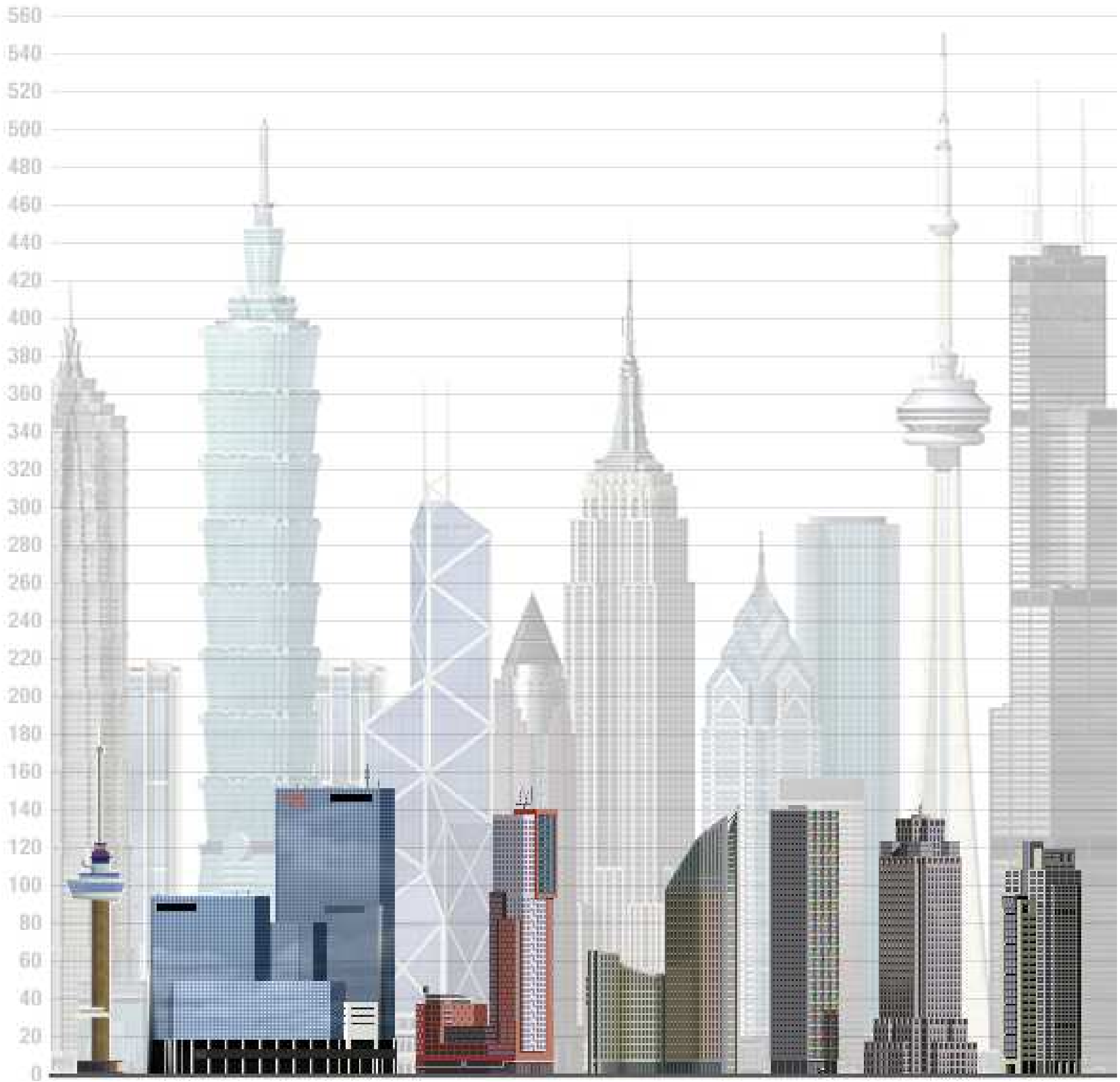
Super high-rise in Rotterdam
Addendum wind-aspects Rijnhaven Tower



Master's Thesis Report **U.M. Winter**

June 2011

Super High-Rise in Rotterdam

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Content

Introduction

There is large difference in height between high-rise buildings in the Netherlands and high-rise in other continents such as North America and Asia. The tallest building in the Netherlands, the "Maastoren", has a height of 164.75 meter whereas in the rest of the world buildings with a height of more than 300 meter are not uncommon. In Dubai the Burj Khalifa has even reached a height of 828 meter. The goal of this thesis is to find the limit to the height of tall buildings and find out if similar heights (such as found in foreign countries) be achieved in the Netherlands"

After a literature study was done on the important aspects of a tall building a so called compound structure was chosen as the structural system of the building. This compound structure consists of 4 slender towers which are tied together at mechanical levels.
3 alternatives were chosen designed and tested in using the FEM software "ESA SCIA Engineer".

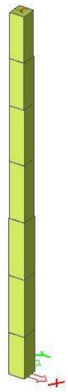
1. Core	2. Core-outrigger	3. Diagrid
		

Table 1: structural alternatives

Wind-induced dynamics play an important role in the design of an 800 meter high building. The Rijnhaven Tower has a unique shape which consists of four quadrants which are tied together at mechanical floors. This creates openings which allow the wind to blow through the building. Earlier the assumption was made that the slots disrupt the vortex shedding forces and reduce the along-wind forces threefold. Later it was found that the primary function of the slots is to mitigate the vortex shedding process.
Furthermore it was mentioned in the conclusion of part 2: Structural Design that the Dutch building code is not equipped to deal with an 800 meter building. For example it gives values (for the static pressure) up to a height of 150 meter .

In this addendum we will re-evaluate these assumptions and several formulas which were used in the report. Also the meaning and background of the formulas in the Dutch building code are explained more in depth and if necessary it is explained whether they are suitable for an 800 meter building with a low natural frequency.

Chapter 1 Problem description

In this chapter the difference between the structal design as a result of wind of a typical Dutch high-rise building and our 800 meter high tower is explained using the wind spectrum and natural frequencies and eurocode .

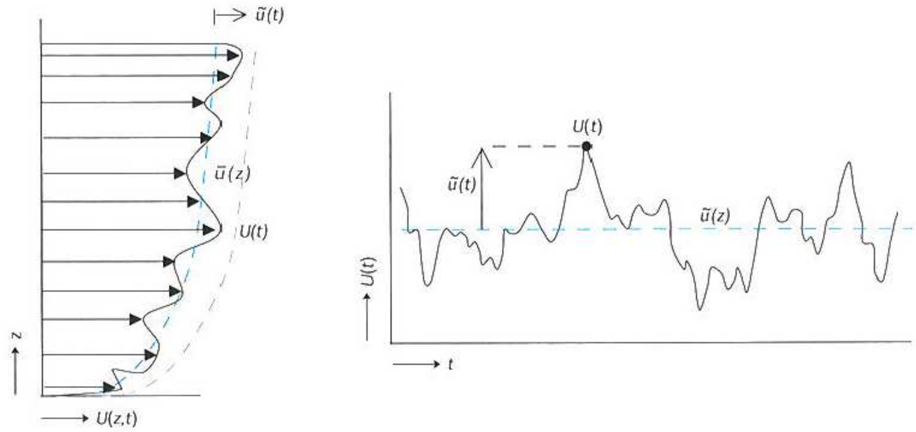


Figure 1: Wind profile and wind load fluctuating with time [1]

Figure 1 shows that the wind fluctuates with the time. According to [2] winds speeds, wind pressure and the resulting structural response are generally treated as stationary random processes in which the time averaged or mean component is separated from the fluctuating component. The time dependent wind speed U(t) is divided into a static component u_z which increases logarithmically with the height of the building and a fluctuating component u_t [1]. When the frequency of the fluctuating wind forces approach the natural frequency of the building resonance occurs. The wind load shakes the building at its most vulnerable frequency resulting in a large dynamic response. This is similar to the building up of the amplitude of a child on a swing by pushing at the natural pendulum frequency.

The NEN 6702 and Eurocode 1991-1-4 allow the wind to be considered as a quasi-static load. This means that the structure is calculated using a static load and the dynamic effect is taken into account by the dynamic amplification factor φ (NEN 6702) or c_d (Eurocode 1991-1-4) [1]. In the report this dynamic amplification factor is included in the structural factor c_sc_d. This factor takes into account the effect of wind actions from the non-simultaneous occurrence of peak wind pressure on the surface together with the effect of turbulence.

While it is allowed to use a quasi-static load in the structural design of the building the dynamic effects still have to be considered.
The Rijnhaven Tower has a large height (800 meter) and a low first natural frequency (0.05 Hz). This requires a different approach as compared to a typical Dutch high-rise building which has a height of ca. 100-160 meter and a first natural frequency of ca. 0.5-1 Hz.
Figure 2 shows the characteristics of the time histories for a structural response of a structure with a high and low natural frequency under wind load.
In the case of a high natural frequency (Figure 2b) the resonant or vibratory component plays a minor role and it can be seen that the response generally follows the time variation of the forces working on the structure in time (Figure 2a). however in the case of a low frequency the resonant response is important (Figure 2c).
According to [2] a frequency below 1 Hz is a well-known rule of thumb which determines if the lowest natural frequency has a significant resonant response.

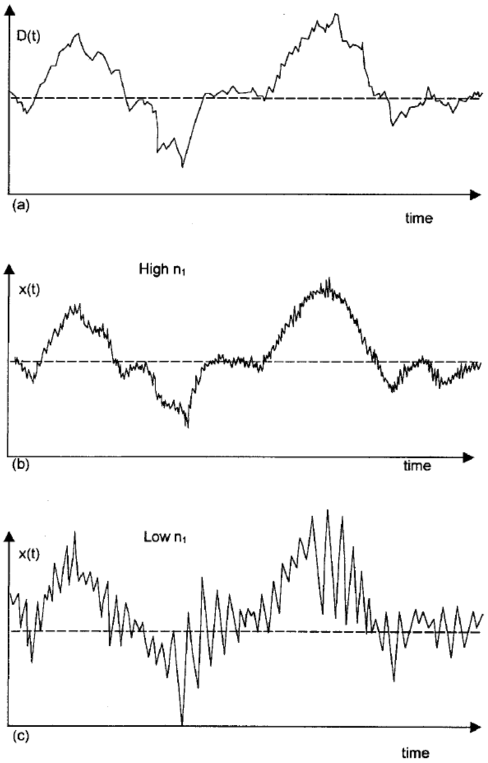


Figure 2: a) Wind force varying with time, (b) structural response varying with time for a high frequency (c) and a low frequency.[2]

Table 2 Shows the natural frequencies of alternative 2, the core-outrigger alternative.

Natural frequency	f [Hz]	T [sec]
1	0.05	18.30
2	0.05	18.30
3	0.19	5.32
4	0.30	3.39
5	0.30	3.39
6	0.76	1.31
7	0.76	1.31
8	0.93	1.08

Table 2: natural frequencies alternative 2 core-outrigger system

It can be seen that our tower has a first natural frequency of ca. 0.05 Hz and two more frequencies below 1 Hz. This means that the dynamic response due to wind requires special attention.

In the case of a tall building the two major causes of resonance are:

- the fluctuation in the upstream wind .
- the alternate vortex shedding which occurs behind bluff cross-sectional shapes.

The dynamic response (accelerations) due to the fluctuation of wind with time is calculated using a separate formula found in Annex C.4 of NEN-EN 1991-1-4.

Another phenomenon which affects the design of a tall building is vortex shedding. Tall buildings are bluff bodies and when the wind blows against the building vortices are created which result in an alternating force perpendicular to the wind direction. When vortex shedding frequency approaches the natural frequency of the building resonance occurs. When the vortex shedding phenomenon takes place along a large part of the height of the building it can result in large forces and amplitudes.

In summary, the following aspects have to be examined when considering the wind working on the building:

- the quasi-static wind load which includes a dynamic amplification factor
- accelerations due to the fluctuation in the upstream wind
- alternating forces due to vortex shedding in the across-wind direction

1.1 The quasi-static wind load which includes a dynamic amplification factor

In the Eurocode 1991-1-4 and NEN 6702 the static wind load and a dynamic amplification factor determine the design load working on the structure. This design load gives the forces and deformation of the structure due to the wind and is necessary to design the structural system. The basic design criteria stability, strength and serviceability should be satisfied. Stability means that the building can resist overturning uplift and/or sliding.

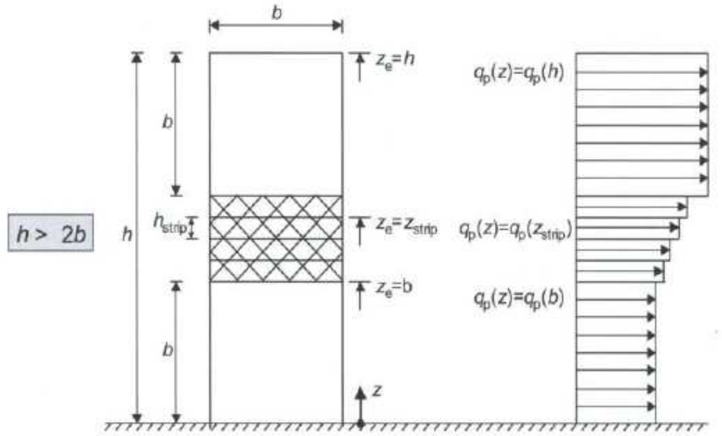


Figure 3: quasi-static wind load according to NEN-EN 1991-1-4

The strength criterion is satisfied when all the structural components are able to withstand the imposed wind loads without failure during the life time of the structure. Also the deflection and motions of the building have to remain within acceptable limits.

The quasi-static wind load is calculated in chapter 2.

1.2 Accelerations due to the fluctuation in the upstream wind

The fluctuation in the upstream wind causes the building to vibrate resulting in accelerations. These accelerations can negatively influence the inhabitants of a tall building. Human comfort is an important issue in tall buildings because accelerations can make inhabitants insecure or even nauseous (building sickness) which may prove the structure undesirable or un-rentable. Table 3 shows the natural frequencies for alternative 2: core-outrigger which have been obtained using ESA Scia Engineer. In this paragraph the wind spectrum and transfer function is used to determine the standard deviation of the acceleration due to the fluctuation in the upstream wind.

Natural frequency	f [Hz]	T [sec]
1	0.05	18.30
2	0.05	18.30
3	0.19	5.32
4	0.30	3.39
5	0.30	3.39
6	0.76	1.31
7	0.76	1.31
8	0.93	1.08

Table 3: natural frequencies alternative 2 core-outrigger system

Figure 4 and Figure 5 show the wind spectrum (a), transfer function(b) and dynamic response(c) for the Rijn haven Tower and a typical (Dutch) high-rise tower.
When we examine the dynamic response of the buildings global vibration in one direction we end up with 3 natural frequencies below 1 Hz.
Figure 4 a and Figure 5 a show the wind spectrum in the Netherlands. The first natural frequency (0.05 Hz) of the Rijnhaven tower is close to the frequency where the wind has the most energy. The other natural frequencies at 0.30 and 0.76 Hz contribute less to the response of the building because the gust have less energy at these frequencies. These three frequencies however all play a role in the response of the building which is very dangerous. Especially the first natural frequency where the gusts have the most energy is problematic.
In the Netherlands most buildings have a first natural frequency at about.0.5-1 Hz and since the second and third frequency are far away from the frequency at which the gust have the most energy their contribution to the response of the building is neglected (Figure 5 b and Figure 4 b)
From Holmes[2] it follows that the area under Figure 4c and fig Figure 5c is the standard deviation of the response.
The formulas for along and across-wind vibrations in NEN 6702 and the Eurocode are therefore based on the response due to the first natural frequency of the building and the neglection of the 2^{nd} and 3^{rd} natural frequency.
Because of this it is not correct to use these formulas to design an 800 meter high building where the 2^{nd} and 3^{rd} natural frequency have a significant contribution to the dynamic response of the building. The formulas used in the Eurocode are suitable for typical high-rise buildings where the first natural frequency is about 0.5- 1Hz.

The peak acceleration for the first natural frequency will be calculated in chapter 3.

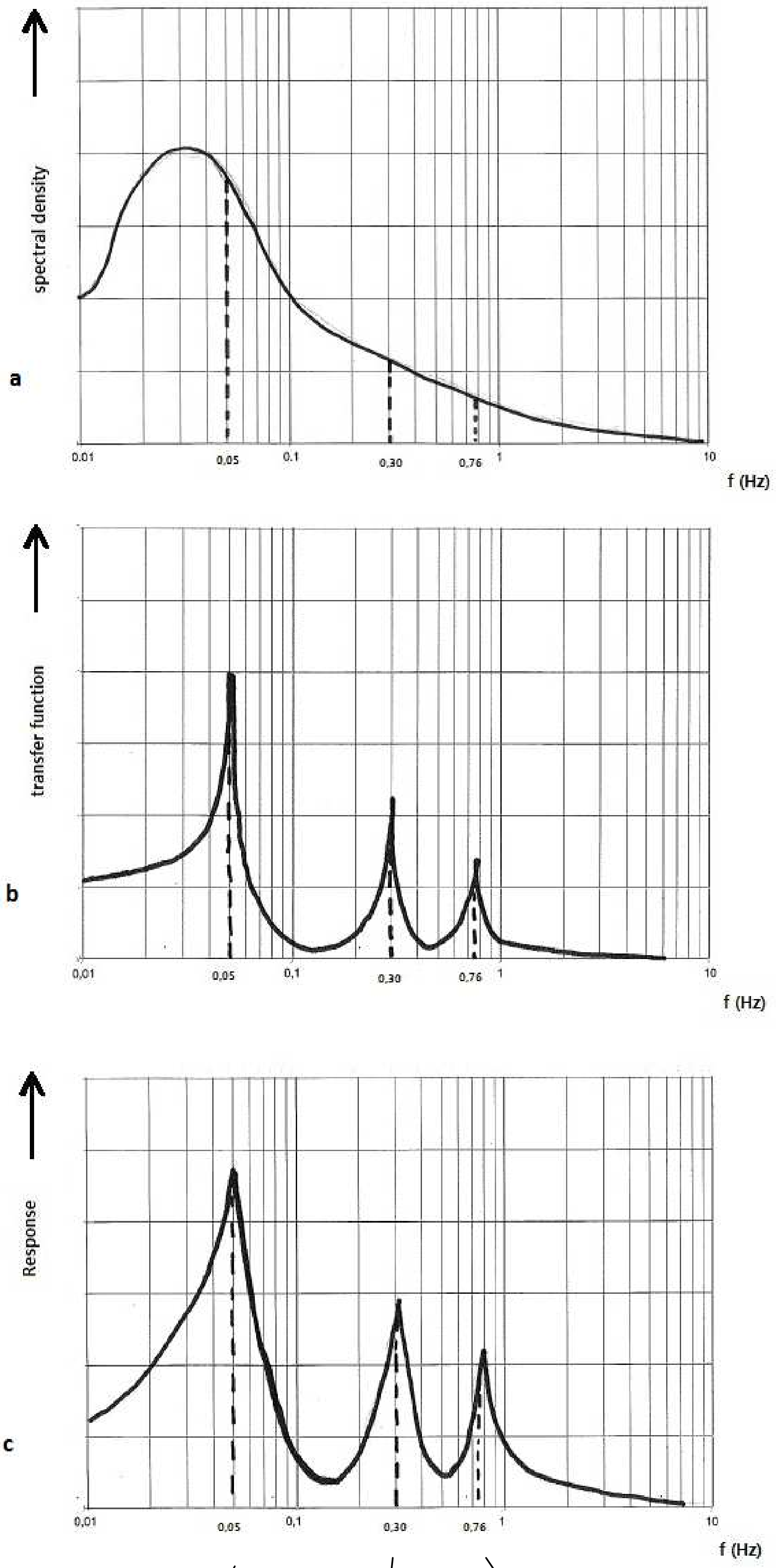


Figure 4: dynamic response Rijnhaven tower

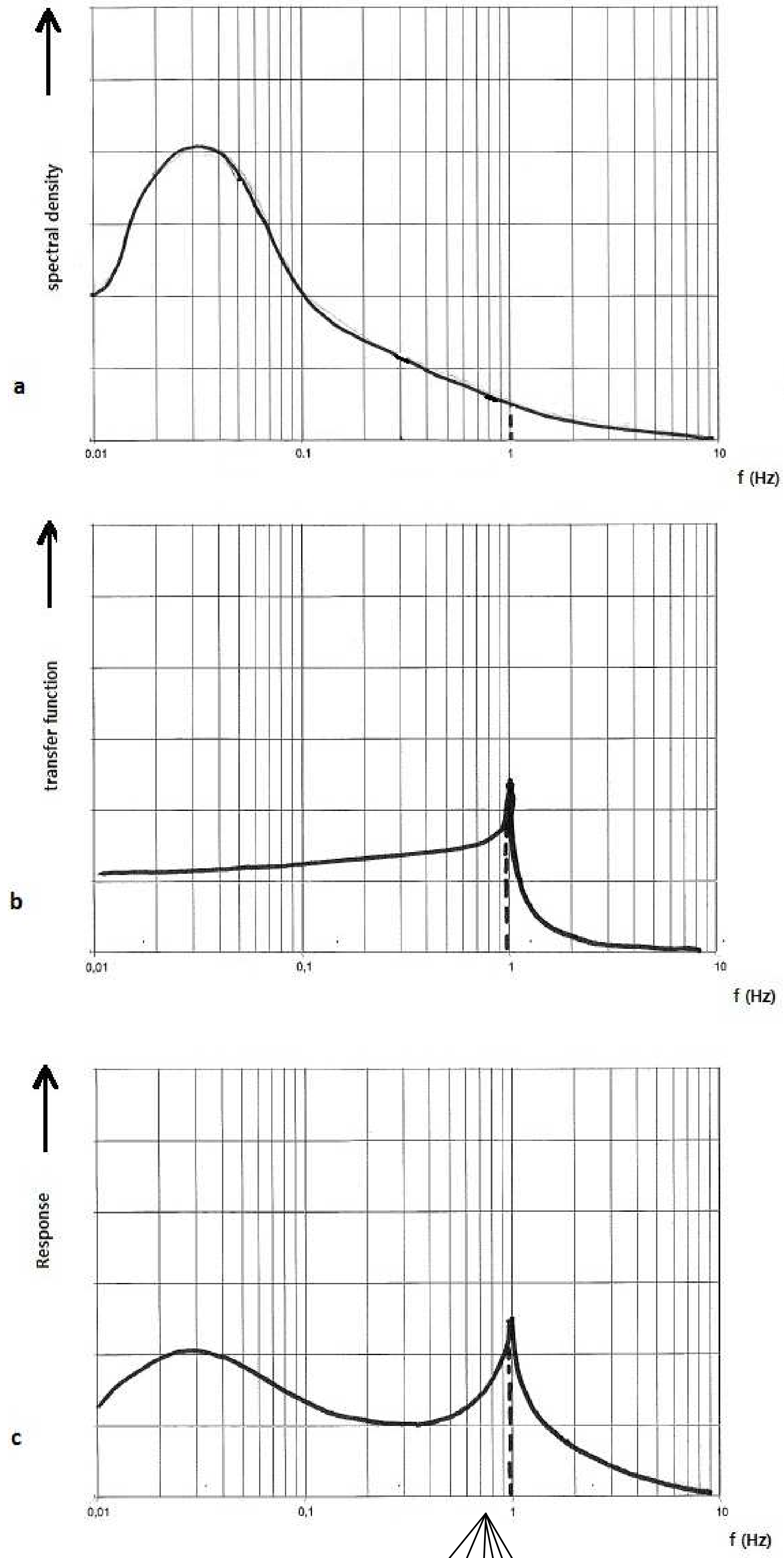


Figure 5: dynamic response typical Dutch high-rise

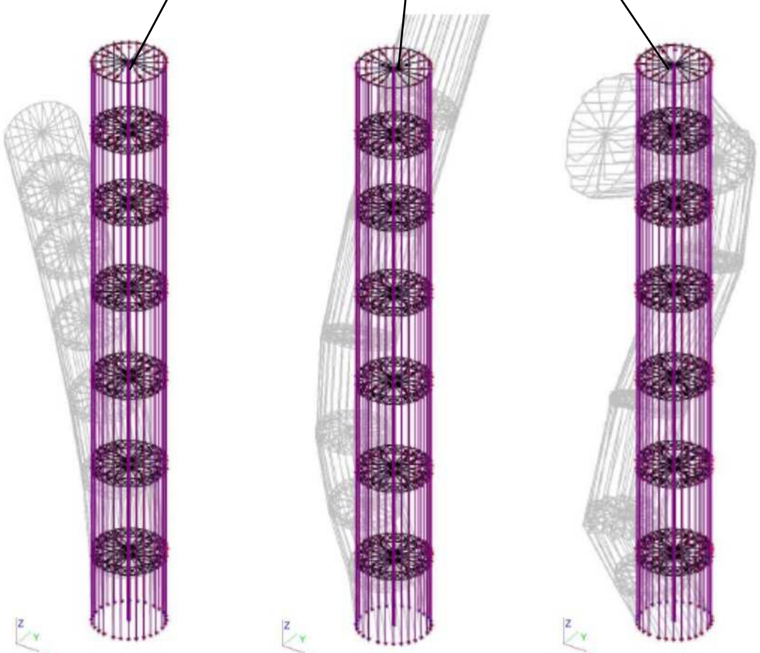


Figure 6: natural frequencies 0.05 Hz (left), 0.30 Hz (middle) and 0.76 Hz (right)

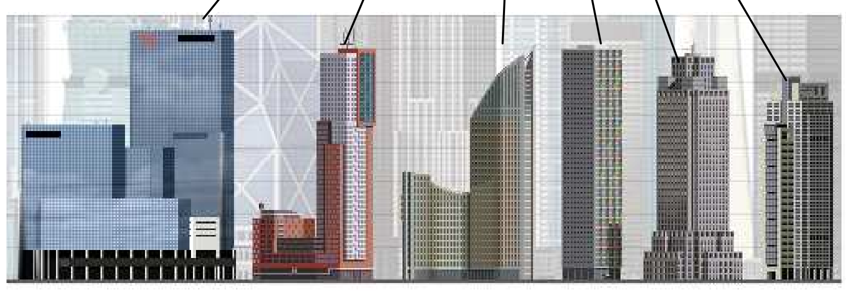


Figure 7: Dutch high-rise (100-160) m ca. 0.5-1Hz

1.3 *Alternating forces due to vortex shedding in the across-wind direction*

Tall buildings are bluff bodies which cause the flow to detach from the structure instead of following the contour of the building. When this happens vortices are created which cause a periodically alternating force perpendicular to the wind direction (see Figure 8). This is called vortex shedding. The vortex shedding phenomenon is very dangerous for a tall building. Without good design and engineering it can result in large forces and accelerations. Because of this the vortex phenomenon needs to be limited as much as possible through good design. Mitigating measures have been mentioned in chapter (3.5) of part1: the literature study.

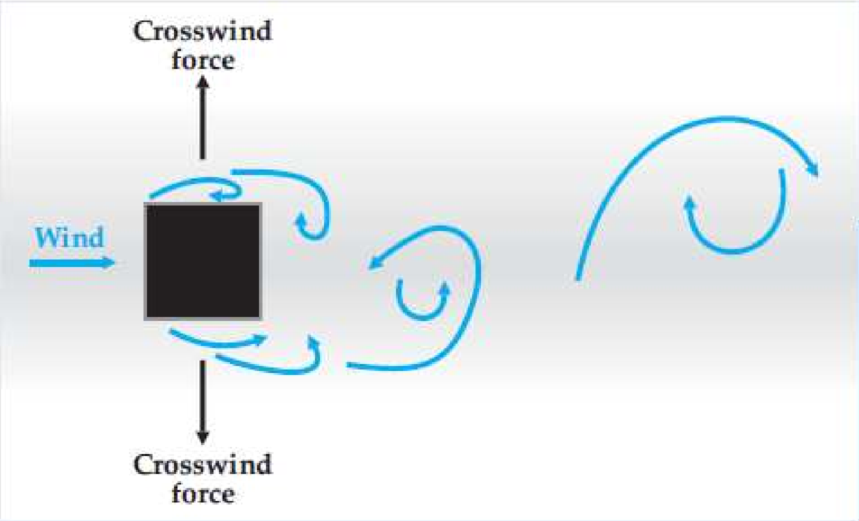


Figure 8: vortex shedding phenomenon

The vortex shedding phenomenon is examined more thoroughly in chapter 4.

Chapter 2 Quasi-static wind load

In this paragraph we will determine the quasi-static design load working on the building according to the Eurocode NEN-EN 1991-1-4 and the NTA Convenant Hoogbouw.

At a height of 800 meter wind from all directions has to be considered. In the report it was assumed that due to the slots the quasi-static wind load could be reduced by a factor 3.This value was based on the reference project the Nakheel Tower.
However, later it was found that the primary function of the slots is to reduce the across-wind response due to vortices. These slots deserve to disturb the wind flow around the building and thus break up the vortices that form on the leeward side.
This means that the quasi-static wind load on the building may not be reduced by a factor 3.

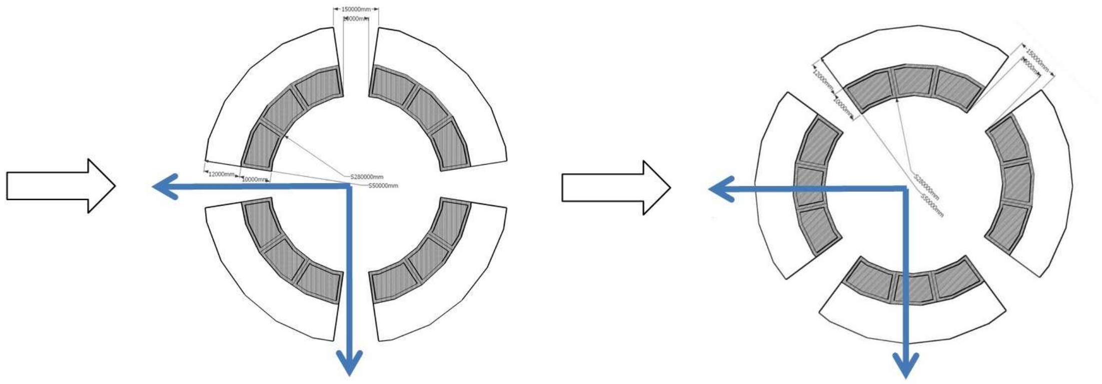


Figure 9: wind load in two directions

The design wind load is determined using NEN-EN 1991-1-4 expression 5.3(2)

$$F_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot A_{ref} \quad \text{in kN} \quad (1)$$
$$Q_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot b_{ref} \quad \text{in kN/m} \quad (2)$$

Where

$c_s c_d$ is the structural factor which is determined according to Appendix C
c_f is the force coefficient for the structure found in table 03-A.2 of NTA Convenant Hoogbouw
b_{ref} is the reference width of the building in m, in case of a cylinder this is the diameter (see figure 7.27 of NEN-EN 1991-1-4)
q_p is the peak velocity pressure at reference height z_e

2.1 Structural factor

The structural factor $c_s c_d$ has been calculated using procedure 2 found in NEN-EN 1991-1-4 Annex C.

$$c_s c_d = \frac{1 + 2 \cdot k_p \cdot I_v(z_e) \cdot \sqrt{B^2 + R^2}}{1 + 7 \cdot I_v(z_e)} \tag{3}$$

It consist of a c_s (size factor) and c_d (dynamic factor)

$$c_S = \frac{1 + 7 \cdot I_v(z_e) \cdot \sqrt{B^2}}{1 + 7 \cdot I_v(z_e)} \tag{4}$$

$$c_D = \frac{1 + 2 \cdot k_p \cdot I_v(z_e) \cdot \sqrt{B^2 + R^2}}{1 + 7 \cdot I_v(z_e)\sqrt{B^2}} \tag{5}$$

z_e is the reference height of the structural factor = 0.6*h
k_p is the peak factor (3.11) because v= 0.114 NEN-EN1991-1-4:2005 B2 (4)
I_v is the turbulence intensity
B^2 is the Background response factor
R^2 is the Resonance response factor

$$k_p = \sqrt{2 \cdot \ln(v \cdot T)} + \frac{0.6}{\sqrt{2 \cdot \ln(v \cdot T)}}$$

Where

T is the averaging time for the mean wind velocity , T=600 seconds
$n_{1,x}$ is the natural frequency of the structure
B^2 is the Background response factor
R^2 is the Resonance response factor

$$I_v(z_s) = \frac{\sigma_v}{v_m(z)} = \frac{k_l}{c_o \cdot \ln(z/z_0)} \quad \text{for} \quad z_{\min} < z < z_{\max}$$
$$I_v(z_s) = I_v(z_{\min}) \quad \text{for} \quad z < z_{\min} \tag{6)(7}$$

Where

k_l is the turbulence factor = 1.0
c_o is 1
z_0 is 0.2 Convenant hoogbouw recommends the use of "*non-built-up area*" values. See Table 4.1 NEN-EN1991-1-4:2005 NB

Background response factor

The background response factor B^2 takes into account the effect of wind actions from the non-simultaneous occurrence of peak wind pressure on the surface.
In the report, B^2 was given the value 1 to be on the safe side. But here the fact that, for a large façade not all gusts working on the building have a maximum value at the same time is taken into account.

$$B^2 = \frac{1}{1+\frac{3}{2}\cdot\sqrt{\left(\frac{b}{L(z_e)}\right)^2+\left(\frac{h}{L(z_e)}\right)^2+\left(\frac{b}{L(z_e)}\cdot\frac{h}{L(z_e)}\right)^2}} = 0.191 \qquad (8)$$

Where

b is the width of the building in m
h is the height of the building in m
L_{ze} is the turbulent length scale at a height z_e

$$L(z) = L_t \cdot \left(\frac{z}{z_t}\right)^{\alpha} \qquad (9)$$

L_t = 300 m
z_t = 200 m
$\alpha = 0.67+0.05\ln(z_0)$

Resonance response factor

R^2 is the resonance response factor allowing for turbulence in resonance with the considered vibration mode of the structure.

$$R^2 = \frac{\pi^2}{2\cdot\delta}\cdot S_L(z_e, n_{1,x})\cdot K_s(n_{1,x}) \qquad (10)$$

$R^2 = 2.275$

Where

δ is the logarithmic decrement of damping given in Annex F
S_L is the wind power spectral density function given in B.1 (2)
$n_{1,x}$ is the natural frequency of the structure (see Table 3)
K_s is the size reduction factor

The values for the structural damping δ_s are found in Table 03 A.4 of the Convenant Hoogbouw NTA. These values are empirical values which follow from measurements. The damping for a building of 800 meter has never been measured and we expect that the higher the building becomes the lower the damping. However we expect that the values in Table 4 are in the same order of magnitude as that of our building. The aerodynamic damping has been neglected.

Structural type	Structural damping δ_s
Reinforced concrete buildings	0.10
Steel buildings	0.05
Mixed structures concrete+steel	0.08

Table 4: Damping according to NTA Wind convenant hoogbouw table 03 A.4

In the report a value of 0.08 was used because the alternatives had not yet been designed. For the core-outrigger the value 0.10 of reinforced concrete buildings is chosen.

The foundation also plays a role in absorbing the vibration energy (see Figure 10). A taller and more slender building has a parabolic mode shape in which the oscillation is small at the bottom compared to a linear mode shape. This means that the foundation plays a smaller role in a (tall) building with a parabolic mode shape.

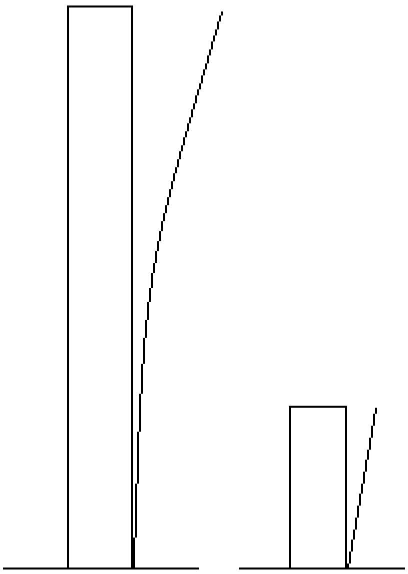


Figure 10: Parabolic (left) and linear (right) mode shape

$$S_L(z,n) = \frac{n \cdot S_v(z,n)}{\sigma_v^2} = \frac{6.8 \cdot f_L(z,n)}{(1+10.2 \cdot f_L(z,n))^{5/3}} \tag{11}$$

$$f_L(z,n) = \frac{n \cdot L(z)}{v_m(z)} \tag{12}$$

$$K_s(n) = \frac{1}{1+\sqrt{(G_y \cdot \varphi_y)^2 + (G_z \cdot \varphi_z)^2 + (\frac{2}{\pi} \cdot G_y \cdot \varphi_y \cdot G_z \cdot \varphi_z)^2}} \tag{13}$$

The values G_y and G_z depend on the mode shape and are found in table C.1 of the Eurocode. In this case the parabolic mode shape is chosen.

$G_y = 1/2$ $\quad$ $G_z = 5/18$

In the report K_s was given the value 1 to be on the safe side.

k_p =3.11 $\quad$ I_v =0.689 $\quad$ B^2 =0.191 $\quad$ R^2 =2.275 $\quad$ (3) gives $c_s c_d$ = 1.32

The calculated $c_s c_d$ factor in the Eurocode is based on the first natural frequency of the building. However, as mentioned earlier, unlike in a typical Dutch high rise building the other natural frequencies are also contributing to the dynamic response of the building. Therefore the factor $c_s c_d$ will be higher and we will assume the factor $c_s c_d$ to be in the order of magnitude of 1.5.

2.2 Force coefficient c_f

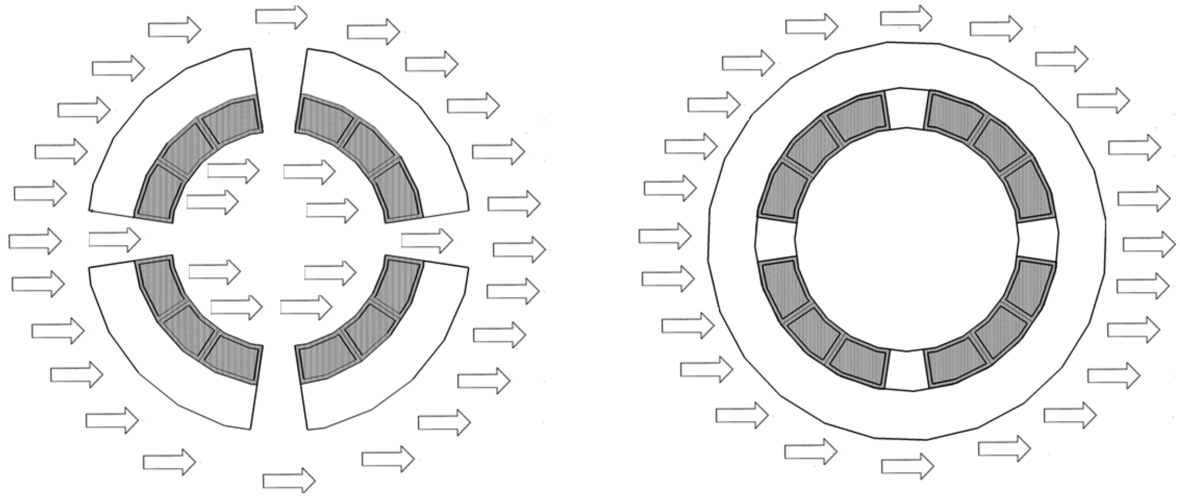


Figure 11: pressure suction and friction due to wind load open footprint (left) closed footprint (right)

c_f is the largest value of the wind load to which the shape is exposed when we consider that the wind can act on the building in any direction.
In the report c_f for a circle has been used (0.84). Due to the open shape of the footprint wind can cause extra pressure, suction and friction in the void. This can result in a larger c_f and has not been taken into account in the calculations. Therefore this factor is unsure and further study is necessary.

2.3 Peak velocity pressure q_p

Values for the extreme wind pressure 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

These values are extrapolated up to a height of 800 meter .This is an assumption which should be examined further. Table 5 shows the extrapolated values for peak velocity pressure q_p

Because the structure has a reference period of 100 years (CC3 see Part 3 appendix B) the wind load is adjusted to a reference period of 100 years using the factor c_{prob} found in NEN-EN 1991-4 4.2 remark 4;

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

$$K = 0,234$$

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

$$n = 0,5$$

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

The values found in Convenanthoogbouw NTA Hoogbouw (03-A) are extrapolated up to a height of 800 meter and multiplied by the factor c_{prob} . The result is shown in Table 5.

Extreme windpressure Area 2 reference period 100 years					
height (m)	**q_p(z)**	**height (m)**	**q_p(z)**	**height (m)**	**q_p(z)**
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 5: peak velocity pressure q_p

2.4 Design wind load

The quasi-static wind load working on the building in kN/m is calculated using (2).

$$Q_w = c_s c_d \cdot c_f \cdot q_p(z_e) \cdot b_{ref} \qquad (2)$$

$c_s c_d$ =1.5
c_f = 0.84
q_p = (see Table 5)
b_{ref} =100

The wind load in kN/m at the top of the structure is 1.5*0.84*2.605*100 = 328.2 kN/m.
The total static wind load working on the building is determined according using Figure 12.

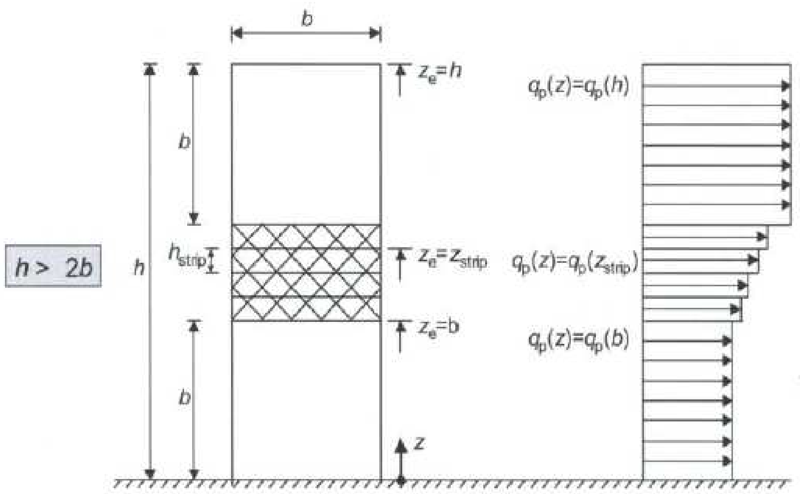


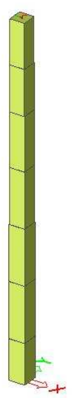
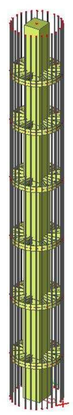
Figure 12: Wind load on building according to NEN-EN 1991-4

0 < Z < 100	q = 218.5 kN/m
100 < Z < 700	q = 218.5–322 kN/m
700 < Z < 800	q = 328.9 kN/m

The difference between this design load and the design load used in the report is a factor 2.3
The effect which this has for the 3 alternatives is discussed in the next paragraph.

2.5 Comparison static wind load of the alternatives

In this chapter the new design load is added to the ESA models of the three alternatives. We will take a look at the deformation of the building as well as the effect which the wind load has on the differential settlements.

1. Core	2. Core-outrigger	3. Diagrid
		

During the structural design firstly the tower was assumed to be full clamped. This was done because the foundation had not yet been designed. The deformation due to the rotational stiffness of the foundation was then included after the rotational stiffness was known. In order to judge the fully clamped tower the assumption was made that the total drift at the tower consists of 50 % deformation due to bending and 50 % deformation due to the rotational

stiffness of the foundation. According to the Eurocode the total drift cannot exceed h/500 which means that the fully clamped alternatives have to satisfy a limit of h/1000.
The values for a tower which is assumed to be fully clamped is given in Table 6.

Alternative	Core	Core-outrigger	Diagrid
Deformation at top (mm)	1490	938	787
Base moment (kNm)	$161.9*10^6$	$125.0*10^6$	$108.2*10^6$

Table 6: Comparison forces and deformation

Diagrid alternative is the only alternative which satisfies the drift limit of h/1000.
The total drift however is the result of the deformation due to the wind load (including the second order effect and rotational stiffness of the foundation) and the deformation due to unequal settlements.
Table 7 shows the deformation of the alternatives when the rotational stiffness of the tower is taken into account. The deformations due to the quasi-static load (including the rotational stiffness of the foundation) of the 800 high meter building for alternative 2 and 3 are within the limits of 1/500 or 1600 mm. It should be noted that that the individual structural elements have not been checked but since deformation is the governing aspect for the structural system of a tall building we expect that the structural elements fulfil the strength requirements.

alternative	Alternative 1 Deformation SLS (mm)	Alternative 2 Deformation SLS (mm)	Alternative 3 Deformation SLS (mm)
Drift clamped tower	1490	938	787
Drift including rotational stiffness (mm)	1788	1126	944

Table 7: drift including rotational stiffness

The concrete in the core-outrigger alternative has better structural damping. Since the dynamic aspects are governing alternative 2 remains the chosen alternative.Table 8 shows the total drift for the core-outrigger alternative which also includes the drift due to the unequal settlements. The unequal settlements are larger due to the increased base moment See appendix A however the drift due to unequal settlements still has a relatively small contribution to the total drift.

Drift	Alternative 2 Deformation SLS (mm)
Drift including rotational stiffness (mm)	1126
Drift due to differential settlements (mm)	74
Total Drift (mm)	1200

Table 8: total drift for alternative 2

Chapter 3 Accelerations due to fluctuations in the upstream wind

Besides having to comply with the comfort demand which limits the deflection, the accelerations in a tall building also have to be kept beneath a certain value.
In a tall building it is not the motion itself but the acceleration which is the cause of discomfort for its inhabitants. This is similar to how a person in a car feels nothing at a constant speed but does feel something when the car accelerates or decelerates.
If the accelerations are too large they can result in insecure or even nauseous inhabitants making the top floors un-rentable.
As mentioned in the problem description, the first natural frequency at 0.05 Hz makes the building very sensitive to wind loading. Also the 2nd and 3rd natural frequencies have to be taken into account when determining the dynamic response.
In this paragraph we will determine the accelerations at the highest occupied floor of the building which is located at 797.8 meter for only the first natural frequency (0.05 Hz) of the building.

The standard deviation of the accelerations due to upstream fluctuating wind for the first natural frequency are calculated according to Annex C.4 of NEN-EN 1991-1-4.

$$\sigma_{a,x}(y,z) = cf \cdot \rho \cdot l_v(z_e) \cdot v_m^2(z_e) \cdot R \frac{K_y \cdot K_z \cdot \Theta(y,z)}{\mu_{ref} \cdot \Theta_{\max}} \qquad (14)$$

Where

c_f is the force coefficient. c_f =0.84
ρ is the air density ρ =1.25 kg/m^3
$I_{v(z_e)}$ is the turbulence intensity at a height z_e above the ground
$v_{m(z_e)}$ is the characteristic mean wind velocity at a height z_e above ground
R is the resonance response factor
K_y and K_z are constants given in C.2.
μ_{ref} reference mass per unit area. μ_{ref} =12813 kg/m^2
$\Theta\ (y,z)$ is the mode shape
Θ_{max} is the mode shape value at the point with maximum amplitude

$\Theta(y,z)/\Theta_{max}$ =1 since the acceleration at the highest occupied floor is calculated

K_y=1 K_z= 5/3 these values correspond to a uniform horizontal mode shape and a parabolic vertical mode shape. See NEN-EN 1991-1-4. C2 table C.1

μ_{ref} is determined according to F.5 (3) of NEN-EN 1991-1-4. According to F.5 (3) a good approximation of μ_{ref} is the mass per unit area at the point of the largest amplitude of the mode shape. The weight at the point with the maximum amplitude of the structure is divided by the area on which the wind force works at that point.

The standard deviation of the characteristic along wind acceleration is multiplied by the peak factor k_p which gives the acceleration at the top of the building. The peak acceleration for alternative 2 are given in Table 9.

Acceleration	Alternative 2 core-outrigger
σ [m/s^2]	0.22
a [m/s^2]	0.68

Table 9 accelerations alternative 2

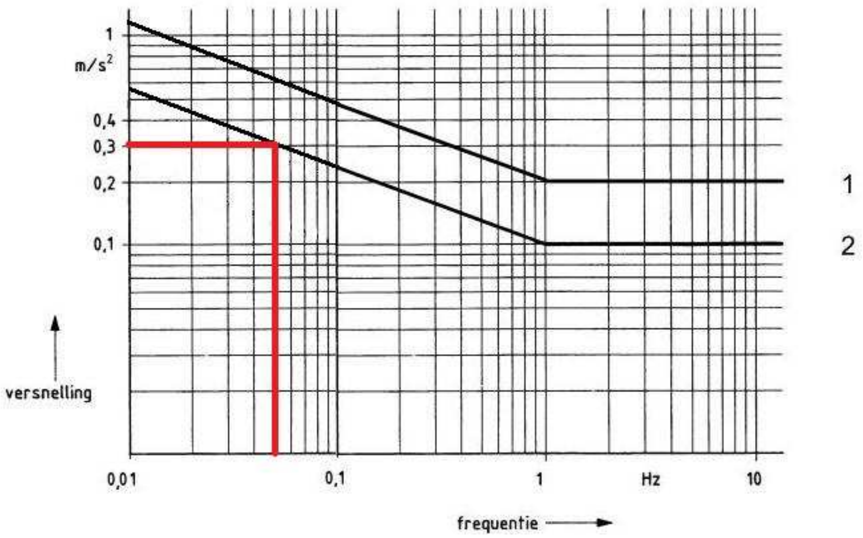


Figure 13 limiting peak accelerations according to NEN 6702

Curve 2 applies to floors with a residential, gathering, health care, hotel sport or commercial function. The acceleration due to upstream wind exceeds the limit value of 0.3 m/s^2 found in Figure 13 by a factor two. Also it should be noted that only the accelerations due to the first natural frequency of the building have been calculated. As mentioned earlier in the problem description the other natural frequencies below 1Hz (see Table 3) also contribute to the dynamic response of the building which results in a larger response.

Conclusion

The building does not satisfy the criteria for accelerations due to first natural frequency and the fluctuating wind and the other contributing natural frequencies have not been taken into account.
Paragraph 3.5.4 of the literature study discusses how the dynamic response of a tall building can be influenced. 4 methods were mentioned, namely:

- Changing its mass.
- Changing its stiffness.
- Increasing its damping.
- Choosing its shape

The shape of the building has already been chosen and changing the mass and stiffness can be very costly if significant improvements are needed. Also they can have adverse effects such as an increase of the jerk component or increased settlements due to a larger load on the foundation.

Increasing the damping can be considered as the last available option and it should be researched if a tuned mass damper would be able to keep the motions of the building within the defined limits. The accelerations (0.68 m/s^2) at the highest occupied floor are however ca 2.5 times as large as the limit of 0.30 m/s^2 found in Figure 13.

This is without taken into consideration the contribution of the 2^{nd} and 3^{rd} frequency to the dynamic response. We expect that the accelerations due to the 2^{nd} and 3^{rd} frequency will increase the value of 0.68 m/s^2 by a factor 2. This would mean that the total accelerations at the highest occupied floor is 1.36 m/s^2 and that the limit is exceeded by a factor 5 Therefore it is unlikely that a TMD can provide the necessary damping to keep the acceleration beneath the limit of 0.30 m/s^2.

Chapter 4 Vortex shedding

Vortex excitation is one of the critical phenomena that affects tall slender towers.
Tall buildings are bluff bodies which cause the flow to detach from the structure instead of following the contour of the building. When this happens vortices are shed which cause a periodically alternating force perpendicular to the wind direction (see Figure 14).

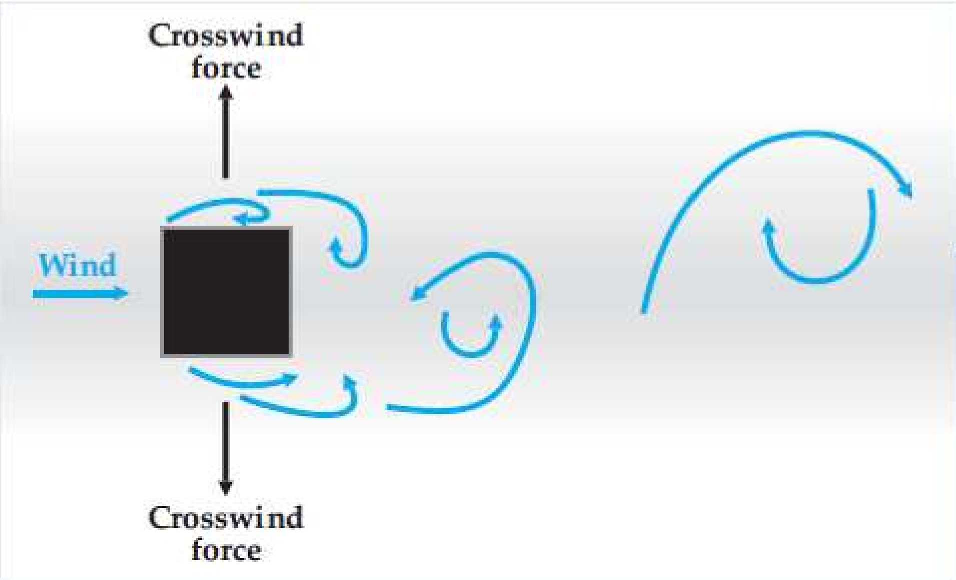


Figure 14: vortex shedding phenomenon

Whether vortex shedding becomes a problem for the building is dependent on two frequencies, namely:

- The fundamental frequency of vibration the building
- The frequency at with which the vortices are shed

When these two frequencies are equal resonance occurs. The forces due to the shedding of vortices then shake the building at its most vulnerable frequency which results in large across-wind vibrations.
The critical wind velocity v_{crit} is defined as the wind velocity at which the frequency of the vortex shedding equals a natural frequency of the building.

The Eurocode state that vortex shedding does not have to be examined if;

$v_{crit} > 1.25\ v_{m.}$

We will calculate if vortex shedding needs to be examined for a closed cylinder.

$$v_{crit} = \frac{b \cdot n_{1,y}}{Str} \qquad (15)$$

Where,

Str is the strouhal number which is 0.18 for a circle (See NEN-EN 1991-1-4 Table E.1)
B is the reference width of the cross-section at which the resonant vortex shedding occurs and where the modal deflection is maximal for the building (100 m).
$n_{1,y}$ is the natural frequency of the structure (0.05 Hz)

$$v_{crit} = \frac{b \cdot n_{1,y}}{Str} = \frac{100 \cdot 0.05}{0.18} = 27,8$$

v_m is calculated using (4.3.1(1)) [2] of NEN-EN 1991-1-4

$$v_b(z) = c_{dir} \cdot c_{season} \cdot v_{b,0} = 27$$

$$v_m(z) = c_r(z) \cdot c_o(z) \cdot v_b = 1.45*27=39.17$$

$v_{crit} > 1,25\ v_m$

27.8 < 48.96

This means that vortex shedding needs to be examined for 800 meter high closed cylinder.

Correlation length

Vortex shedding is a problem when it occurs along a large part of the buildings height. In NEN-EN 1991-1-4 E 1.5.2.3 figures are given to determine the correlation length. The correlation length defines the length at which the vortices are correlated across the height of the building.

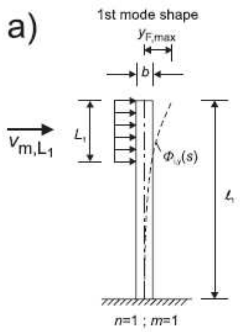


Figure 15: correlation length NEN-EN 1991-1-4 E 1.5.2.3

$Y_{F(sj)}/b$	L_j/b
<0.1	6
0.1 to 0.6	$4.8+12 * Y_{F(sj)}/b$
>0.6	12

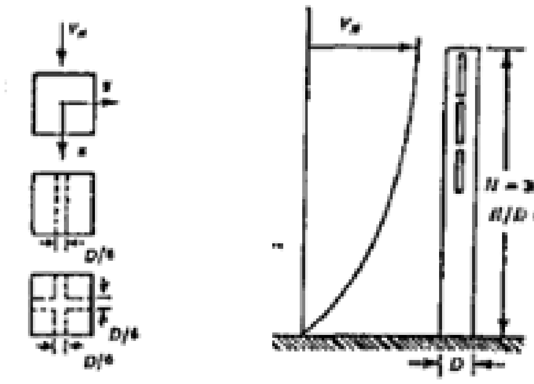
Table 10: correlation length

Table E.4 shows that in the first mode shape our building with b=100 has a correlation length ranging from 600-800 meter. This means that a vortices are shed across a large part of the building.

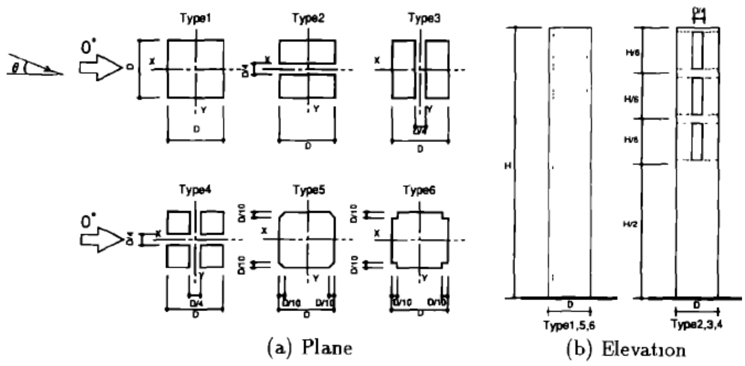
Mitigating measures

Because vortex shedding is a serious problem the structural engineer should try to mitigate the vortex shedding process.

Reduction of the vortex shedding can be achieved in the following ways
- Confusing the vortex shedding by changing the cross-section of the tower along the height of the building. Changing the cross-section changes the frequency at which the vortices are shed. If vortices aren't shed across a large part of the structure the alternating forces are small.
- Disrupting the vortex shedding process by allowing the wind to bleed through slots. The slots also allow the wind to bleed through the building which disrupts the vortices. Studies [27][34][57] have shown that this method is very efficient in mitigating vortex shedding . For a detailed description of the experiments and the results see appendix A.



[34]



[57]

Figure 16: Setup for experiments with voids and slots

Conclusion

Vortex shedding for a closed cylinder with a height of 800 meter would take place along a large part of the buildings height. (600-800 meter). This is a serious problem for tall slender buildings with a constant footprint and was recognized early in the design which led to the chosen vortex reducing shape with slots and a void. Experiments and research have shown that the addition of slots can result in a significant reduction of the forces and deformation due to vortex shedding.

Chapter 5 Conclusion

In this thesis an attempt was made to find the limits of a skyscraper in the Netherlands and examine if it is structurally possible to build supertalls as seen in foreign countries.
There is large difference in height between high-rise buildings in the Netherlands and high-rise in other continents such as North America and Asia. The tallest building in the Netherlands, the "Maastoren", has a height of 164.75 meter whereas in the rest of the world buildings with a height of more than 300 meter are not uncommon. In Dubai the Burj Khalifa has even reached a height of 828 meter. Figure 17 illustrates the difference in height between high-rise in the Netherlands and the rest of the world.

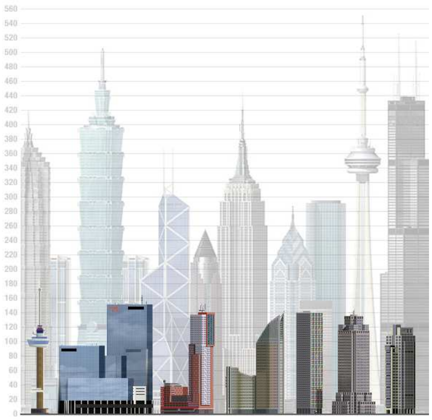


Figure 17: Dutch versus foreign high-rise buildings

Each high-rise project is unique and depends on the many conditions which influence the choices made in the design of a tall building. Examples of such conditions are the wind climate, the characteristics of the subsoil and culture. Because of this the following question was asked:

"*Is it technically possible to achieve similar heights (as found in foreign countries) in the Netherlands*?"

In order to answer this question the goal was to deliver a structural design for an 800 meter high tower. Three structural alternatives were chosen and tested using ESA Scia Engineer and the Dutch building code, namely:

- core
- core-outrigger
- diagrid

It was found that the deformations due to the quasi-static load of the 800 high meter building for alternative core-outrigger system and diagrid are still within the limits of 1/500 or 1600 mm.
However, the accelerations at the top of the building become very large and do not satisfy the criteria concerning accelerations in NEN 6702. It should be noted that in this addendum only the accelerations due to the first natural frequency have been calculated. As mentioned in the problem description the other natural frequencies also contribute to the dynamic response of the building which results into an even larger dynamic response .
It is still unlikely that a tuned mass damper or a tuned liquid columns damper is able to keep the accelerations below the limit of 0.30 m/s^2 at the highest occupied floor.

It has been shown that vortex shedding for a closed cylinder with a height of 800 meter would take place along a large part of the buildings height, namely 600 to 800 meter. The importance of the vortex shedding phenomenon was recognized early in the design and led to the addition of slots which disrupt the vortex shedding process.

Therefore, the conclusion is that designed 800 meter building does not satisfy the criteria concerning accelerations at the highest occupied floor.
Even with a tuned mass damper it is unlikely that the accelerations due to the upstream fluctuating wind of the 800 meter building can be kept within the limits of Figure 13.
When the designing a tall building it is recommended to avoid the natural frequencies in the range where the gust have the most energy (0.01-0.5 Hz). By avoiding these frequencies the dynamic response is reduced.

Whether heights as seen in foreign countries are possible in the Netherlands requires some explaining. If we want to make a fair comparison between our tower and the supertalls in foreign countries we need to consider not only the height of the buildings but also the slenderness and shape of the buildings which are influenced by the rules regarding daylight-entry.

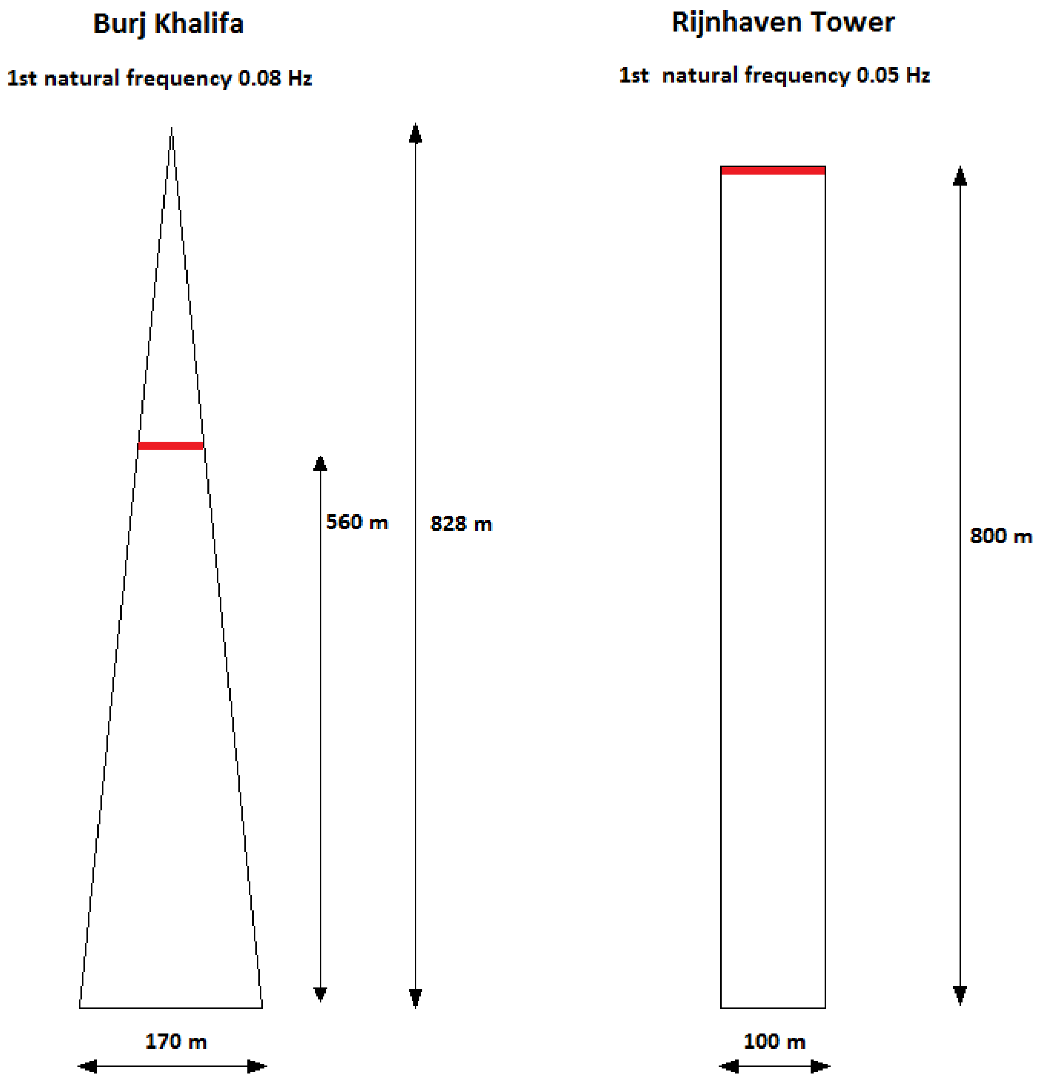


Figure 18: comparison Burj Khalifa and Rijnhaven Tower

Figure 18 shows a comparison of the Rijnhaven tower and the Burj Khalifa which at the time of writing this thesis is the highest building in the world. The figure shows the dimensions, first natural frequency and the location of the highest occupied floor (red).

Chapter 2, 3 and 4 show that the governing aspect with respect to wind for our tower is the peak accelerations at the highest occupied floor. This aspect is greatly influenced by two variables, namely:

- the first natural frequency of the building
- the height of the highest occupied building

The difference between a low and high first natural frequency is mentioned in the problem description and chapter 3. A first natural frequency located close to the frequency where the gust have the most energy in addition to several other contributing frequencies can result in a significant dynamic response. This is shown in Figure 4(c) and Figure 5(c) where the area under the dynamic response is the standard deviation of the accelerations which is calculated in chapter 3 for the first natural frequency of the building.

Formula (14) includes the mode shape. In case of the the Rijnhaven Tower, $\Theta(y,z)/\Theta_{max}=1$ since the acceleration at the highest occupied floor is located at the top of the building. If a tower has a spire or tapered shape the highest occupied floor is not located at the top where the largest accelerations occur.

There are 3 differences which should be taken into consideration when we compare Dutch high-rise buildings to foreign high-rise buildings, namely:

- The way in which the height of a building is measured
- The shape of the building
- The limitations due to daylight entry

These differences all have a large influence on the dynamic response.

Measuring method

The Council of Tall Building and Urban Habitat (CTBUH) created three categories for determining a buildings height, namely:

1. height to architectural top
2. highest occupied floor
3. height to tip

In this thesis the second criterion of the CTBUH to determine the height of a building was used. This means that we start measuring from the buildings lowest significant open-air-entrance to the highest occupied floor. If we judge the Burj khalifa and Nakheel Tower according to this criterion their respective heights will be ca. 550 meter and 676 meter. This means that an occupied floor at a height of 800 meter has not yet been reached. And that for these buildings $\Theta(y,z)/\Theta_{max}<1$ resulting in a smaller accelerations than would be the case if the highest occupied floor would be located at the top.
This makes a large difference in the structural response of the building.

Shape of the building - Tapering

Many of the aforementioned foreign (proposed) tall buildings have a tapering shape with either spires or antennas on top.
As a tapered building gets higher, practical minimal floor sizes limit the location of the highest occupied floor. The Burj Khalifa (828 meter) [20] for example has a spire which is over 200 meter high and the Nakheel Towers (1000 meter) spire [27] has the same height as the Eiffel tower. According to [4] a highest occupied floor at 800-1000 meter can require a 1600 meter high tapered structure.

The advantages of a tapered shape are:

- a large base and a tapered shape result in a higher first natural frequency
- the fact that the quasi-static wind load is reduced due to a smaller reference area

As mentioned in the problems description a higher first frequency results in a smaller dynamic response.

daylight entry -Slenderness

In the Netherlands the rules concerning daylight-entry are more strict than in foreign countries The former World Trade Centre for example had a footprint of 63.4 by 63.4 meter and with a height of 417 and 415 meters the slenderness was 1:6.6. Because of their large floor areas, the twin towers had office spaces which were never reached by natural daylight. Such a structure is not possible in Holland because the slenderness is limited by the fact that Arbo laws forbid office spaces which lack the entry of natural daylight.
Daylight entry is a non-structural limiting factor which has an influence on the slenderness of a tall building. This means that even though it could be structurally possible to build a tall building the Dutch building code does not allow it.

This means that even though it might structurally possible to achieve heights as seen in foreign countries that the slenderness and shape of the building will be limited by the daylight entry rules in the Dutch building code.

Bibliography

[1] Woudenberg, I.A.R, *Wind belasting en het hoogbouw ontwerp*, cement 2006

[2] Holmes, J., *Wind loading on structures*,

[3] NEN-EN 1991-1-4 *Wind actions*

[4] Baker B., *supertalls the next generation*, CTBUH 2010 world conference – India

[27] Mitcheson-Low M., Rahimian A.,O'Brien, D. *,Case study Nakheel tower the vertical city* ,CTBUH journal 2009 issue 2

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

[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

A:Effect increased wind loads on unequal settlements

Because the quasi-static wind load is increased by a factor 2.3 the unequal settlements due to the wind will increase.

The same procedure which is found in Part2: Structural Design chapter 5.6.2 and Appendix J is used to calculate the new unequal settlements.

Unequal settlements

M= 84.1 * 10^6 kNm
V = 220.7 * 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).

84.1 * 10^6 + 220.7 * 10^3 * 21 = 88.7 * 10^6 kNm

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.

$$F_{res} = \frac{88,7 \cdot 10^6}{(2 \cdot 0,589 \cdot 70)} = 1075673 \text{ kN}$$

And

$$\sigma_{\max} = \frac{F_{res}}{\frac{1}{4} \cdot \pi \cdot 70^2} = 280 kN/m^2$$

All the values necessary to calculate the settlements are given in Table 11

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 11 Stress increase and maximum stress value

The differential settlements due to the wind load are given in Table 12 (for more details see appendix J).

layer	C_p	d	$\sigma'_{v;z;0}$ (kPa)	$\Delta\sigma'_{v;z}$ (kPa)	w1 (m)	w2 (m)
5	2000	17	1313.5	280	0.00164	-0.00204
6	∞	1	1351	280	0.00000	0.00000
7	3000	3	1363	280	0.00019	-0.00023
8	∞	5	1399.5	280	0.00000	0.00000
9	3000	4	1449	280	0.00024	-0.00029
10	∞	4	1493	280	0.00000	0.00000
11	3000	2	1486	268.8	0.00011	-0.00013
12	∞	3	1495.6	260.4	0.00000	0.00000
13	900	7	1527.8	254.8	0.00120	-0.00142
14	∞	1	1524.4	245	0.00000	0.00000
15	400	7	1481.6	231	0.00254	-0.00297
Total					0.00591	-0.00707

Table 12 Soil layer Settlements

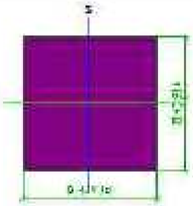
$W_{1,d}$ compression = 5.9 mm
$W_{1,d}$ tension = 7.1 mm
$\Delta W_{1,d}$ = 13.0 mm
Rotation = $9.3 * 10^{-5}$ rad
This gives a deformation of $4 * 10^{-5} * 800000 = 74$ mm at the top of the building.

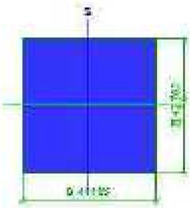
B:ESA Output

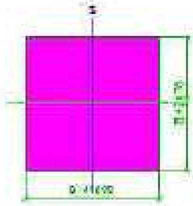
Alternative 1: core

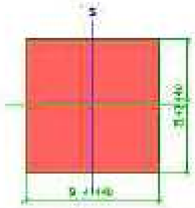
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

1. Doorsneden

Naam	CS3	
Type	Rechthoek	
Uitgebreid	43916; 43916	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
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	x	
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	

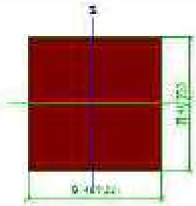
Naam	CS5	
Type	Rechthoek	
Uitgebreid	42078; 42078	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		
A [m²]	1,7706e+03	
A y, z [m²]	1,4755e+03	1,4755e+03
I y, z [m⁴]	2,6124e+05	2,6124e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,4076e+05
Wel y, z [m³]	1,2417e+04	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	x	
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	

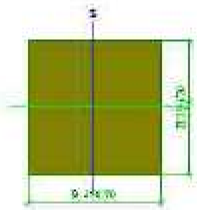
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

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



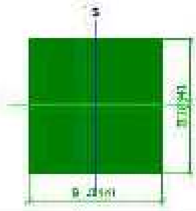
A [m^2]	1,6592e+03	
A y, z [m^2]	1,3826e+03	1,3826e+03
I y, z [m^4]	2,2941e+05	2,2941e+05
I w [m^6], t [m^4]	0,0000e+00	3,8705e+05
Wel y, z [m^3]	1,1264e+04	1,1264e+04
Wpl y, z [m^3]	1,6896e+04	1,6896e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20367	20367
alpha [deg]	0,00	
AL [m^2/m]	1,6293e+02	

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



A [m^2]	1,5737e+03	
A y, z [m^2]	1,3114e+03	1,3114e+03
I y, z [m^4]	2,0638e+05	2,0638e+05
I w [m^6], t [m^4]	0,0000e+00	3,4820e+05
Wel y, z [m^3]	1,0405e+04	1,0405e+04
Wpl y, z [m^3]	1,5607e+04	1,5607e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	19835	19835
alpha [deg]	0,00	
AL [m^2/m]	1,5868e+02	

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



A [m^2]	1,5164e+03	
A y, z [m^2]	1,2637e+03	1,2637e+03
I y, z [m^4]	1,9162e+05	1,9162e+05
I w [m^6], t [m^4]	0,0000e+00	3,2331e+05
Wel y, z [m^3]	9,8417e+03	9,8417e+03
Wpl y, z [m^3]	1,4763e+04	1,4763e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	19471	19471
alpha [deg]	0,00	
AL [m^2/m]	1,5576e+02	

2. Materialen

Naam	S235
Type	Staal
Thermisch uitz. [m/mK]	0,00
Massa eenheid [kg/m^3]	7850,00
E-mod [MPa]	2,1000e+05
Poisson - nu	0,3
Onafhankelijke G-modulus	x
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/m^3]	2500,00
E-mod [MPa]	3,8500e+04
Poisson - nu	0,2

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Onafhankelijke G-modulus	×
G-mod [MPa]	1,8042e+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]	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

NEMETSCHEK Scia	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	-218,50	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		1,000	Lengte	
Lijnlast2	S691	Kracht	Z	-218,50	0,000	Abso	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		7,900	Lengte	
Lijnlast3	S1188	Kracht	Z	-328,90	2,200	Abso	Vanaf begin
	BG3 - wind	LCS	Gelijkmatig		102,200	Lengte	
Lijnlast4	S691	Kracht	Z	-218,50	7,900	Abso	Vanaf begin
	BG3 - wind	LCS	Trapez	-238,99	126,700	Lengte	
Lijnlast5	S940	Kracht	Z	-238,99	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-260,84	1,000	Lengte	
Lijnlast6	S1101	Kracht	Z	-260,84	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-282,72	1,000	Lengte	
Lijnlast7	S1106	Kracht	Z	-282,72	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-304,52	1,000	Lengte	
Lijnlast8	S1159	Kracht	Z	-304,52	0,000	Rela	Vanaf begin
	BG3 - wind	LCS	Trapez	-321,95	1,000	Lengte	
Lijnlast9	S1188	Kracht	Z	-321,95	0,000	Abso	Vanaf begin
	BG3 - wind	LCS	Trapez	-322,00	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	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast18	S1159	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast19	S1106	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast20	S1101	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast21	S691	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast22	S940	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	
Lijnlast23	S1189	Kracht	Z	-13207,00	0,000	Rela	Vanaf begin
	BG1 - self weight	GCS	Trapez	-13207,00	1,000	Lengte	

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**	197446,46	**0,00**	-75145347,07	**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	**217570,32**	0,00	**-94256873,47**	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	**326355,49**	0,00	**-141385302,02**	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**	296169,70	**0,00**	-112718020,61	**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	**217570,32**	0,00	**-94256873,47**	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**	197446,46	**0,00**	-75145347,07	**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	**-14867328,00**	**0,00**	**330881,63**	**0,00**	**-161940127,74**	**0,01**
S1188	combi1	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S691	combi1	0,000	-13159333,89	**0,00**	321384,00	0,00	-132201996,29	**-0,98**
S940	combi1	0,000	-10809934,85	0,00	292063,94	**0,00**	-93522591,74	0,01

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	**-12029692,93**	0,00	**221231,95**	**0,00**	**-107290394,62**	**0,01**
S1188	combi2	102,200	**0,00**	0,00	**0,00**	0,00	**0,00**	0,00
S1189	combi2	46,050	-11338817,54	**0,00**	214874,18	0,00	-97243136,00	0,01
S940	combi2	0,000	-8746959,87	**0,00**	193930,43	**0,00**	-61833531,39	**-0,46**

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**	-28,0	**0,0**	0,6	**0,0**
BG3	S1188	102,200	0,0	0,0	**-1265,8**	0,0	**2,2**	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	**-1898,7**	0,0	**3,3**	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**	-42,0	**0,0**	0,9	**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	**-1265,8**	0,0	**2,2**	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**	-28,0	**0,0**	0,6	**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	-75,3	0,0	-2252,1	0,0	3,9	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	-48,4	0,0	1,0	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	-61,1	0,0	-1489,4	0,0	2,6	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	-32,1	0,0	0,7	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	-217570,32	0,00	12029382,66	0,00	-94256873,47	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	-217570,32	0,00	0,00	0,00	-94256873,47	0,00

Centraalpunt:

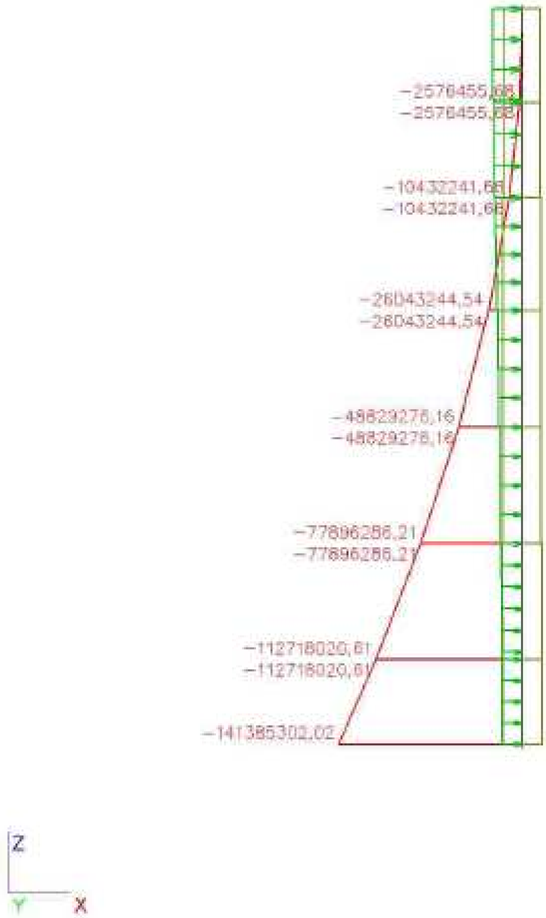
X [m]	Y [m]	Z [m]
0,000	0,000	0,000

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

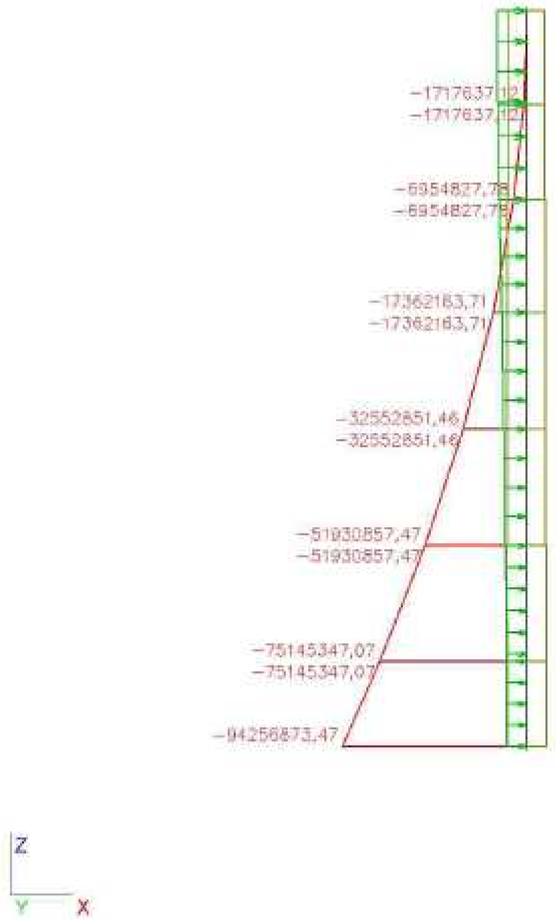
NEMETSCHEK Scia	**Project**	Outrigger Stijfheid
	Onderdeel	- -
	Omschrijving	-
	Auteur	wtu

27. UGT Linear



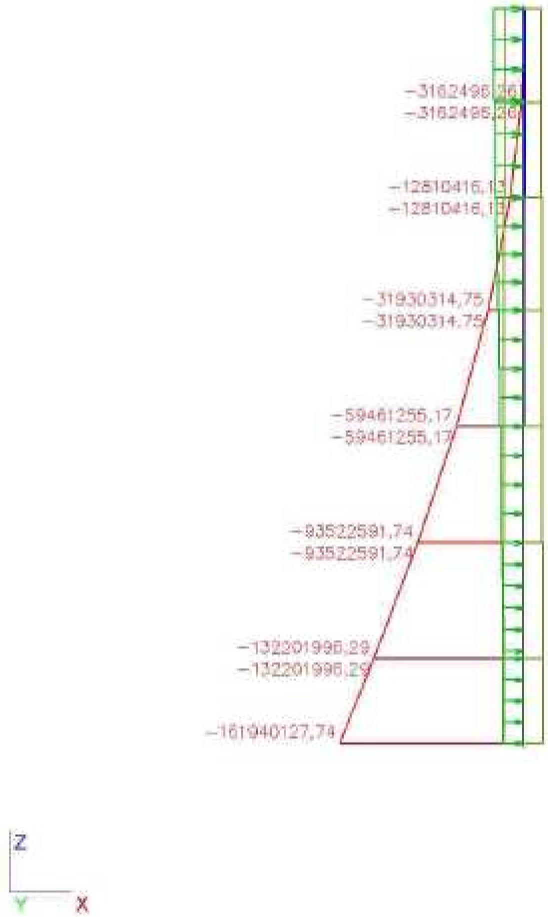
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

28. BGT linear



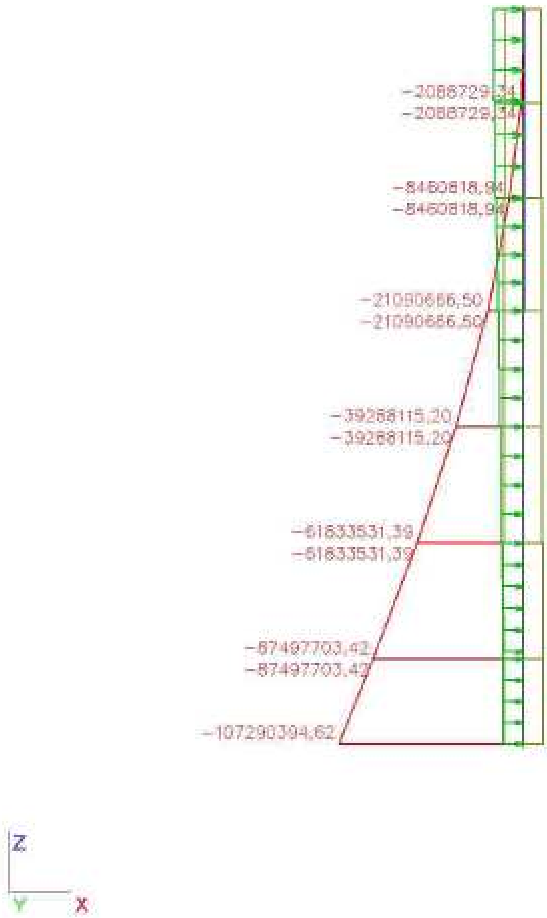
Project	Outrigger Stijfheid
Onderdeel	- -
Omschrijving	-
Auteur	wtu

29. UGT non linear



Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

30. BGT non linear

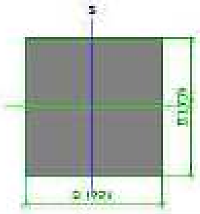


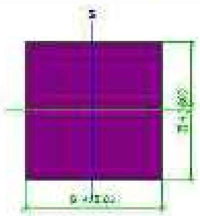
Alternative 2: Core-outrigger

NEMETSCHEK Scia

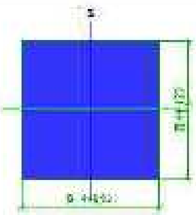
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

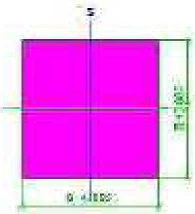
1. Doorsneden

Naam	CS1	
Type	Rechthoek	
Uitgebreid	1770; 1770	
Onderdeelmateriaal	Emod44000	
Bouwwijze	beton	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		
A [m^2]	3,1329e+00	
A y, z [m^2]	2,6108e+00	2,6108e+00
I y, z [m^4]	8,1792e-01	8,1792e-01
I w [m^6], t [m^4]	0,0000e+00	1,3800e+00
Wel y, z [m^3]	9,2421e-01	9,2421e-01
Wpl y, z [m^3]	1,3863e+00	1,3863e+00
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	885	885
alpha [deg]	0,00	
AL [m^2/m]	7,0800e+00	

Naam	CS3	
Type	Rechthoek	
Uitgebreid	45803; 45803	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		
A [m^2]	2,0979e+03	
A y, z [m^2]	1,4236e+03	1,4236e+03
I y, z [m^4]	3,6677e+05	3,6677e+05
I w [m^6], t [m^4]	0,0000e+00	2,8493e+05
Wel y, z [m^3]	1,6015e+04	1,6015e+04
Wpl y, z [m^3]	2,4023e+04	2,4023e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22902	22902
alpha [deg]	0,00	
AL [m^2/m]	1,8321e+02	

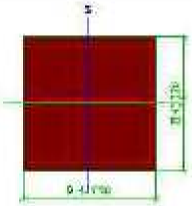
Naam	CS4	
Type	Rechthoek	

Uitgebreid	44623; 44623	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		
A [m^2]	1,9912e+03	
A y, z [m^2]	1,6593e+03	1,6593e+03
I y, z [m^4]	3,3041e+05	3,3041e+05
I w [m^6], t [m^4]	0,0000e+00	5,5747e+05
Wel y, z [m^3]	1,4809e+04	1,4809e+04
Wpl y, z [m^3]	2,2213e+04	2,2213e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22312	22312
alpha [deg]	0,00	
AL [m^2/m]	1,7849e+02	

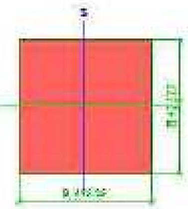
Naam	CS5	
Type	Rechthoek	
Uitgebreid	43885; 43885	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		
A [m^2]	1,9259e+03	
A y, z [m^2]	1,6049e+03	1,6049e+03
I y, z [m^4]	3,0909e+05	3,0909e+05
I w [m^6], t [m^4]	0,0000e+00	5,2149e+05
Wel y, z [m^3]	1,4086e+04	1,4086e+04
Wpl y, z [m^3]	2,1129e+04	2,1129e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21943	21943
alpha [deg]	0,00	
AL [m^2/m]	1,7554e+02	

Naam	CS7	
Type	Rechthoek	
Uitgebreid	43220; 43220	
Onderdeelmateriaal	Emod44000	

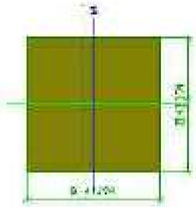
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

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

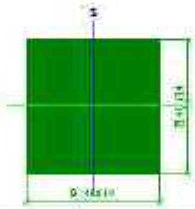
A [m²]	1,8680e+03	
A y, z [m²]	1,5566e+03	1,5566e+03
I y, z [m⁴]	2,9078e+05	2,9078e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,9060e+05
Wel y, z [m³]	1,3456e+04	1,3456e+04
Wpl y, z [m³]	2,0183e+04	2,0183e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21610	21610
alpha [deg]	0,00	
AL [m²/m]	1,7288e+02	

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

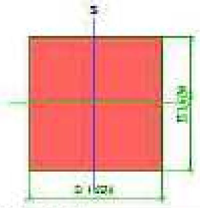
Naam	CS9	
Type	Rechthoek	
Uitgebreid	40614; 40614	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		

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	x	

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

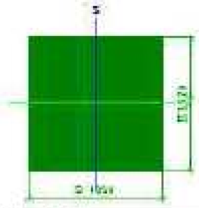
Afbeelding



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	x	

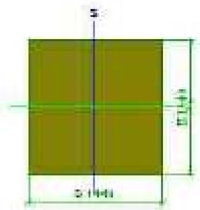
Afbeelding



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	x	

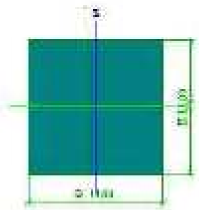
Afbeelding



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	x	

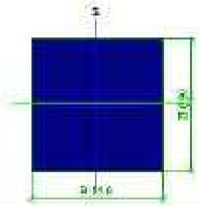
Afbeelding



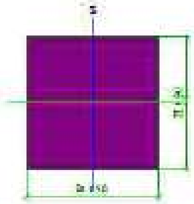
A [m²]	1,2100e+00	
A y, z [m²]	1,0083e+00	1,0083e+00
I y, z [m⁴]	1,2201e-01	1,2201e-01
I w [m⁶], t [m⁴]	0,0000e+00	2,0585e-01
Wel y, z [m³]	2,2183e-01	2,2183e-01
Wpl y, z [m³]	3,3275e-01	3,3275e-01
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	550	550
alpha [deg]	0,00	
AL [m²/m]	4,4000e+00	

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

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	x	
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	x
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	x
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	x
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)	x

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)	x

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	**-20964,37**	0,00	0,00	0,00	0,00	0,00
S387	BG3	0,000	**20964,38**	0,00	0,00	0,00	0,00	0,00
S769	BG3	0,000	-1073,43	**-123,88**	-35,34	-44,97	212,67	644,30
S776	BG3	0,000	1073,77	**123,93**	35,36	44,97	-212,98	-644,21
S777	BG3	0,000	1322,53	-114,36	**-53,33**	-31,63	282,89	586,14
S1189	BG3	0,000	0,92	-0,02	**217571,10**	38,09	**-79949668,35**	-8,10
S1554	BG3	0,000	737,15	122,15	-7,51	**-154,63**	75,06	**-816,74**
S1562	BG3	0,000	736,40	-122,63	-7,57	**155,54**	75,33	819,73
S1566	BG3	0,000	3610,96	-5,91	-44,13	21,77	**478,40**	5,98
S1561	BG3	0,000	-736,60	-122,88	7,51	154,24	-75,22	**821,75**

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/2	0,000	**-16762150,91**	-1,11	**326357,50**	89,55	**-119924695,04**	102,73
S1747	UGT/2	0,000	**25825,32**	-16,39	-141,45	-8,43	1598,40	116,78
S1885	UGT/2	0,000	-545,27	**-452,17**	160,43	234,82	-841,10	2441,22
S1912	UGT/2	0,000	-546,04	**452,39**	-160,36	-234,77	850,48	-2327,49
S1937	UGT/2	0,000	2479,73	188,65	**-199,40**	-115,21	1054,21	-1094,45
S1586	UGT/2	0,000	11890,14	201,41	59,42	**-304,84**	63,60	-1274,33

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1594	UGT/2	0,000	11892,70	-200,85	59,58	**304,40**	62,91	1271,79
S1754	UGT/2	0,000	25825,30	16,44	-141,45	8,39	**1598,41**	-117,22
S1905	UGT/2	10,545	-1068,70	-425,06	156,21	261,44	845,87	**-2334,53**
S1912	UGT/2	10,545	-546,04	452,39	-160,36	-234,77	-840,50	**2443,01**

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/1	0,000	**-13545973,76**	-0,87	**217571,76**	63,70	**-79949815,81**	82,50
S1747	BGT/1	0,000	**19291,13**	-11,77	-105,04	-11,00	1193,56	88,11
S1885	BGT/1	0,000	-88,52	**-335,18**	119,91	173,00	-631,18	1801,95
S1912	BGT/1	0,000	-88,98	**335,32**	-119,86	-172,96	633,12	-1732,87
S1937	BGT/1	0,000	2211,50	134,25	**-149,11**	-77,58	782,15	-780,43
S1586	BGT/1	0,000	9238,41	139,45	47,75	**-214,12**	39,72	-876,53
S1594	BGT/1	0,000	9240,27	-139,03	47,87	**213,89**	39,21	874,73
S1754	BGT/1	0,000	19291,12	11,80	-105,04	10,97	**1193,56**	-88,36
S1905	BGT/1	10,545	-437,39	-317,10	117,09	190,74	630,04	**-1737,56**
S1912	BGT/1	10,545	-88,98	335,32	-119,86	-172,96	-630,77	**1803,11**

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	**-16762070,02**	-1,09	**330278,46**	107,82	**-125026648,06**	104,54
S1754	NLCombi1	0,000	**26280,60**	16,31	-144,20	6,18	**1626,60**	-112,58
S1885	NLCombi1	0,000	-696,25	**-455,51**	170,54	232,21	-890,81	2464,42
S1912	NLCombi1	0,000	-696,76	**455,67**	-170,47	-232,16	907,34	-2339,15
S1937	NLCombi1	0,000	2365,22	183,38	**-200,48**	-107,07	1065,56	-1061,08
S1586	NLCombi1	0,000	11945,20	206,66	59,96	**-308,92**	64,91	-1309,90
S1594	NLCombi1	0,000	11947,15	-206,18	60,10	**308,85**	64,32	1307,97
S1905	NLCombi1	10,545	-1245,74	-425,87	152,69	261,55	830,77	**-2344,06**
S1912	NLCombi1	10,545	-696,76	455,67	-170,47	-232,16	-890,27	**2465,75**

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	**-13545922,56**	-0,86	**220738,03**	77,96	**-84057399,30**	83,92
S1754	NLCombi2	0,000	**19658,38**	11,71	-107,26	9,19	1216,28	-84,81
S1885	NLCombi2	0,000	-208,40	**-338,17**	127,77	171,28	-669,84	1822,11
S1912	NLCombi2	0,000	-208,66	**338,26**	-127,72	-171,24	677,33	-1743,98
S1937	NLCombi2	0,000	2120,29	130,49	**-150,09**	-71,63	791,78	-756,38
S1586	NLCombi2	0,000	9282,56	143,75	48,16	**-217,69**	40,82	-905,66

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

Staaf	BG	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
S1594	NLCombi2	0,000	9283,95	-143,40	48,26	**217,74**	40,39	904,32
S1747	NLCombi2	0,000	19658,37	-11,71	-107,26	-9,19	**1216,29**	84,82
S1905	NLCombi2	10,545	-578,28	-318,14	114,50	191,14	619,08	**-1747,13**
S1912	NLCombi2	10,545	-208,66	338,26	-127,72	-171,24	-669,48	**1822,91**

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	**-868,8**	0,0	-10,6	0,0	-1,4	0,0
BG3	S1463	0,000	**868,8**	0,0	10,6	0,0	1,4	0,0
BG3	S1472	7,500	0,0	**-868,8**	70,0	1,4	0,0	0,0
BG3	S1460	0,000	-131,4	**858,8**	0,0	**-1,5**	-0,2	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	S1163	102,200	-70,0	0,0	**-868,8**	0,0	1,5	0,0
BG3	S1845	17,250	-473,5	-111,3	**555,9**	0,2	-1,4	-0,2
BG3	S1445	0,000	131,4	-858,8	0,0	**1,5**	0,2	0,0
BG3	S1453	0,000	-858,8	-131,4	0,0	0,2	**-1,5**	0,0
BG3	S1124	123,000	47,1	0,6	-565,6	0,0	**1,6**	0,0
BG3	S2321	15,988	68,2	-712,2	-183,4	0,9	0,4	**-1,1**
BG3	S2326	0,000	-68,2	-712,2	-183,4	0,9	-0,4	**1,1**

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/2	S1481	0,000	**-1303,2**	0,0	-154,2	-1,5	-2,5	0,0
UGT/2	S1463	0,000	**1303,2**	0,0	-122,5	-1,5	1,7	0,0
UGT/2	S1472	7,500	0,0	**-1303,2**	-31,7	0,6	0,0	0,0
UGT/2	S1461	18,589	197,2	**1288,2**	-98,7	-2,2	1,4	0,0
UGT/2	S1167	102,200	-218,5	0,0	**-1303,2**	0,0	2,0	-0,3
UGT/2	S1845	17,250	-786,9	-167,6	**751,6**	0,4	-1,8	-0,4
UGT/2	S1496	0,000	552,6	1180,2	-231,7	**-3,5**	0,6	0,0
UGT/2	S1494	0,000	0,0	-1303,2	-243,3	**3,6**	-0,4	0,0
UGT/2	S1830	17,250	-637,6	-162,9	-871,4	0,2	**-3,0**	0,2
UGT/2	S1492	6,196	1288,2	-197,2	-220,5	0,2	**3,7**	0,0
UGT/2	S2321	15,988	17,7	-1070,5	-349,1	1,7	0,4	**-1,9**
UGT/2	S2326	0,000	-17,7	-1070,5	-349,1	1,7	-0,4	**1,9**

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/1	S1481	0,000	**-868,8**	0,0	-120,5	-1,2	-1,7	0,0
BGT/1	S1463	15,000	**868,8**	0,0	-120,5	-1,2	1,7	0,0
BGT/1	S1472	7,500	0,0	**-868,8**	-38,7	0,2	0,0	0,0
BGT/1	S1461	29,742	131,4	**858,8**	-92,1	-1,5	1,4	0,0
BGT/1	S1160	102,200	-164,0	0,0	**-868,8**	0,0	1,3	0,2
BGT/1	S1845	17,250	-534,7	-111,8	**490,3**	0,3	-1,1	-0,3
BGT/1	S1496	0,000	368,4	786,8	-172,7	**-2,5**	0,4	0,0
BGT/1	S1490	0,000	215,9	-841,5	-177,9	**2,6**	0,1	0,0
BGT/1	S1830	17,250	-415,4	-108,6	-590,8	0,2	**-2,1**	0,2
BGT/1	S1492	6,196	858,8	-131,4	-163,6	0,1	**2,6**	0,0
BGT/1	S2321	15,988	0,7	-713,9	-242,4	1,1	0,3	**-1,3**
BGT/1	S2326	0,000	-0,7	-713,9	-242,4	1,1	-0,3	**1,3**

18. Vervormingen van staaf

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

Project	Outrigger Stijfheid
Onderdeel	- .
Omschrijving	-
Auteur	wtu

BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
NLCombi1	S1481	0,000	**-1375,2**	0,0	-154,9	-1,5	-2,7	0,0
NLCombi1	S1463	7,500	**1375,2**	0,0	-136,5	-1,5	2,2	0,0
NLCombi1	S1472	0,000	0,0	**-1375,1**	-29,1	0,7	-0,5	0,0
NLCombi1	S1460	29,742	-208,1	**1359,2**	-98,7	-2,1	1,1	0,0
NLCombi1	S1167	88,323	-221,2	4,3	**-1383,3**	0,0	-0,2	-0,3
NLCombi1	S1845	17,250	-825,5	-177,0	**797,7**	0,4	-1,9	-0,4
NLCombi1	S1496	0,000	583,2	1245,1	-238,2	**-3,6**	0,7	0,0
NLCombi1	S1494	0,000	0,0	-1374,8	-251,0	**3,7**	-0,4	0,0
NLCombi1	S1830	17,250	-676,5	-171,6	-915,0	0,3	**-3,2**	0,2
NLCombi1	S1167	32,815	-206,7	10,5	-1248,3	0,0	**4,4**	0,2
NLCombi1	S2325	15,988	-355,4	-1129,5	68,4	1,7	-0,4	**-2,0**
NLCombi1	S2322	0,000	355,4	-1129,5	68,4	1,7	0,4	**2,0**

19. Vervormingen van staaf

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

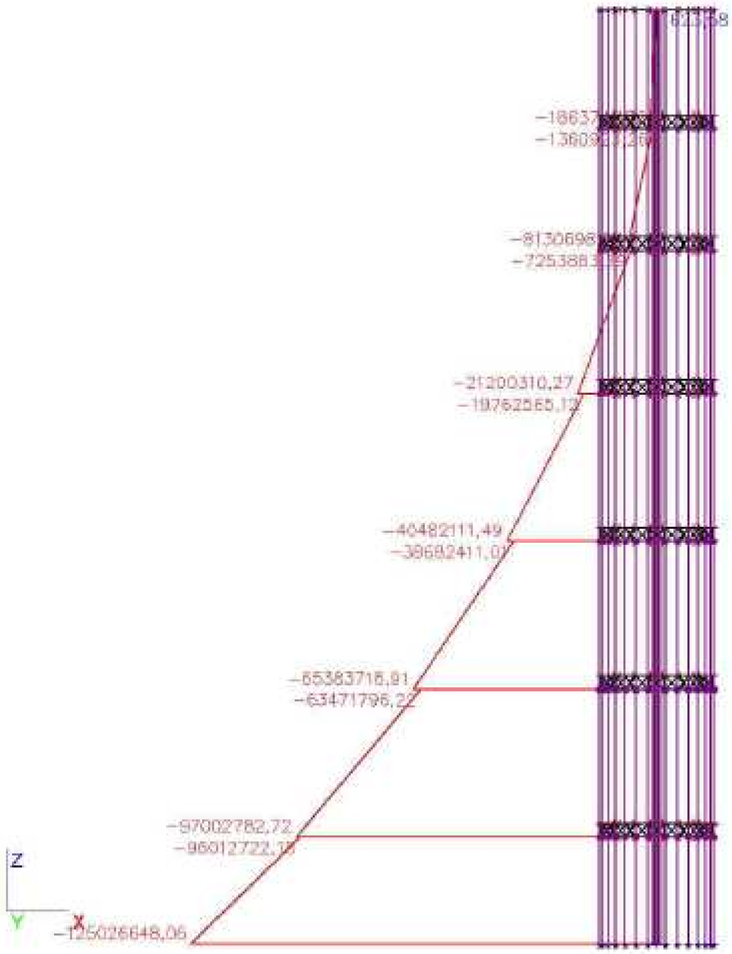
BG	Staaf	dx [m]	ux [mm]	uy [mm]	uz [mm]	fix [mrad]	fiy [mrad]	fiz [mrad]
NLCombi2	S1481	0,000	**-926,7**	0,0	-121,1	-1,2	-1,8	0,0
NLCombi2	S1463	15,000	**926,7**	0,0	-121,1	-1,2	1,8	0,0
NLCombi2	S1472	15,000	0,0	**-926,7**	-36,3	0,3	0,4	0,0
NLCombi2	S1460	29,742	-140,2	**916,0**	-79,9	-1,4	0,9	0,0
NLCombi2	S1167	81,385	-165,5	4,9	**-937,5**	0,0	0,0	-0,2
NLCombi2	S1845	17,250	-565,8	-119,3	**527,3**	0,3	-1,2	-0,3
NLCombi2	S1496	0,000	393,0	839,0	-177,7	**-2,6**	0,4	0,0
NLCombi2	S1494	0,000	0,0	-926,4	-185,9	**2,7**	-0,3	0,0
NLCombi2	S1830	17,250	-446,8	-115,6	-626,0	0,2	**-2,2**	0,2
NLCombi2	S1160	32,815	-154,9	-8,3	-844,9	0,0	**3,2**	-0,1
NLCombi2	S2325	15,988	-250,2	-761,4	36,6	1,2	-0,2	**-1,4**
NLCombi2	S2322	0,000	250,2	-761,4	36,6	1,2	0,2	**1,4**

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
5	0,30	1,85	3,44	3,39
6	0,76	4,80	23,05	1,31
7	0,76	4,80	23,05	1,31
8	0,93	5,84	34,15	1,08

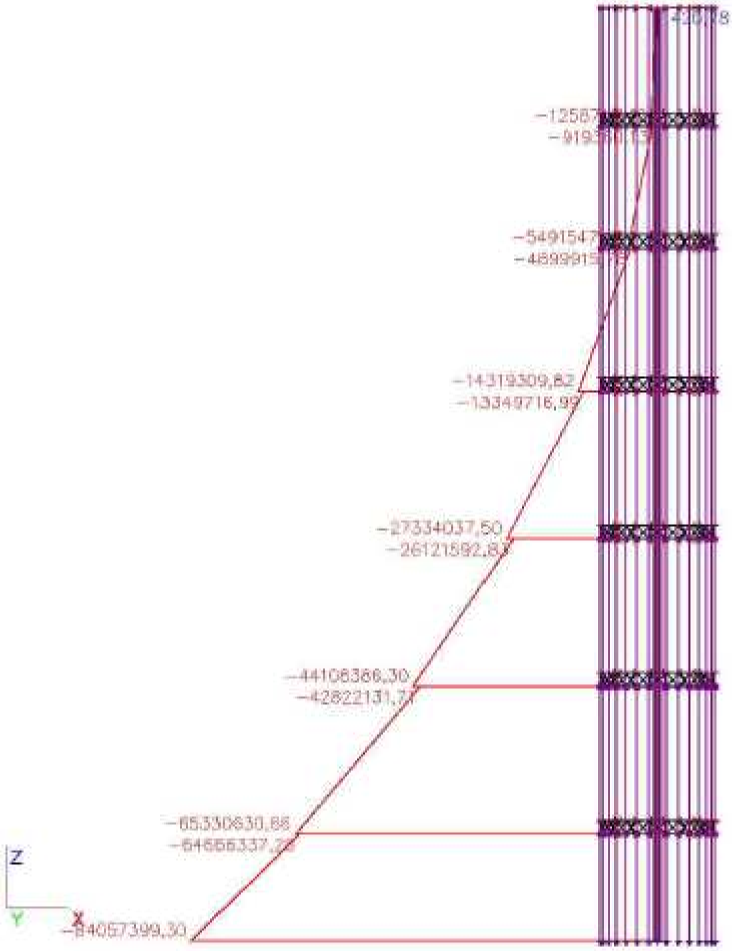
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

21. Interne krachten in staaf



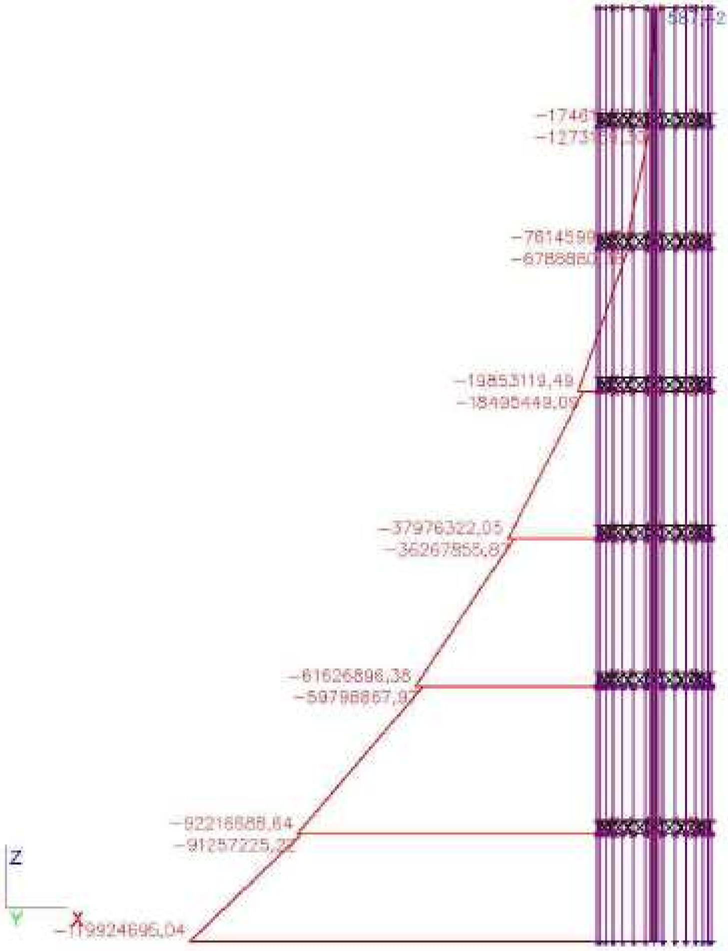
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

22. Interne krachten in staaf



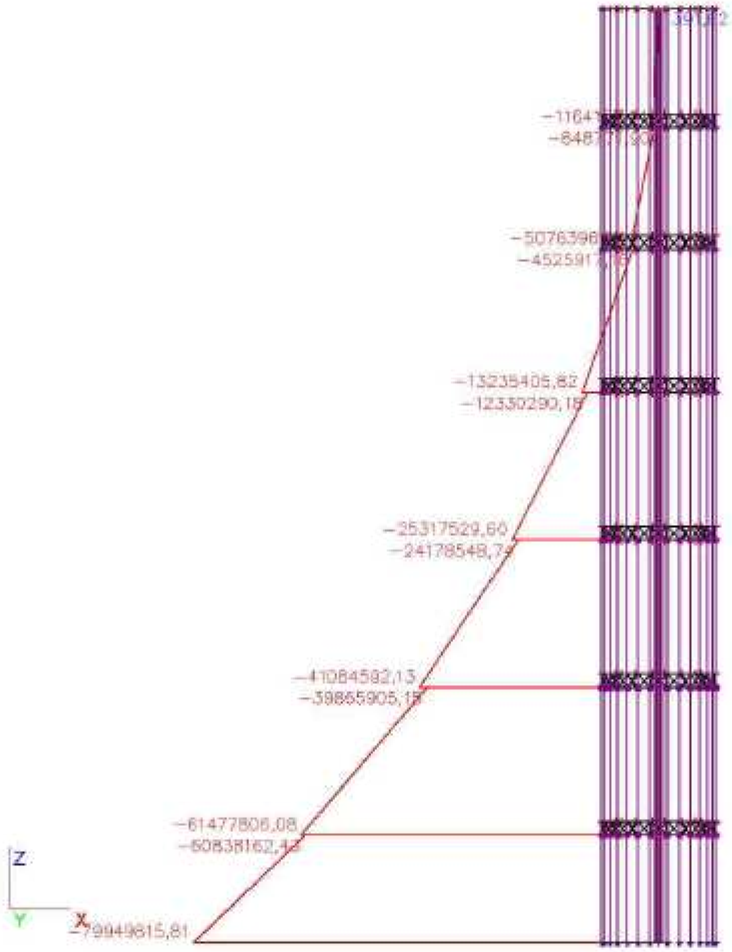
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

23. Interne krachten in staaf



Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

24. Interne krachten in staaf

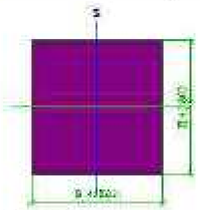


Alternative 3: Diagrid

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

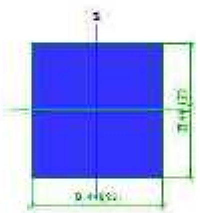
1. Doorsneden

Naam	CS3	
Type	Rechthoek	
Uitgebreid	45803; 45803	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		



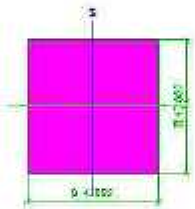
A [m²]	2,0979e+03	
A y, z [m²]	1,4236e+03	1,4236e+03
I y, z [m⁴]	3,6677e+05	3,6677e+05
I w [m⁶], t [m⁴]	0,0000e+00	2,8493e+05
Wel y, z [m³]	1,6015e+04	1,6015e+04
Wpl y, z [m³]	2,4023e+04	2,4023e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22902	22902
alpha [deg]	0,00	
AL [m²/m]	1,8321e+02	

Naam	CS4	
Type	Rechthoek	
Uitgebreid	44623; 44623	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		



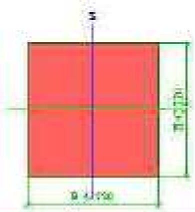
A [m²]	1,9912e+03	
A y, z [m²]	1,6593e+03	1,6593e+03
I y, z [m⁴]	3,3041e+05	3,3041e+05
I w [m⁶], t [m⁴]	0,0000e+00	5,5747e+05
Wel y, z [m³]	1,4809e+04	1,4809e+04
Wpl y, z [m³]	2,2213e+04	2,2213e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	22312	22312
alpha [deg]	0,00	
AL [m²/m]	1,7849e+02	

Naam	CS5	
Type	Rechthoek	
Uitgebreid	43885; 43885	
Onderdeelmateriaal	Emod44000	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
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	x	
Afbeelding		

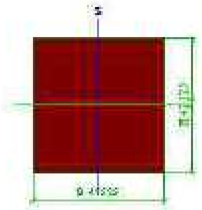


A [m²]	1,8680e+03	
A y, z [m²]	1,5566e+03	1,5566e+03
I y, z [m⁴]	2,9078e+05	2,9078e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,9060e+05
Wel y, z [m³]	1,3456e+04	1,3456e+04
Wpl y, z [m³]	2,0183e+04	2,0183e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21610	21610
alpha [deg]	0,00	
AL [m²/m]	1,7288e+02	

Naam	CS7	
Type	Rechthoek	
Uitgebreid	42525; 42525	
Onderdeelmateriaal	Emod44000	

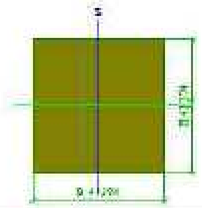
Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

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



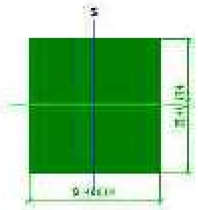
A [m²]	1,8084e+03	
A y, z [m²]	1,5070e+03	1,5070e+03
I y, z [m⁴]	2,7252e+05	2,7252e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,5979e+05
Wel y, z [m³]	1,2817e+04	1,2817e+04
Wpl y, z [m³]	1,9225e+04	1,9225e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	21263	21263
alpha [deg]	0,00	
AL [m²/m]	1,7010e+02	

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



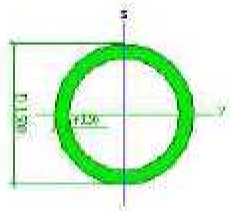
A [m²]	1,7118e+03	
A y, z [m²]	1,4265e+03	1,4265e+03
I y, z [m⁴]	2,4419e+05	2,4419e+05
I w [m⁶], t [m⁴]	0,0000e+00	4,1200e+05
Wel y, z [m³]	1,1804e+04	1,1804e+04
Wpl y, z [m³]	1,7706e+04	1,7706e+04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	20687	20687
alpha [deg]	0,00	
AL [m²/m]	1,6550e+02	

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

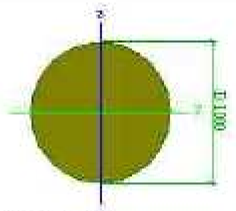
Naam	CS11	
Type	Buis	
Uitgebreid	1500; 150	
Onderdeelmateriaal	S235	
Bouwwijze	Algemeen	
Knik y-y, z-z	b	b
EEM berekening	x	
Afbeelding		



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	x	

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
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	×
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

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	**-20470,91**	21,38	163,03	-36,45	-1025,11	-234,81
S25315	BG3	0,000	**20468,64**	21,35	-163,08	-36,45	1025,36	-234,60
S25871	BG3	0,000	137,95	**-1141,51**	-69,78	0,26	51,36	-808,09
S25870	BG3	0,000	193,56	**1215,13**	-66,18	-0,30	47,09	738,82
S26751	BG3	0,000	866,66	-165,54	**-563,57**	-0,06	279,37	-95,58
S2729	BG3	0,000	-122,86	-59,16	**251539,62**	-21605,64	**-69595668,48**	-2155,09
S2729	BG3	11,100	-129,19	-65,61	214082,98	**-29764,90**	-66988404,74	-3043,74
S2	BG3	18,900	-6,80	-5,98	188583,20	**14730,14**	-50254729,22	1429,39
S7	BG3	88,400	6,52	-4,22	3656,24	206,12	**39214,58**	186,59
S25871	BG3	49,571	137,95	-1141,51	-69,78	0,26	-3407,91	**-57393,32**
S25870	BG3	49,571	193,56	1215,13	-66,18	-0,30	-3233,62	**60973,76**

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	**-17149833,22**	67,76	**377260,51**	-32225,25	**-104284217,34**	30881,92
S25414	Combi2/1	0,000	**12398,60**	5,03	212,94	-0,01	-158,26	3,95
S26003	Combi2/1	0,000	5506,44	**-1965,00**	-984,59	0,30	7,86	2934,71
S25994	Combi2/1	0,000	5541,87	**2090,79**	-1102,13	-0,59	6,09	-3583,16
S26752	Combi2/1	0,000	962,60	212,16	**-2098,73**	0,14	545,55	145,19
S2729	Combi2/1	11,100	-16937795,58	79,01	321148,00	**-44255,97**	-100373274,62	35286,09
S2	Combi2/1	0,000	-15268268,03	621,77	290919,74	**21110,89**	-79508013,06	-18413,78
S7	Combi2/1	88,400	-324313,18	581,61	5341,09	-375,52	**98871,59**	300,30
S26003	Combi2/1	49,996	5506,44	-1965,00	-984,59	0,30	-49217,90	**-95308,24**
S25994	Combi2/1	49,996	5541,87	2090,79	-1102,13	-0,59	-55096,46	**100948,89**

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	**-13880797,18**	68,11	**251498,35**	-21456,68	**-69504753,66**	25158,28
S25414	Combi3/2	0,000	**9048,46**	3,22	112,77	-0,01	-97,04	2,52
S26003	Combi3/2	0,000	4293,82	**-1349,94**	-822,23	0,25	27,04	2519,91
S25994	Combi3/2	0,000	4327,99	**1436,77**	-919,12	-0,49	23,88	-3068,43
S26752	Combi3/2	0,000	593,01	131,81	**-1580,04**	0,10	381,95	93,76
S2729	Combi3/2	11,100	-13709215,74	78,32	214101,66	**-29447,04**	-66897477,63	28926,11
S2	Combi3/2	0,000	-12358068,22	504,67	193957,01	**13940,39**	-52988764,16	-15524,39
S7	Combi3/2	88,400	-262523,78	473,64	3534,62	-339,87	**72572,03**	68,99
S26003	Combi3/2	49,996	4293,82	-1349,94	-822,23	0,25	-41081,71	**-64972,06**
S25994	Combi3/2	49,996	4327,99	1436,77	-919,12	-0,49	-45928,63	**68764,82**

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	**-17149814,78**	64,48	**380441,38**	-33628,37	**-108179726,34**	30941,78
S25414	combi1	0,000	**12675,45**	5,29	221,51	-0,01	-154,08	4,15
S26003	combi1	0,000	5557,31	**-2039,58**	-982,67	0,29	4,84	2890,46
S25994	combi1	0,000	5591,27	**2170,05**	-1100,01	-0,59	3,08	-3531,97
S26752	combi1	0,000	1022,49	225,66	**-2122,17**	0,14	557,56	153,04
S2729	combi1	11,100	-16937765,89	74,91	323023,17	**-46189,34**	-104237924,35	35310,22
S2	combi1	18,900	-14850934,78	673,44	290050,30	**22030,77**	-78790864,19	-28065,52
S7	combi1	88,400	-324304,83	581,40	5707,38	-378,69	**102234,77**	313,14
S26003	combi1	49,996	5557,31	-2039,58	-982,67	0,29	-49125,29	**-99080,87**
S25994	combi1	49,996	5591,27	2170,05	-1100,01	-0,59	-54993,39	**104962,43**

14. Interne krachten in staaf

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

NEMETSCHEK Scia	**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	**-13880786,94**	65,48	**254072,91**	-22591,96	**-72657756,16**	25209,72
S25414	combi2	0,000	**9272,70**	3,43	119,69	-0,01	-93,63	2,69
S26003	combi2	0,000	4334,94	**-1410,26**	-820,77	0,24	24,55	2484,06
S25994	combi2	0,000	4367,90	**1500,88**	-917,49	-0,49	21,40	-3026,91
S26974	combi2	0,000	604,74	134,61	**-1600,15**	0,11	386,15	94,96
S2729	combi2	11,100	-13709197,31	75,03	215619,41	**-31011,34**	-70025494,53	28948,77
S2729	combi2	88,800	-12407507,97	505,53	199537,50	**14679,18**	-56563486,72	-17141,18
S7	combi2	88,400	-262518,14	473,48	3831,07	-342,75	**75294,48**	79,34
S26003	combi2	49,996	4334,94	-1410,26	-820,77	0,24	-41010,88	**-68024,00**
S25994	combi2	49,996	4367,90	1500,88	-917,49	-0,49	-45849,63	**72011,66**

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

NEMETSCHEK Scia

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	**-741,2**	0,0	-9,5	0,0	-1,3	0,0
BG3	S33080	0,000	**741,2**	0,0	9,5	0,0	1,3	0,0
BG3	S33087	0,000	0,0	**-741,2**	-61,8	1,3	0,0	0,0
BG3	S33229	15,000	0,0	**741,2**	61,8	-1,3	0,0	0,0
BG3	S7	102,200	0,0	0,0	**-744,6**	0,0	1,3	0,0
BG3	S33016	12,235	-318,1	89,3	**663,6**	-0,1	-1,3	0,1
BG3	S33007	0,000	0,0	713,2	61,8	**-1,3**	0,0	0,0
BG3	S32865	0,000	0,0	-713,2	-61,8	**1,3**	0,0	0,0
BG3	S33101	50,000	-727,2	0,0	0,0	0,0	**-1,3**	0,0
BG3	S7	77,300	0,0	0,0	-713,2	0,0	**1,3**	0,0
BG3	S32767	6,118	21,3	-673,3	99,9	0,5	-0,2	**-1,1**
BG3	S32606	6,118	-21,3	673,3	-99,9	-0,5	0,2	**1,1**

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	**-1109,6**	0,2	-68,4	0,0	-1,9	0,0
Combi2/1	S33080	0,000	**1109,6**	-0,2	-68,6	0,0	1,9	0,0
Combi2/1	S33087	15,000	-0,2	**-1109,6**	-174,5	1,9	0,0	0,0
Combi2/1	S33229	15,000	0,2	**1109,6**	9,9	-1,9	0,0	0,0
Combi2/1	S7	102,200	-81,1	-0,2	**-1114,7**	0,0	1,9	0,0
Combi2/1	S33052	12,235	-551,1	-133,5	**958,6**	0,1	-1,9	-0,2
Combi2/1	S33007	15,000	0,2	1067,7	10,1	**-1,9**	0,0	0,0
Combi2/1	S32865	15,000	-0,2	-1067,7	-174,5	**1,9**	0,0	0,0
Combi2/1	S31685	6,717	-401,8	112,7	-743,2	-0,1	**-1,9**	-0,1
Combi2/1	S33080	7,500	1109,6	-0,2	-82,8	0,0	**1,9**	0,0
Combi2/1	S32814	12,235	-104,3	-1060,0	-189,9	0,8	0,2	**-1,7**
Combi2/1	S33037	12,235	212,4	-1060,0	43,1	0,8	0,2	**1,7**

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	**-739,3**	0,2	-57,4	0,0	-1,3	0,0
Combi3/2	S33080	0,000	**739,4**	-0,2	-57,5	0,0	1,3	0,0
Combi3/2	S33087	15,000	-0,2	**-739,3**	-128,0	1,3	0,0	0,0
Combi3/2	S33229	15,000	0,2	**739,4**	-5,2	-1,3	0,0	0,0
Combi3/2	S7	102,200	-65,6	-0,2	**-742,7**	0,0	1,3	0,0
Combi3/2	S33052	12,235	-377,9	-88,9	**633,8**	0,1	-1,2	-0,1
Combi3/2	S33007	15,000	0,2	711,5	-5,1	**-1,3**	0,0	0,0
Combi3/2	S32865	15,000	-0,2	-711,4	-128,0	**1,3**	0,0	0,0
Combi3/2	S31685	6,717	-258,3	75,2	-501,7	-0,1	**-1,3**	-0,1
Combi3/2	S33080	7,500	739,3	-0,2	-67,0	0,0	**1,3**	0,0
Combi3/2	S32814	12,235	-80,2	-706,3	-131,5	0,5	0,1	**-1,1**
Combi3/2	S33037	12,235	152,2	-706,3	23,7	0,5	0,1	**1,1**

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	**-1163,3**	0,2	-67,4	0,0	-2,0	0,0
combi1	S33080	0,000	**1163,4**	-0,2	-67,6	0,0	2,0	0,0
combi1	S33087	15,000	-0,2	**-1163,1**	-180,4	2,0	0,0	0,0
combi1	S33229	15,000	0,2	**1163,4**	13,3	-2,0	0,0	0,0
combi1	S7	102,200	-80,9	-0,2	**-1168,7**	0,0	2,0	0,0
combi1	S33052	12,235	-574,0	-140,3	**1006,7**	0,1	-2,0	-0,2
combi1	S33007	15,000	0,2	1119,4	13,5	**-2,0**	0,0	0,0
combi1	S32865	15,000	-0,2	-1119,1	-180,3	**2,0**	0,0	0,0
combi1	S31685	6,717	-424,3	117,9	-776,6	-0,2	**-2,0**	-0,1
combi1	S33080	7,500	1163,3	-0,2	-82,6	0,0	**2,0**	0,0
combi1	S33051	12,235	219,1	1111,3	43,9	-0,8	0,2	**-1,8**
combi1	S33037	12,235	219,0	-1111,4	43,6	0,8	0,2	**1,8**

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	**-782,8**	0,2	-56,6	0,0	-1,3	0,0
combi2	S33080	0,000	**782,9**	-0,2	-56,8	0,0	1,3	0,0
combi2	S33087	15,000	-0,2	**-782,7**	-132,6	1,3	0,0	0,0
combi2	S33229	15,000	0,2	**782,9**	-2,3	-1,3	0,0	0,0
combi2	S7	102,200	-65,5	-0,2	**-786,5**	0,0	1,3	0,0
combi2	S33052	12,235	-396,5	-94,4	**672,7**	0,1	-1,3	-0,1
combi2	S33007	15,000	0,2	753,3	-2,1	**-1,3**	0,0	0,0
combi2	S32865	15,000	-0,2	-753,1	-132,6	**1,3**	0,0	0,0
combi2	S31685	6,717	-276,5	79,4	-528,7	-0,1	**-1,3**	-0,1
combi2	S33080	7,500	782,9	-0,2	-66,9	0,0	**1,3**	0,0
combi2	S33051	12,235	157,6	747,8	24,8	-0,6	0,2	**-1,2**
combi2	S33037	12,235	157,5	-747,9	24,6	0,6	0,2	**1,2**

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	**-251539,62**	**-59,16**	**122,86**	**-2155,09**	**-69595668,48**	**-21605,64**
Sn1/K987	BG3	**2223,87**	**751,06**	**12841,97**	**0,00**	**0,00**	**0,00**
Sn2/K948	BG3	**1549,10**	**1544,91**	**19816,11**	**0,00**	**0,00**	**0,00**
Sn3/K989	BG3	**817,78**	**1747,84**	**25789,95**	**0,00**	**0,00**	**0,00**
Sn4/K972	BG3	**114,67**	**1582,84**	**30914,28**	**0,00**	**0,00**	**0,00**
Sn5/K952	BG3	**582,95**	**920,16**	**34202,96**	**0,00**	**0,00**	**0,00**
Sn6/K941	BG3	**258,29**	**1082,52**	**31937,99**	**0,00**	**0,00**	**0,00**
Sn9/K978	BG3	**3041,55**	**374,56**	**4554,44**	**0,00**	**0,00**	**0,00**
Sn30/K1662	BG3	**255,64**	**-1061,77**	**31943,84**	**0,00**	**0,00**	**0,00**
Sn31/K1663	BG3	**575,96**	**-901,29**	**34223,53**	**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	99,56	-1561,30	30950,51	0,00	0,00	0,00
Sn33/K1668	BG3	791,40	-1723,20	25844,38	0,00	0,00	0,00
Sn34/K1673	BG3	3008,48	-370,19	4585,89	0,00	0,00	0,00
Sn35/K1675	BG3	2166,04	-728,54	12943,35	0,00	0,00	0,00
Sn36/K1679	BG3	1507,64	-1520,27	19892,17	0,00	0,00	0,00
Sn37/K1683	BG3	257,45	-1075,81	-31946,45	0,00	0,00	0,00
Sn38/K1684	BG3	1532,57	-1535,13	-19848,11	0,00	0,00	0,00
Sn39/K1685	BG3	580,11	-912,44	-34214,73	0,00	0,00	0,00
Sn40/K1690	BG3	108,17	-1573,61	-30930,67	0,00	0,00	0,00
Sn41/K1692	BG3	2203,91	-743,21	-12885,02	0,00	0,00	0,00
Sn42/K1693	BG3	806,66	-1737,45	-25812,88	0,00	0,00	0,00
Sn43/K1701	BG3	256,41	1067,57	-31950,87	0,00	0,00	0,00
Sn44/K1702	BG3	577,07	904,15	-34228,62	0,00	0,00	0,00
Sn45/K1704	BG3	100,62	1563,11	-30954,49	0,00	0,00	0,00
Sn46/K1709	BG3	3077,55	-379,35	-4514,63	0,00	0,00	0,00
Sn47/K1713	BG3	792,37	1724,30	-25847,75	0,00	0,00	0,00
Sn48/K1715	BG3	3008,52	370,18	-4588,61	0,00	0,00	0,00
Sn49/K1717	BG3	2166,53	728,70	-12946,20	0,00	0,00	0,00
Sn50/K1720	BG3	1508,41	1520,84	-19895,18	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	-217570,38	0,00	-0,03	-0,64	-94256898,05	0,04

Centraalpunt:

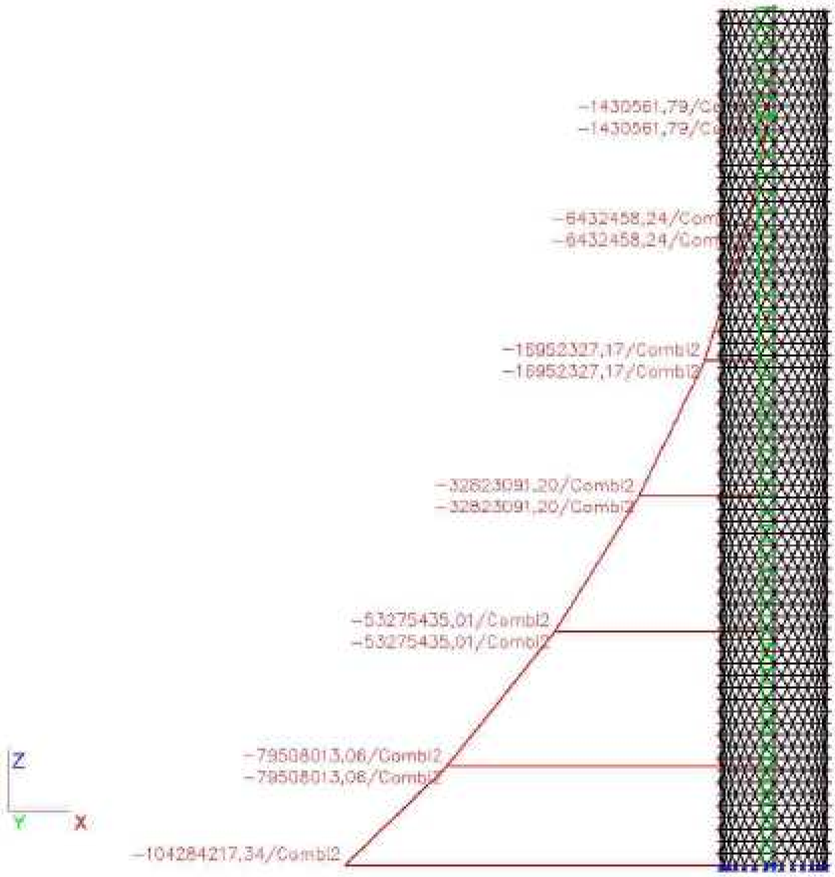
X [m]	Y [m]	Z [m]
0,000	0,000	0,000

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

Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

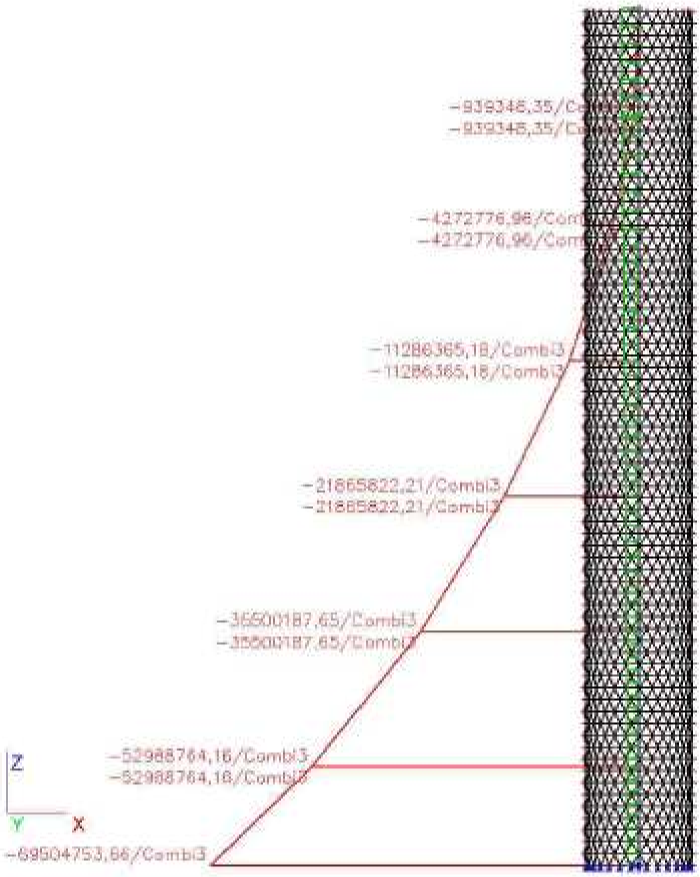
25. Interne krachten in staaf



NEMETSCHEK Scia

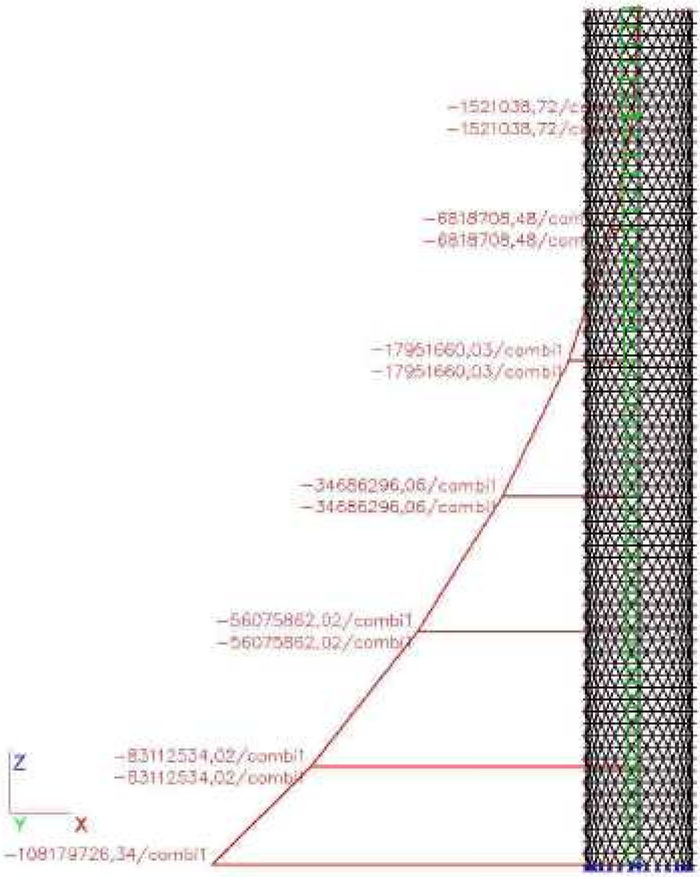
Project	Outrigger Stijfheid
Onderdeel	- -
Omschrijving	-
Auteur	wtu

26. Interne krachten in staaf



Project	Outrigger Stijfheid
Onderdeel	-
Omschrijving	-
Auteur	wtu

27. Interne krachten in staaf



Project	Outrigger Stijfheid
Onderdeel	- -
Omschrijving	-
Auteur	wtu

28. Interne krachten in staaf