	w2 (m)
5	2000	17	1313,5	121	0,00075	-0,00082
6	∞	1	1351	121	0,00000	0,00000
7	3000	3	1363	121	0,00009	-0,00009
8	∞	5	1399,5	121	0,00000	0,00000
9	3000	4	1449	121	0,00011	-0,00012
10	∞	4	1493	121	0,00000	0,00000
11	3000	2	1486	163,2	0,00005	-0,00005
12	∞	3	1495,6	158,1	0,00000	0,00000
13	900	7	1527,8	154,7	0,00054	-0,00058
14	∞	1	1524,4	105,875	0,00000	0,00000
15	400	7	1481,6	99,825	0,00114	-0,00122
total					0,00267	-0,00289

Table 42 Soil layer Settlements

Feedback rotation stiffness of the foundation

In chapter 4 (superstructure) several alternatives were modelled in ESA because the foundation had not yet been designed the tower was assumed to be fully clamped. In reality the foundation should be modelled as rotational spring. In this paragraph we will determine the rotational stiffness of the foundation and determine the final deflection due to the windload working on the building

The rotation stiffness of the foundation will be calculated using the foundation raft from chapter 5
The rotation stiffness of the foundation is important because there is no point in adding stiffness to the superstructure when the rotation stiffness of the foundation is insufficient.

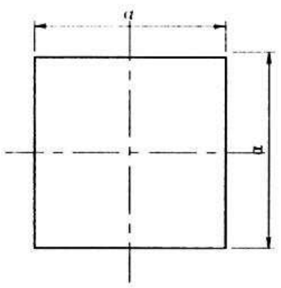
The rotational stiffness is determined according to [chapter 2, voorbeelden in de praktijk VSSD]

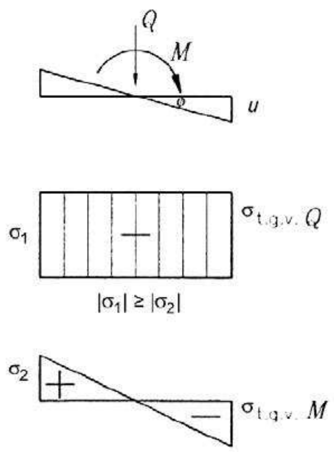
Rotation stiffness raft

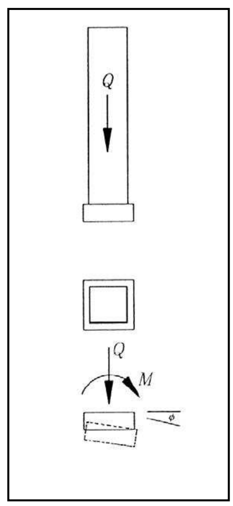
We assume raft has infinite stiffness and since the foundation raft transfers loads to a Sand layer we are allowed to use Table 43

Area foundation raft (m^2)	Beddingsconstante in (kN/m^3)
<10	$5*10^4$
10-20	$4*10^4$
20-100	$3*10^4$
>100	$2*10^4$

Table 43 "Beddings constante"







This gives the following formulas for the calculation of the raft rotation spring constant ''r''

$$r = \frac{M}{\varphi} = \frac{1}{12} ka^4 \quad \text{square raft} \qquad (9)$$

$$r = \frac{\pi}{64} kd^4 \quad \text{circular raft} \qquad (10)$$

Foundation element	**Area (m^2)**	**r**
Raft Rotational stiffness (20000 kN/m^3)	15394	3.77E11

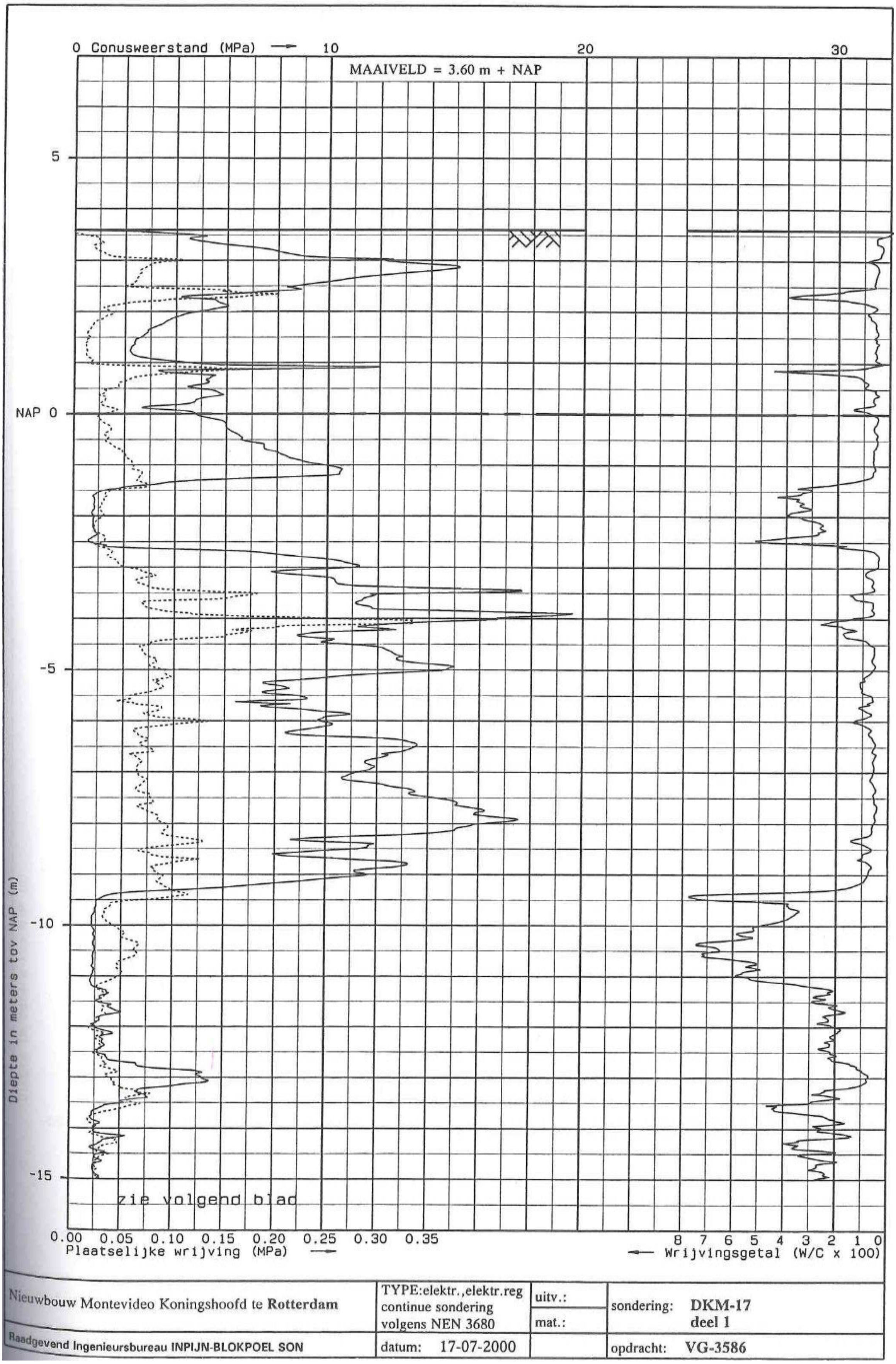
Rotational stiffness

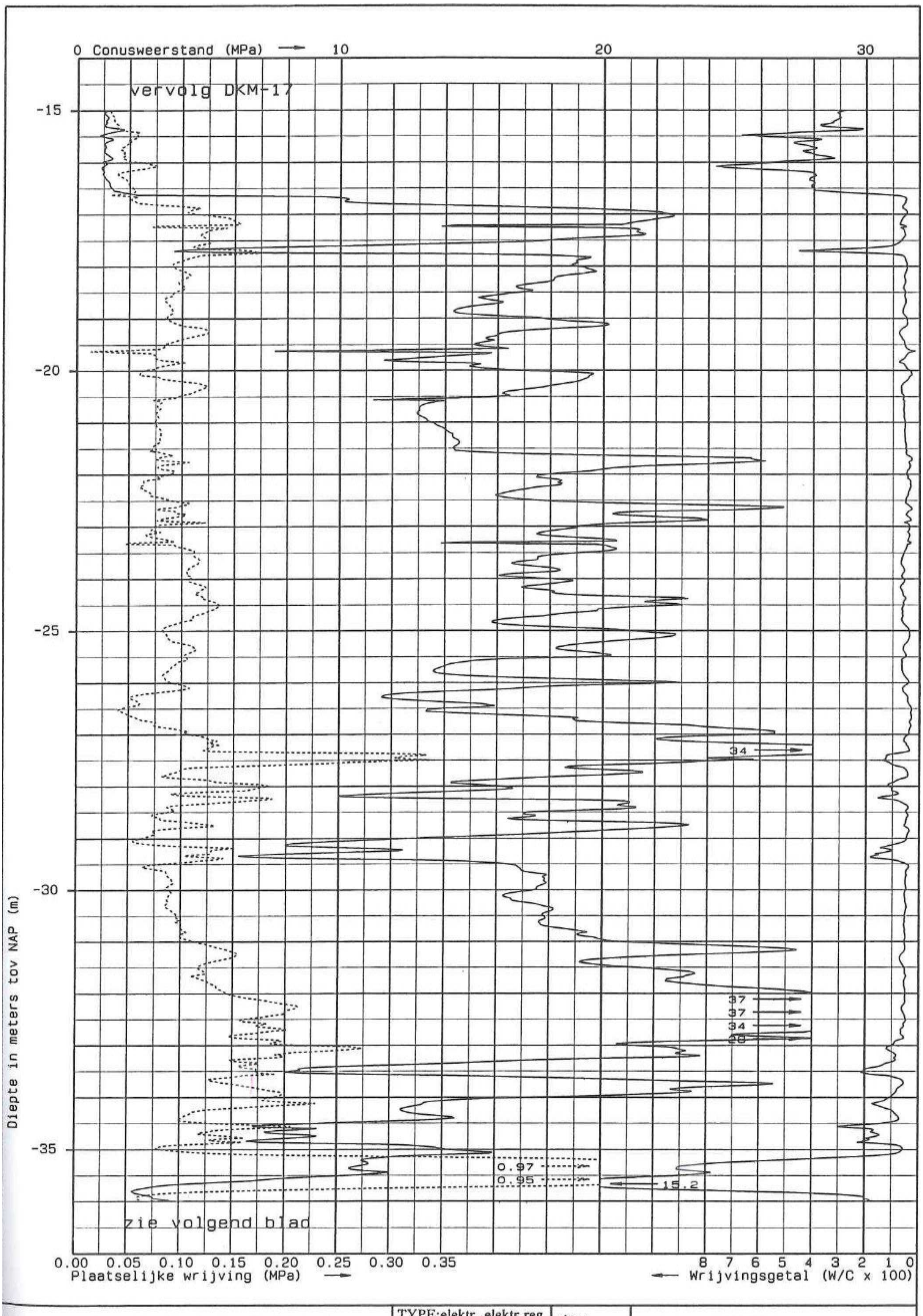
Table 44 The rotational stiffness's are added to the ESA models from chapter 4 and give the following results.

alternative	**Alternative 1 Deformation SLS (mm)**	**Alternative 2 Deformation SLS (mm)**	**Alternative 3 Deformation SLS (mm)**
Clamped	648	411	339
Rotational stiffness (20000 kN/m^3)	766	476	381

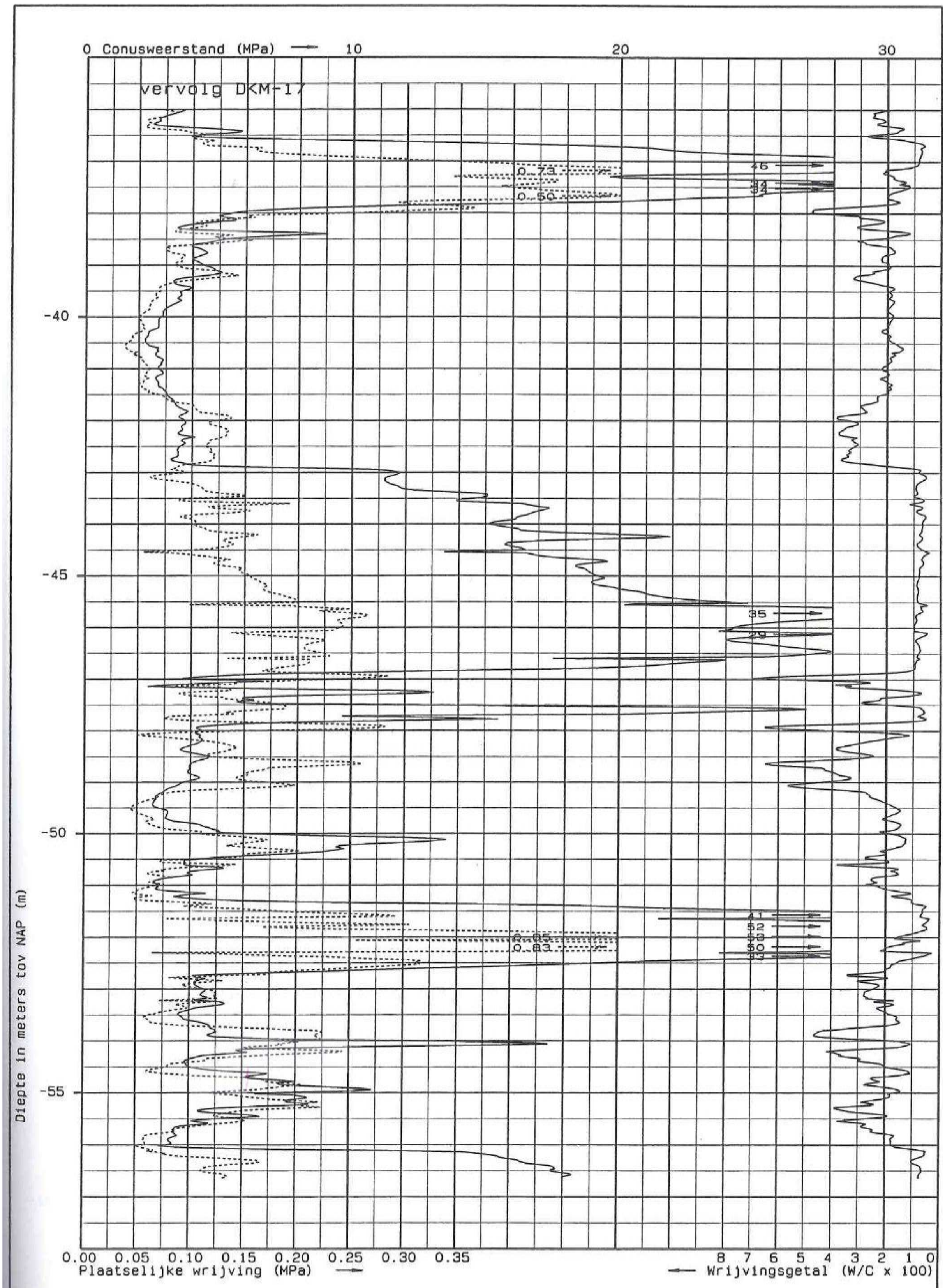
Table 45 rotational stiffness deformation

Appendix K: Montevideo (Probing-Soil drilling test)





Nieuwbouw Montevideo Koningshoofd te **Rotterdam**	TYPE:elektr.,elektr.reg continue sondering volgens NEN 3680	uitv.: mat.:	sondering: **DKM-17 deel 2**
Raadgevend Ingenieursbureau INPIJN-BLOKPOEL SON	datum: 17-07-2000		opdracht: **VG-3586**



Nieuwbouw Montevideo Koningshoofd te **Rotterdam**	TYPE:elektr.,elektr.reg continue sondering volgens NEN 3680	uitv.: / mat.:	sondering: **DKM-17 deel 3**
Raadgevend Ingenieursbureau INPIJN-BLOKPOEL SON	datum: 17-07-2000		opdracht: **VG-3586**