Contents

This documentation confirms to the following standards:

- ASCE 07-05 Minimum Design Loads for Buildings
- AISC 360-10 Specification for Structural Steel Buildings
- CAN/CSA A.23-04 Design of concrete structures

1. Geometry, FE model

Height of the booth: $h := 144in = 3.66\,m$

Diameter of the booth: $d := 158in = 4.01\,m$

We used a mixed beam-shell model to analyse the structure. Beam elements are 6-DOF 2-node beam elements, shell elements are 9-node quadrilateral finite elements. Modeling stiffness uncommon joints is properly done by applying s[illegible] elements.

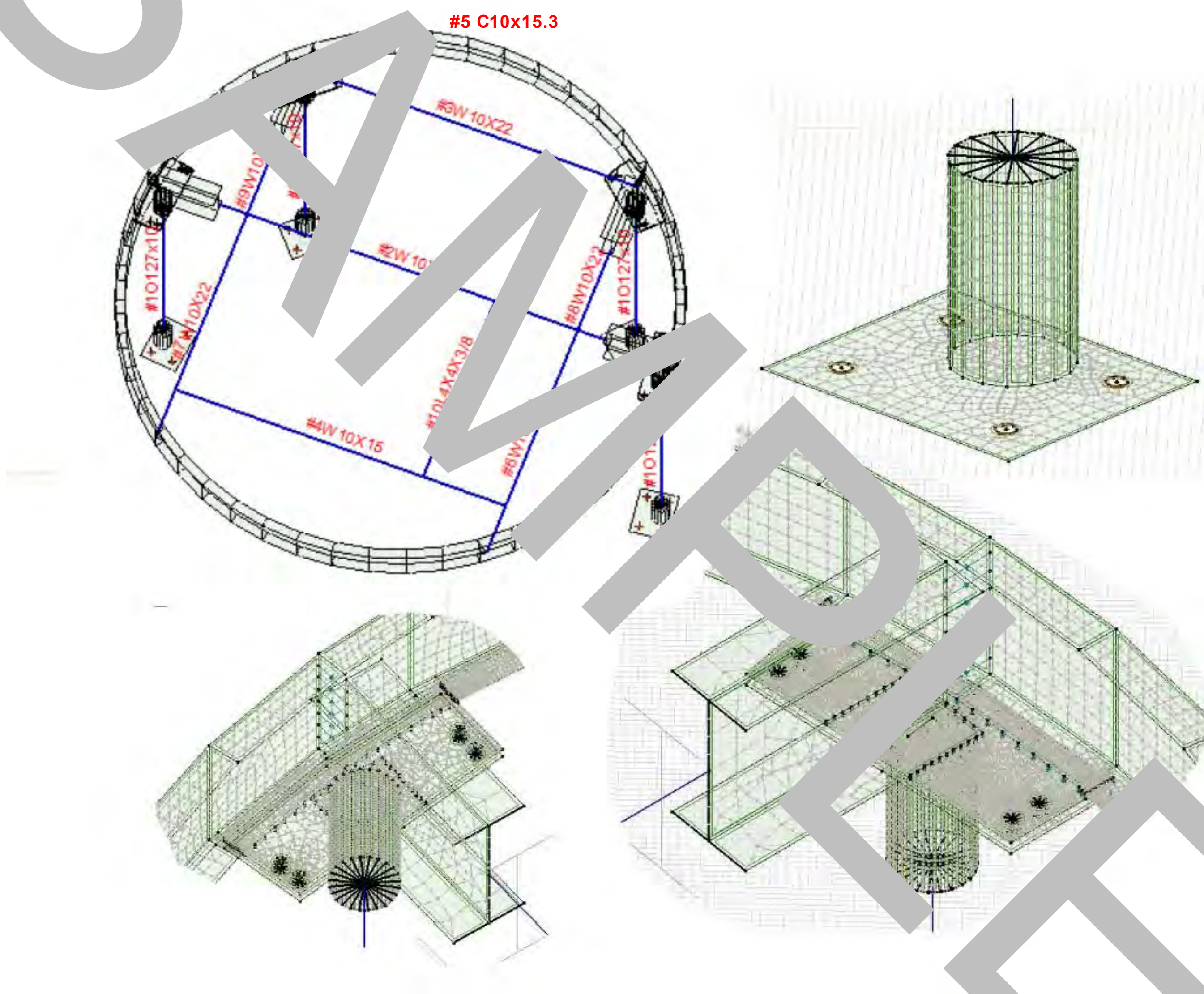
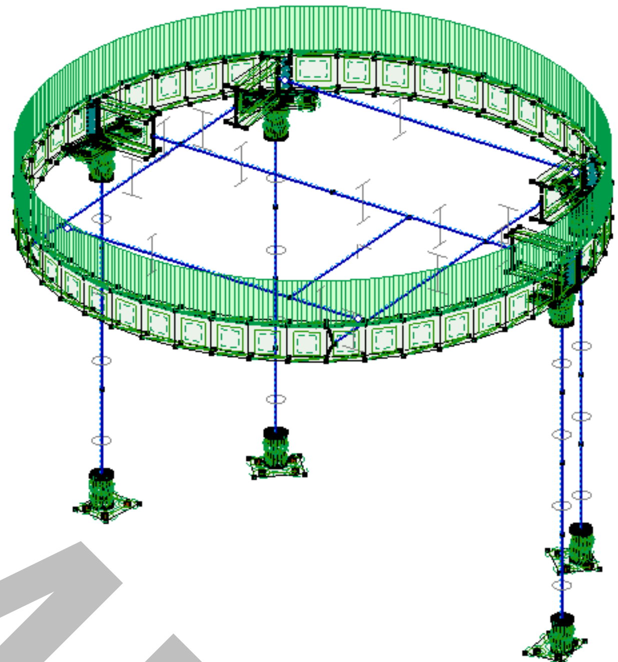


Figure showing 3D FE model with details

2. Loads

The evaluation of the loads was carried out as per ASCE Minimum Design Loads for Building 2005.

2.1. Dead load



Dead load of structural members:

calculated by [illegible]E software

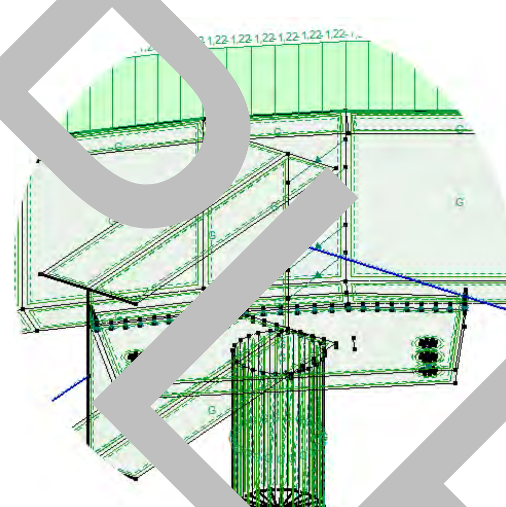
Dead load of sheeting, enveloping:

$$d_s := 0.5kPa$$

$$\frac{d}{2} \cdot 2 \cdot \pi \cdot h \cdot d_s = 23.06 \cdot kN$$

We assume that 2/3 of this load is acting on the curved members:

$$D_s := \frac{\frac{2}{3} \cdot \left(\frac{d}{2} \cdot 2 \cdot \pi \cdot h \cdot d_s\right)}{d \cdot \pi} = 1.22 \cdot \frac{kN}{m}$$



Structural dead load distributed to all elements, sheeting dead load distributed along curved member #5

2.2. Wind load (according to Section 6)

Basic Wind Speed: $V := 49\frac{m}{s}$ *(Fig. 6-1 - New Jersey)*

Directionality factor: $K_d := 0.95$ *(Table 6-4)*

The building is classified as occupancy category 'I' according to Table 1-1.

Importance factor: $I := 0.77$ *(Table 6-1)*

Exposure category: B (Assumed)

Velocity Pressure Exposure Coefficient: $K_z := 0.7$ *(Table 6-3)*

Topographic factor: $K_{zt} := 1.0$

Gust-effect factor: $G := 0.85$

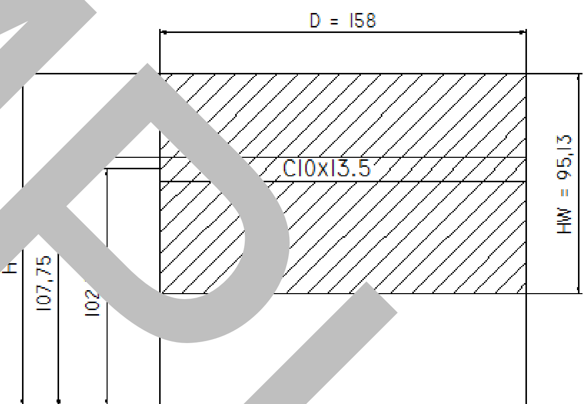
Velocity pressure: $q_z := 0.613 \cdot K_z \cdot K_{zt} \cdot K_d \cdot \left(\frac{V}{\frac{m}{s}}\right)^2 \cdot I \cdot \frac{N}{m^2} = 753.64 \cdot \frac{N}{m^2}$

Force coefficient: $C_f := 0.7$ *(Table 6-3)*

Distribution area of wind for superstructure: $HW := 95.125in$

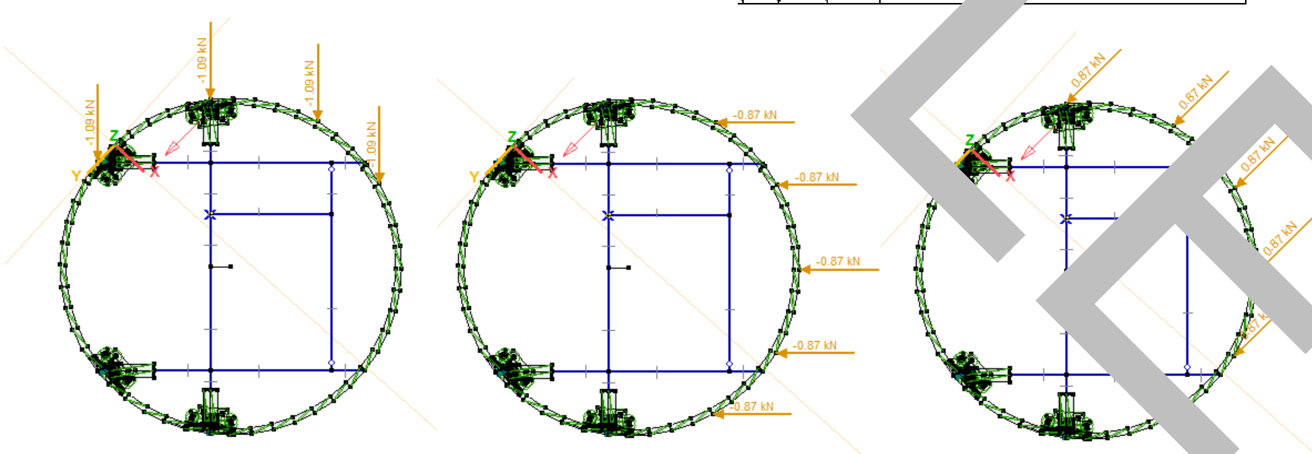
Projected area normal to the wind: $A_f := d \cdot HW = [illegible] m^2$

Design wind load: $F := q_z \cdot G \cdot C_f \cdot A_f = 4.[illegible] kN$



Wind load is applied as distributed into 4 or 5 parts:

$\frac{F}{5} = 0.87 \cdot kN$ $\frac{F}{4} = 1.09 \cdot kN$



2.3. Snow load (according to Section 7)

Ground snow load: $p_g := 30 \frac{lb}{ft^2}$ *(Fig. 7-1)*

$C_e := 1.2$ *(Table 7-2)*

$C_t := 1.0$ *(Table 7-3)*

$I := 0.8$ *(Table 7-4)*

Snow load for flat roofs:

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot p_g \cdot I, 20 \cdot \frac{lb}{ft^2} \cdot I\right) \cdot g = 0.77 \cdot \frac{kN}{m^2}$$

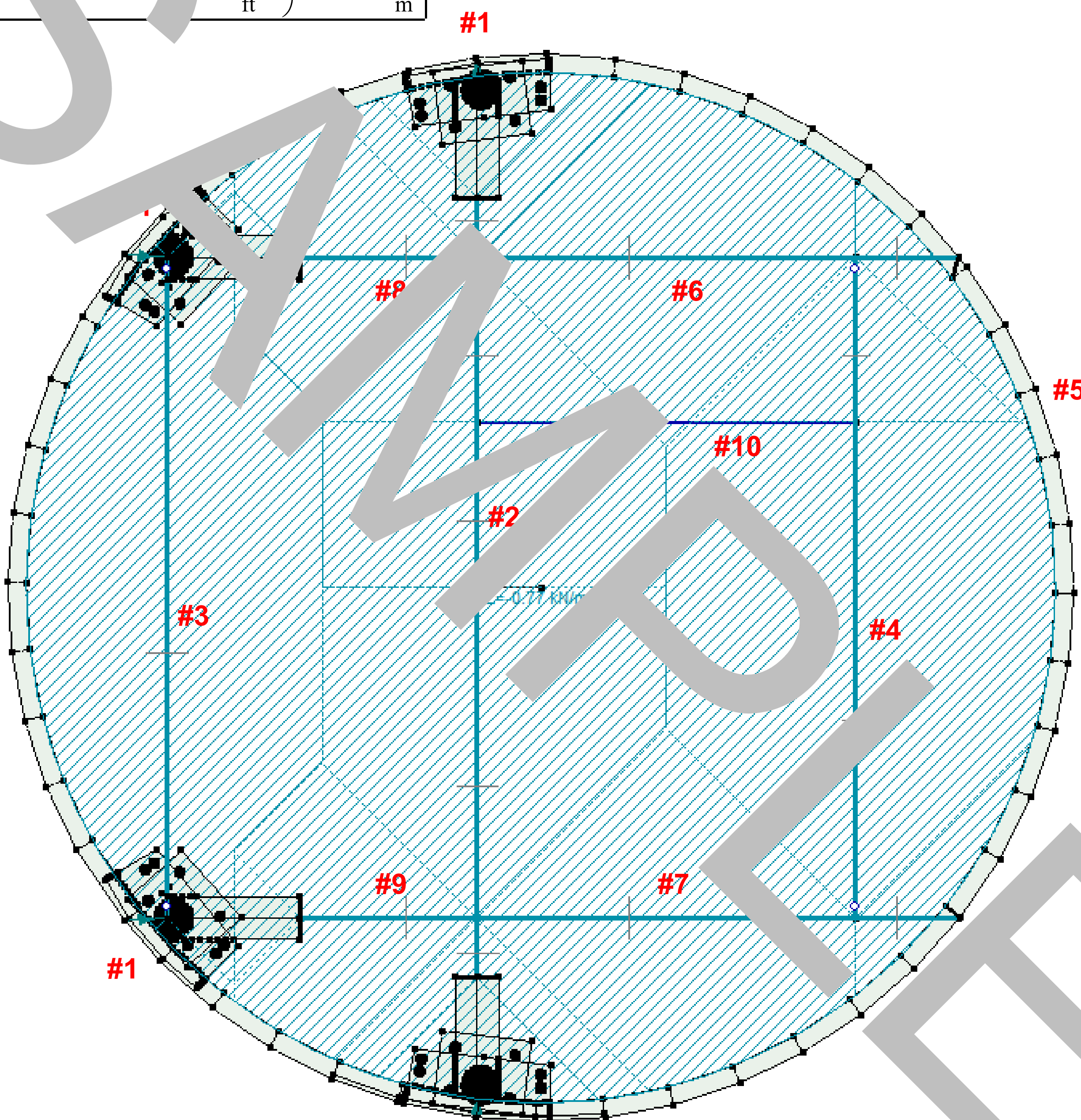
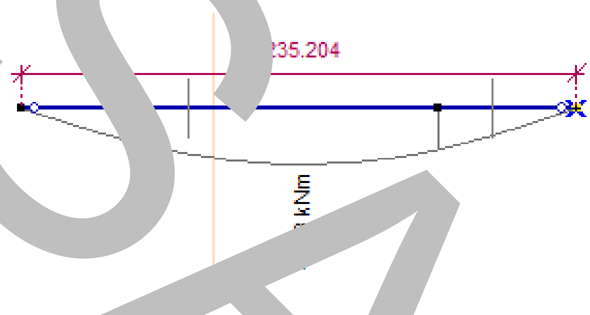


Figure showing snow load with distribution areas belonging to each particular member

1. *Yielding*: $M_p := F_y \cdot Z_x = 76.27 \cdot kN \cdot m$

2. *Lateral-Torsional Buckling*:

Limiting length: $L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 0.96\,m$ $\quad c := 1.0$



Moment diagram of member #4

$$r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 25.85 \cdot mm$$

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_0}} \cdot \sqrt{1 + \sqrt{1 + 6.76\left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_0}{J \cdot c}\right)^2}}$$

$$L_r = 2.95\,m$$

$$L_p < L_b < L_r$$

$$M_n := \min\left[C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right], M_p\right]$$

Nominal flexural strength: M_n = [illegible] $\cdot kN \cdot m$

Design flexural strength: $M_{[illegible]} := \phi_b \cdot M_n = $ [illegible]$9.38 \cdot kN \cdot m$

Efficiency: $\frac{M_{max}}{M_{[illegible]}} = $ [illegible]$2 \cdot \%$ ***Adequate!***

4.5. Check of member #5 (curved channel)

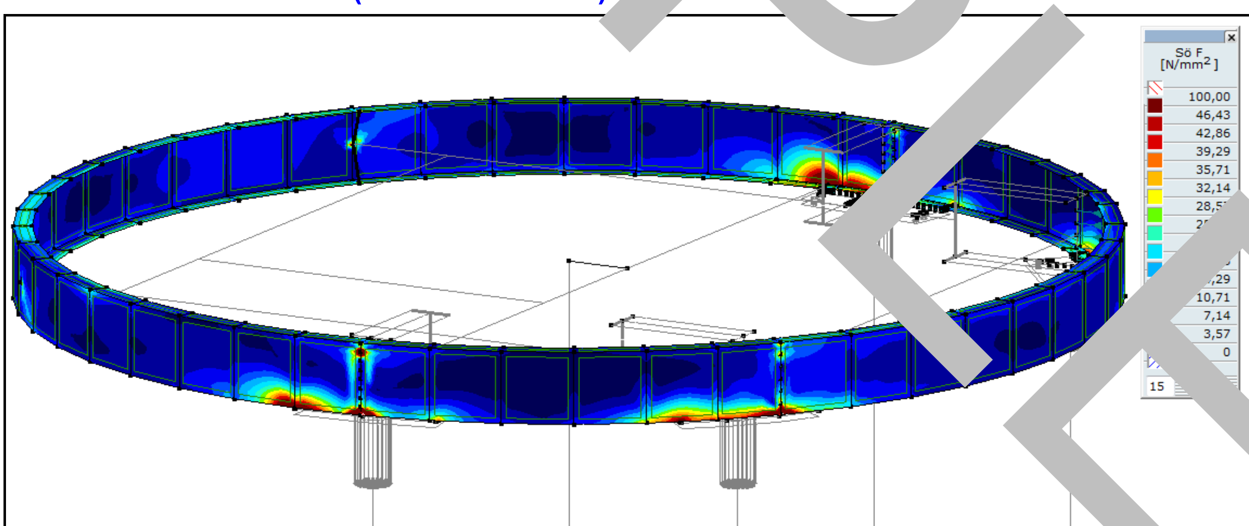
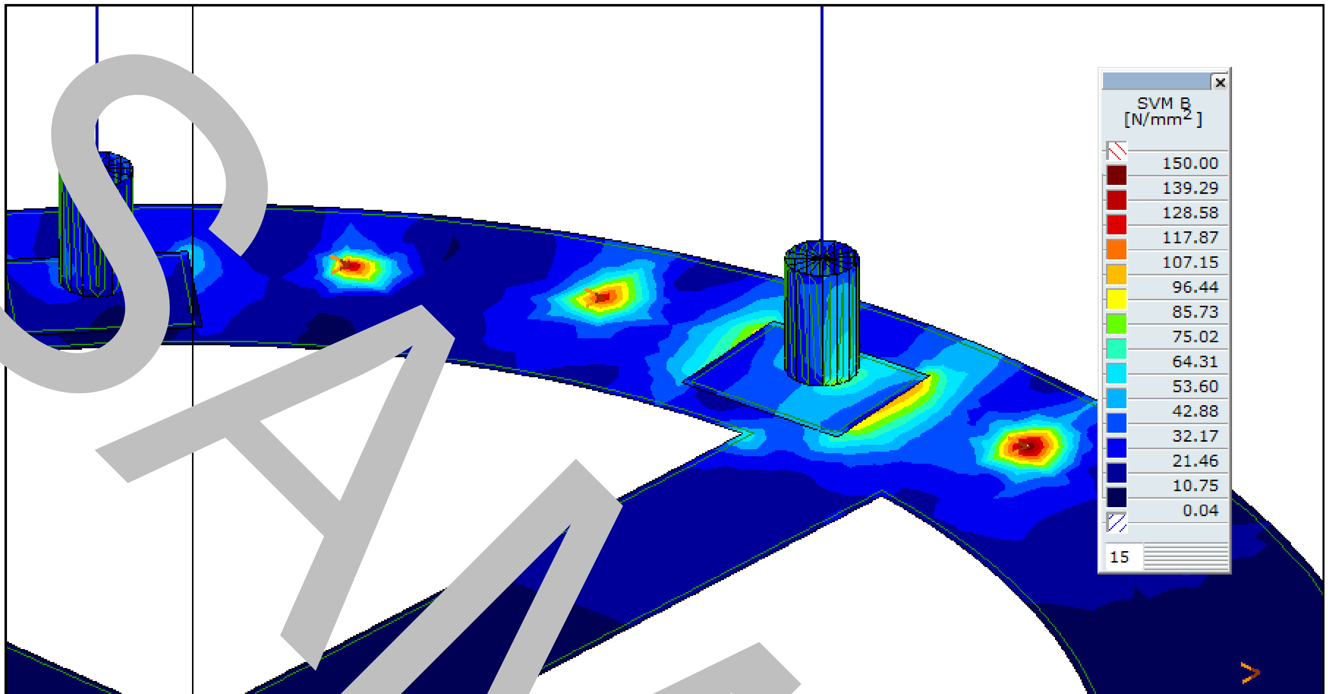


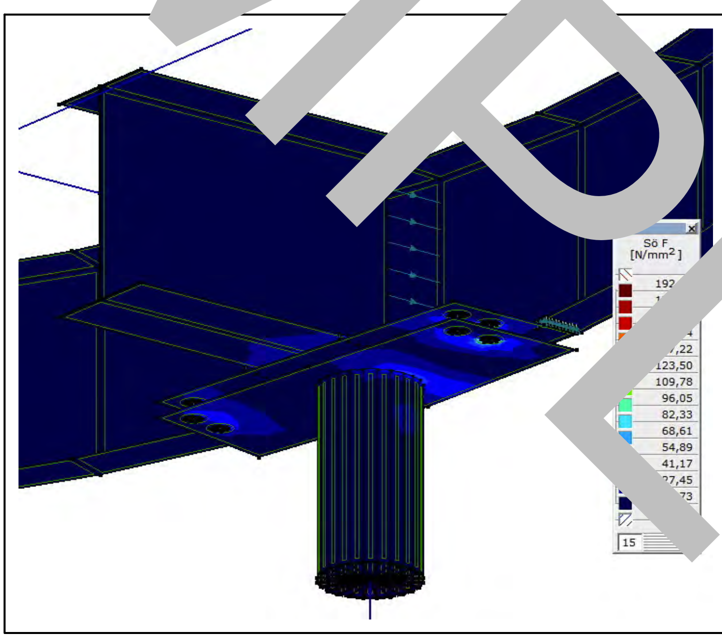
Figure showing Von-Mises stress in member #5 - peak values are below 100 MPa

The largest Von-Mises stress is below the yield strength of the steel. The Channel is ***adequate.***

4.10. Check of base and top plates

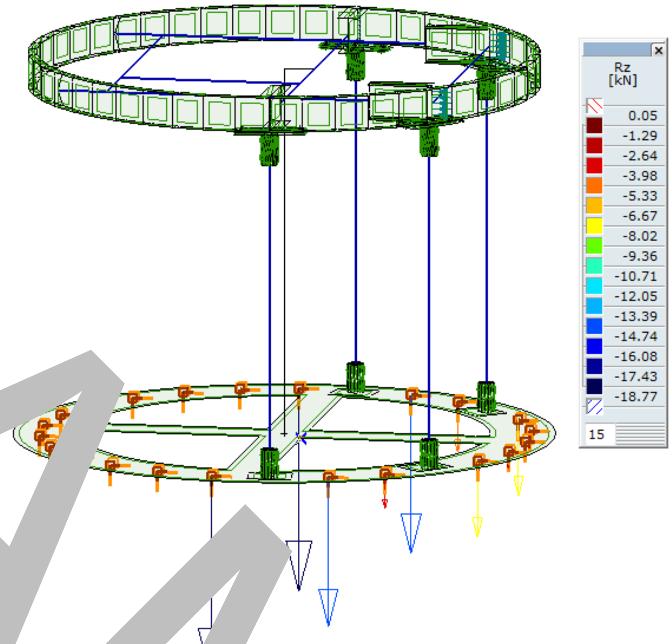


Von-Mises stress at the bottom plate of HSS

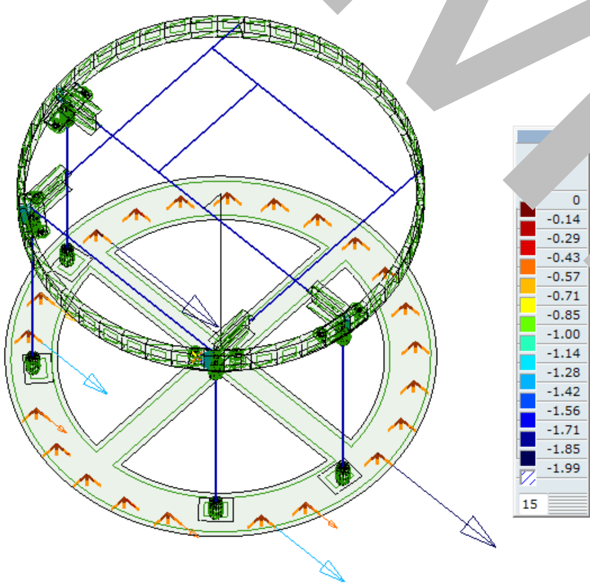


Von-Mises stress at the upper connection

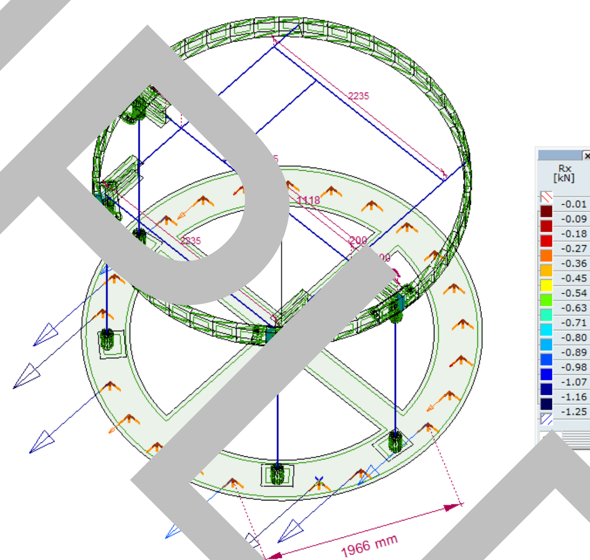
The Von-Mises stresses are below the yield strength of the steel, the connection, and the plates are ***adequate.***



Distribution of reaction forces (R_{max} = 18.77 kN)



Distribution of reaction forces (R_{max} = 2 kN)

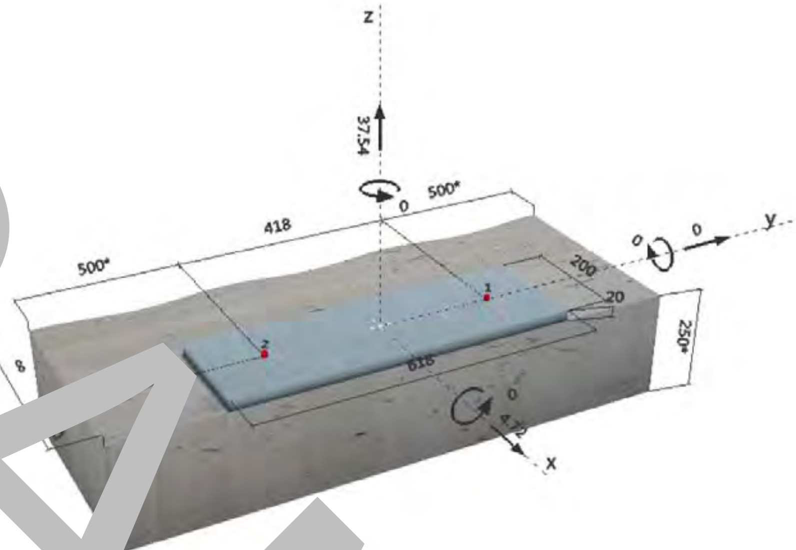


Distribution of reaction forces (R_{max} = 1.25 kN)

Summarizing the shear forces, the reaction forces for anchoring design are:

Vertical force: 18.77kN

Horizontal force: $\sqrt{(2\text{kN})^2 + (1.25\text{kN})^2} = 2.36\cdot\text{kN}$



(Figure sh[illegible]g lo[illegible]tion of the two mostly loaded
anc[illegible]bolts [illegible]etween the HSS columns)

The reaction force of the mostly lo[illegible] ancho[illegible] assumed to be [illegible]g on both anchors, which is a conservative design
Calculation complies with CAN/C[illegible] A.23-04[illegible]

2 Proof I Utilization (Governing Cas[illegible])

Loading	Proof	Design va[illegible] Load	Capacity	Utilization β_N / β_V [%]	Status
Tension	Splitting failure	37.5[illegible]	52.333	72 / -	OK
Shear	Concrete edge failure in direction x[illegible]	[illegible]	29.795	- / 16	OK

Loading	β_N	β_V	[illegible]ization [illegible]%]	Status
Combined tension and shear loads	0.717	0.158	6[illegible]	OK

Anchorage is adequate!

5. Check deflection - SLS

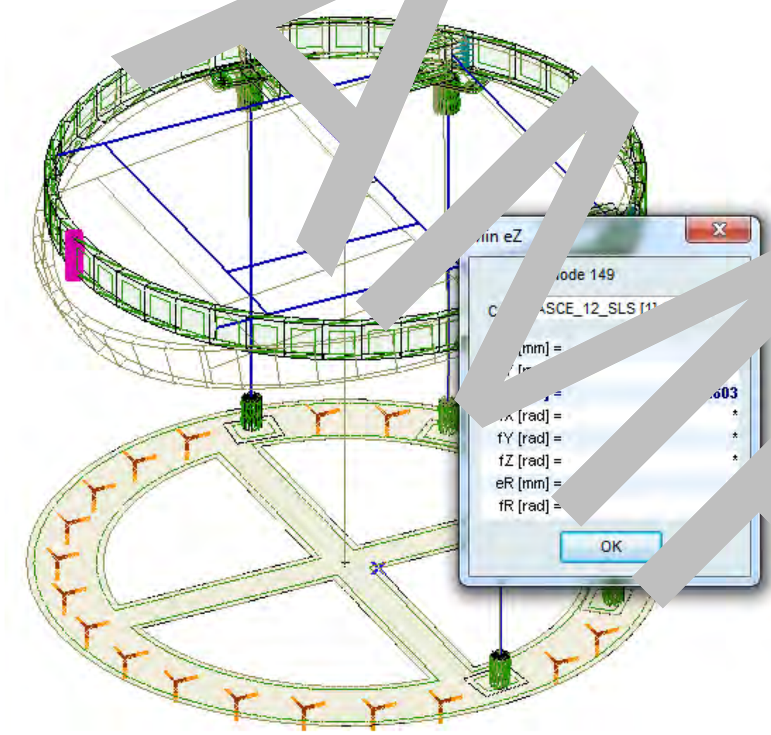
According to ASCE 7-05 CC.1.1.

5.1 Vertical displacement

Length of #6-7 console beams: $L := 1631\text{mm}$

Maximum allowable vertical deflection of members: $\delta_{all} := \dfrac{L}{240} = 6.8{\cdot}\text{mm}$

Actual deflection: $\delta := 5.6\text{mm}$



For ASCE_12_SLS load case see Clause 3 of this documentation.

Vertical deflections

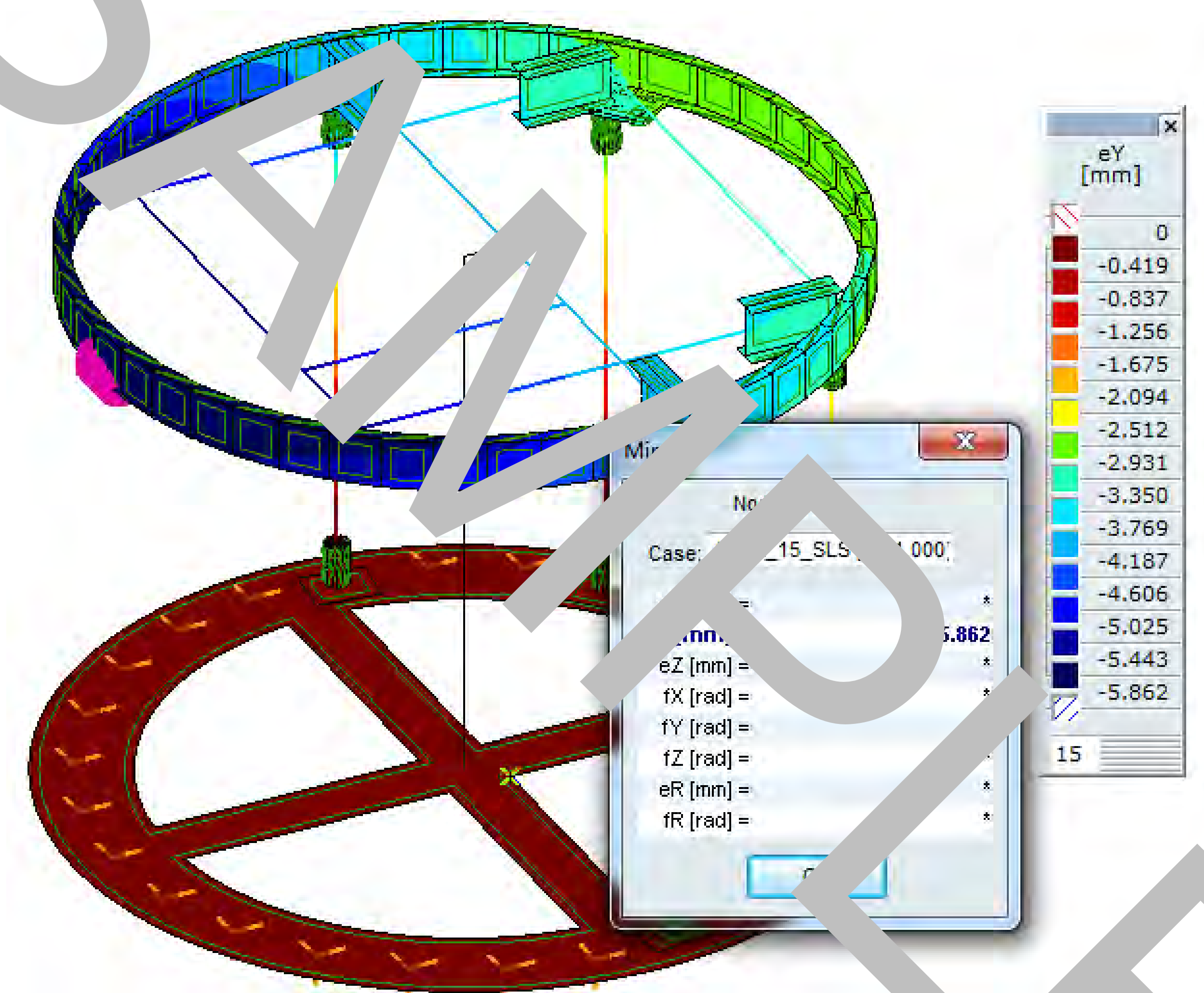
$\delta = 5.6{\cdot}\text{mm}$ < $\delta_{all} = 6.8{\cdot}\text{mm}$ ***Adequate!***

5.2 Horizontal displacement (drift)

Height of the investigated point: $h := 108in$

Maxim[illegible] allowa[illegible] drift of storey height (H): $\Delta_{all} := \frac{h}{400} = 6.86 \cdot mm$

Actual [illegible]: $\Delta := 5.86mm$



For ASCE_15_SL[illegible]ad cas[illegible] C[illegible]e 3 of this documentation.

Horizontal drift

$\Delta = 5.86 \cdot mm$ < $\Delta_{all} = 6.86 \cdot mm$ ***Adeq[illegible]e!***