LED TRAILER STRUCTUAL ANALYSIS

CONTENT

1. PREAMBLE

1.1. STANDARDS

LST EN 13814
Fairground and amusement park machinery and structures – Safety

LST EN 13782
Temporary structure – Tents – Safety

1.2. SUPPORTING DOCUMENTS

Data sheets of the used trailer and calculation model

1.3. BUILDING MATERIAL

Truss elements
Structural steel S355JO in accordance with EN 10025
Welds accordance with ISO 13920-B

LED Screen 5760x3200 mm
Dead weight 553 kg

Mechanical properties

Hot-rolled EN 10025-2: 2004 **S355J0**

Testing at room temperature Kv 0 °C

size mm		**R**	**size** mm		$\mathbf{R_{eH}}$	**size** mm		**A**% L	**A**% T	***HB***
from	to	N/mm²	over	to	N/mm² min	over	to	min	min	*for information*
	3	510-680		16	355	3	40	22	20	*154-208*
3	100	470-630	16	40	345	40	63	21	19	*141-192*
100	150	450-600	40	63	335	63	100	20	18	*135-178*
150	250	450-600	63	80	325	100	150	18	18	*135-178*
			80	100	315	150	250	17	17	
			100	150	295					
			150	200	285	over	to	**Kv** 0 °C J min [a]		
			200	250	275	10	150	27		
						150	250	27		

[a] values to be agreed for thickness > 100 mm (**normalization** is advised)

1.4. GENERAL PRELIMINARY NOTES

The structural analysis concerns a trailer frame which contains LED screen of 5760x3200 mm. Support on which screen is attached is 6000 mm long.

Trailer calculated for 8 class of resistance for wind load in outdoors. Wind speed for this class is 17,2 – 20,7 m/s. For calculations used value is 20,7 m/s.

Static calculations made for situation when trailer is raised on supporting legs.

Analysis contains two calculations models. One is for calculations to determine if trailer will roll over and for stress analysis. Second is simplified version of trailer to calculate forces and moments graphs for each structural element.

The used construction material for the main structure is structural steel : S355JO.

All active loads and dead weights are described in loads paragraph.

1.5. LOADING ASSUMPTIONS

Wind load acc. EN 13814

Table 1 — Wind pressure values for amusement devices

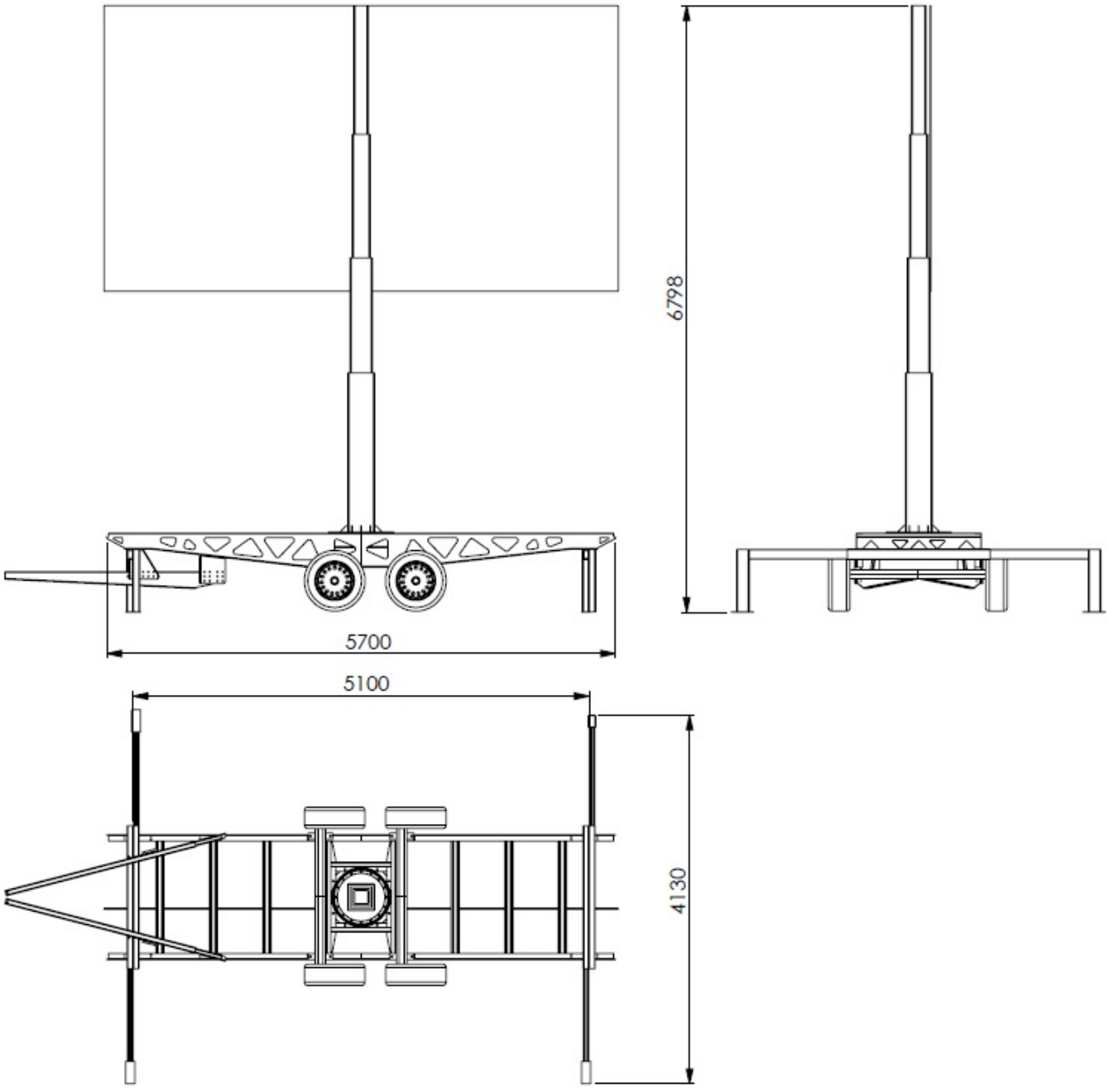
Height of the structure	Pressure $q_{eq} = q_{ref} \times ce(ze) \times c_d$ (kN/m^2) for reference wind speed	
	$v_{ref} \leq$ 15 m/s (in service)	$v_{ref,0} \leq$ 28 m/s (out of service)
0 ≤ 8 m	0,20	0,35
8 ≤ 20 m	0,30	0,50
20 ≤ 35 m	0,35	0,90
35 ≤ 50 m	0,40	1,00

Structure height < 8 m.

Wind load: p_d = 268 N/m^2 F = 4939 N

Dead weight of LED screen: 5425 N

1.6. DRAWINGS

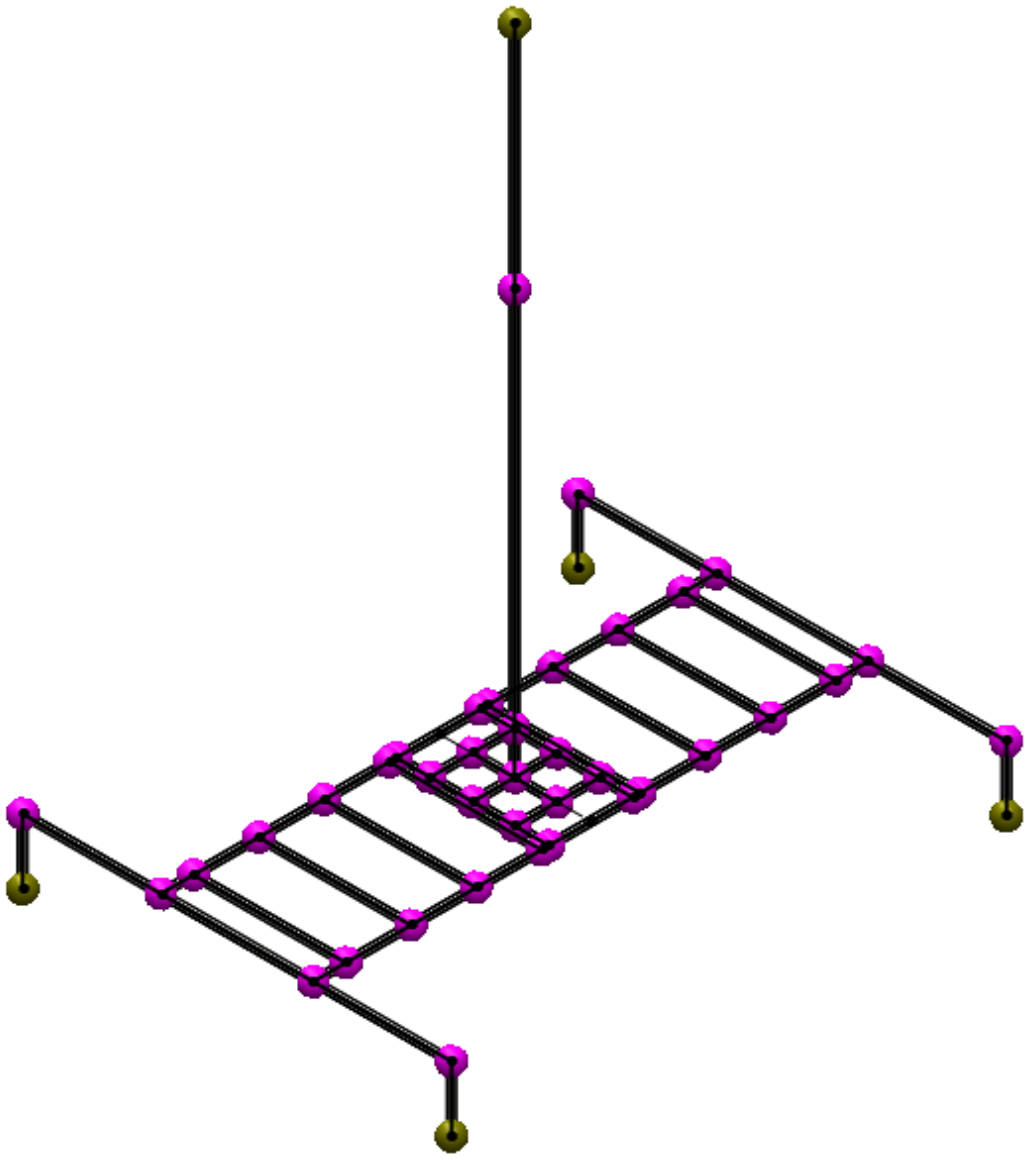


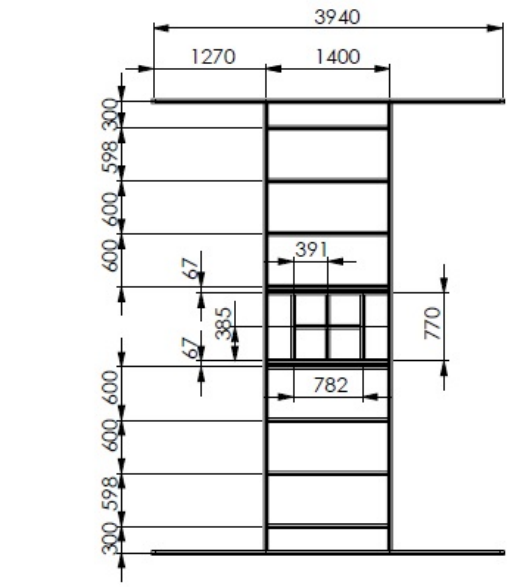
1.7. SYSTEM

Calculations made in 2 situations. First situation is when structure stands stable on ground. Second situation is imitating structure rolling over possibility. All calculations made using LED screen dead weight, structure weight and wind pressure for 8 class which stands for max value of wind speed 20,7 m/s.

This is simplified structure model. This model is used for forces and force moments diagrams create. Value 3885 mm stands for LED screen gravity center when attached on support.

Structural system:

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600
600
67
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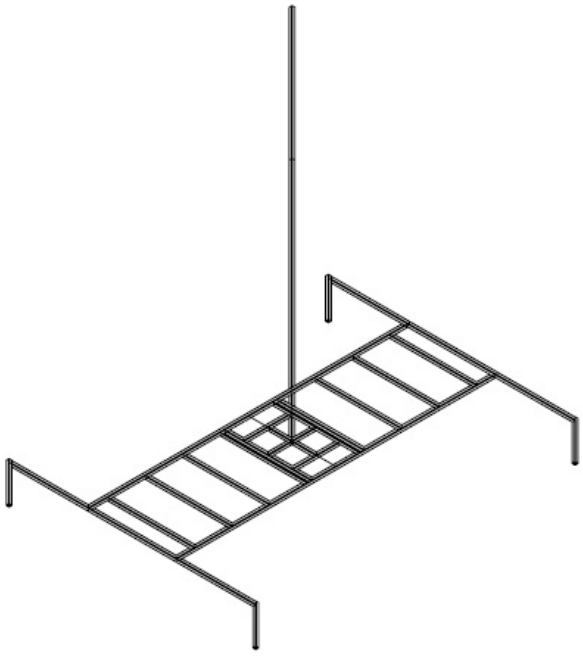
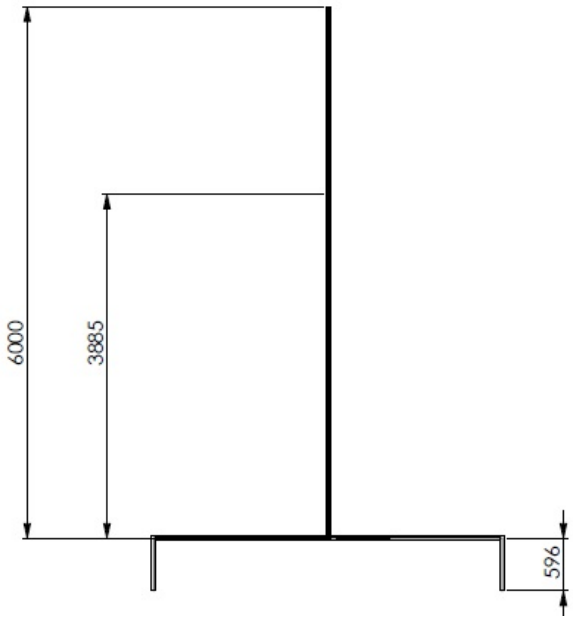
770
600
782
600
598
300




6000
3885
596

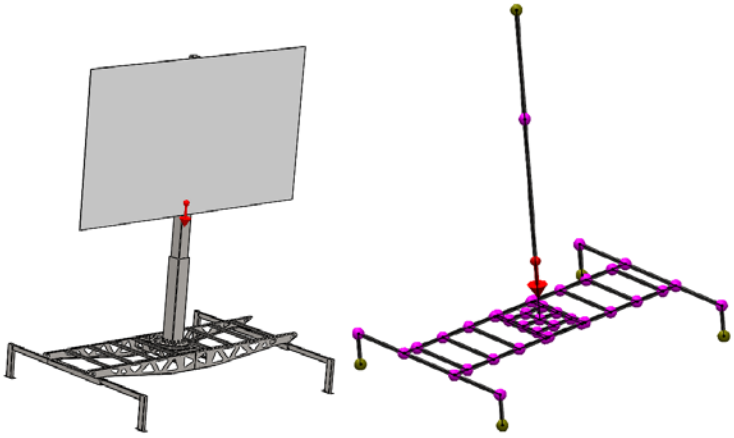
2. LOADINGS

Load case 1: structure dead weight

For the main model dead weight of the structure is calculated by the software.

For the simplified model weight difference is compensated by adding additional force as gravity force:

Real structure weight is 420 kg simplified model structure weight is 196 kg. Difference of 224 kg is compensated by adding force as gravity: $F_g = 224 \cdot 9{,}81 = 2197\ N$



Load case 2: dead weight of additional components that were not used in calculation model

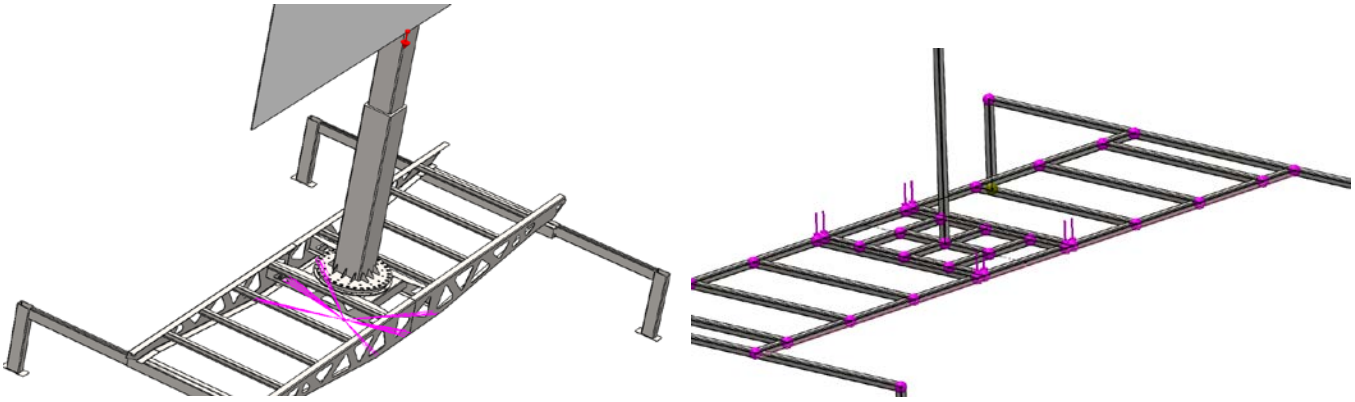
Axels – 2 x 90 kg ; 1766 N

Tyres – 4 x 20 kg ; 785 N

Additional structure – 45 kg ; 441 N

Oil tank – 40 kg ; 392 N

Hydraulic pump – 30 kg ; 294 N



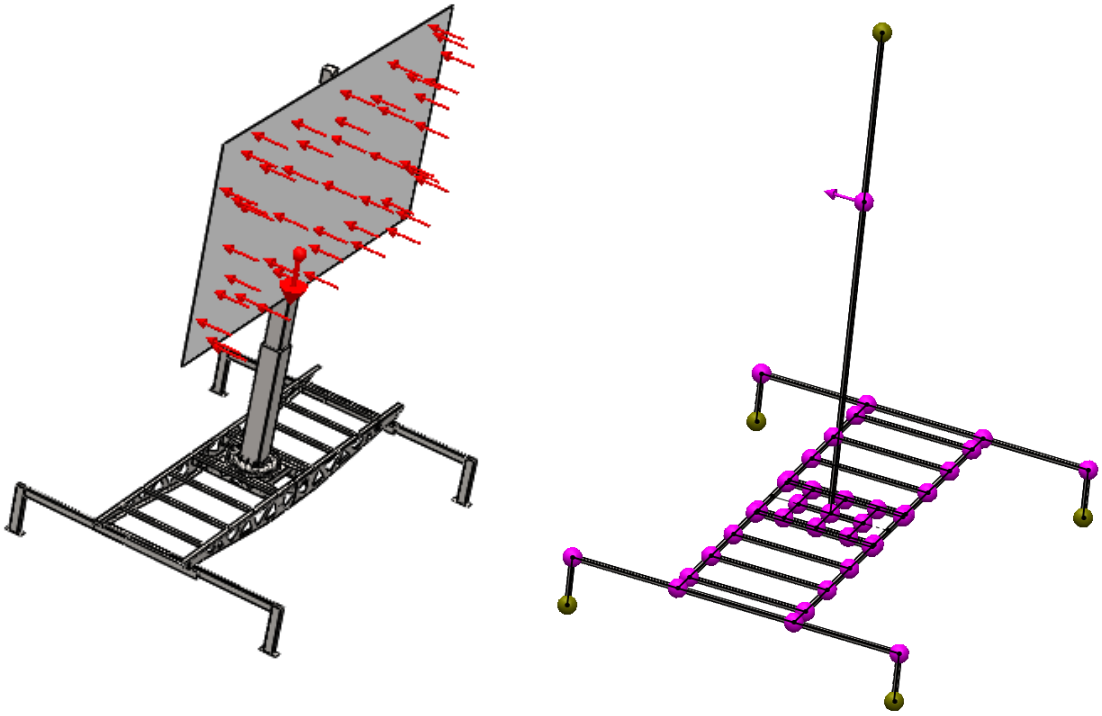
Load case 3: dead weight LED screen

LED screen weight is 553 kg. In main structure it's calculated by the software.

In simplified model weight of screen and difference of screen support is compensated by adding additional force as gravity force.

Load case 4: wind pressure

p_d = 268 N/m^2 ; In accordance that LED screen is 5760x3200 mm the concentrated force to mass gravity of screen is F = 4939 N.



2.1. SECTION PROPERTIES OF STANDART ELEMENTS

All structural elements are made from S355JO steel.

Acc. to EN 10210

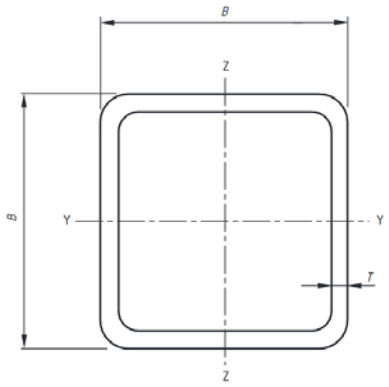


Figure B.2 — Square hollow section

Square hollow sections:

Specified side dimension	Specified thickness	Mass per unit length	Cross-sectional area	Second moment of area	Radius of gyration	Elastic section modulus	Plastic section modulus	Torsional inertia constant	Torsional modulus constant
B	T	M	A	I	i	W_{el}	W_{pl}	I_t	C_t
mm	mm	kg/m	cm^2	cm^4	cm	cm^3	cm^3	cm^4	cm^3
160	6,3	30,1	38,3	1499	6,26	187	220	2333	275
200	6,3	38,0	48,4	3011	7,89	301	350	4653	444
250	6,3	47,9	61,0	6014	9,93	481	556	9238	712
300	6,3	57,8	74	10550	12,0	703	809	16140	1689

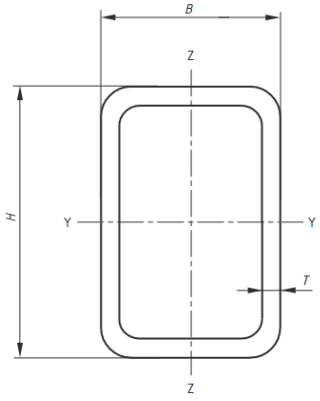
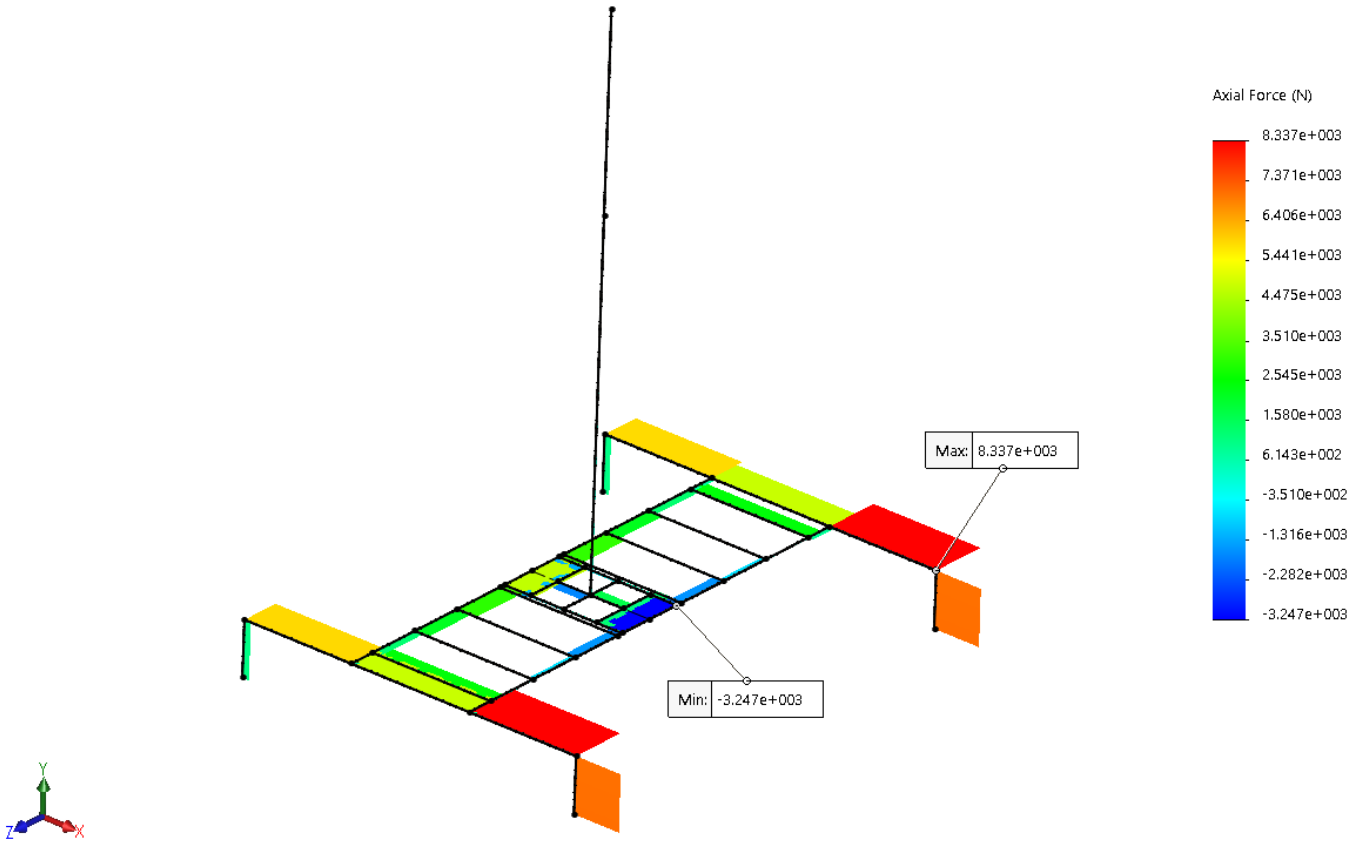
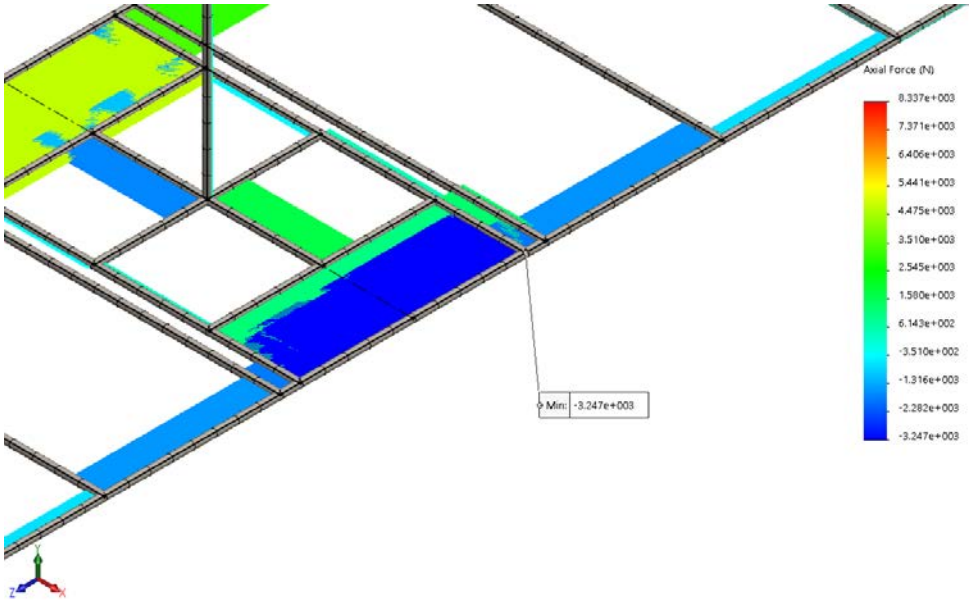


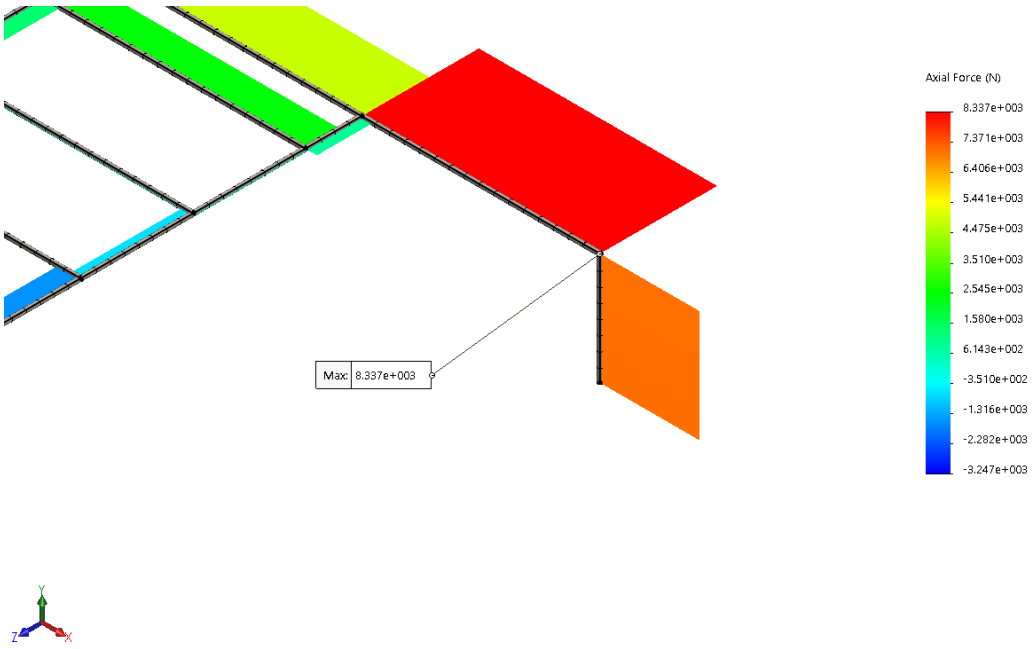
Figure B.3 — Rectangular hollow section

Specified side dimension		Specified thickness	Mass per unit length	Cross-sectional area	Second moment of area		Radius of gyration		Elastic section modulus		Plastic section modulus		Torsional inertia constant	Torsional modulus constant
HxB		T	M	A	I_{yy}	I_{zz}	i_{yy}	i_{zz}	$W_{el,xx}$	$W_{el,yy}$	W_{plyy}	W_{plzz}	I_t	C_t
mm	mm	mm	kg/m	cm^2	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3
140	80	5	16,3	20,7	534	221	5,08	3,27	76,3	55,3	94,3	63,6	499	92

2.2. DIAGRAMS OF FORCES AND FORCE MOMENTS






Axial Force (N)
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7.371e+003
6.406e+003
5.441e+003
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3.510e+003
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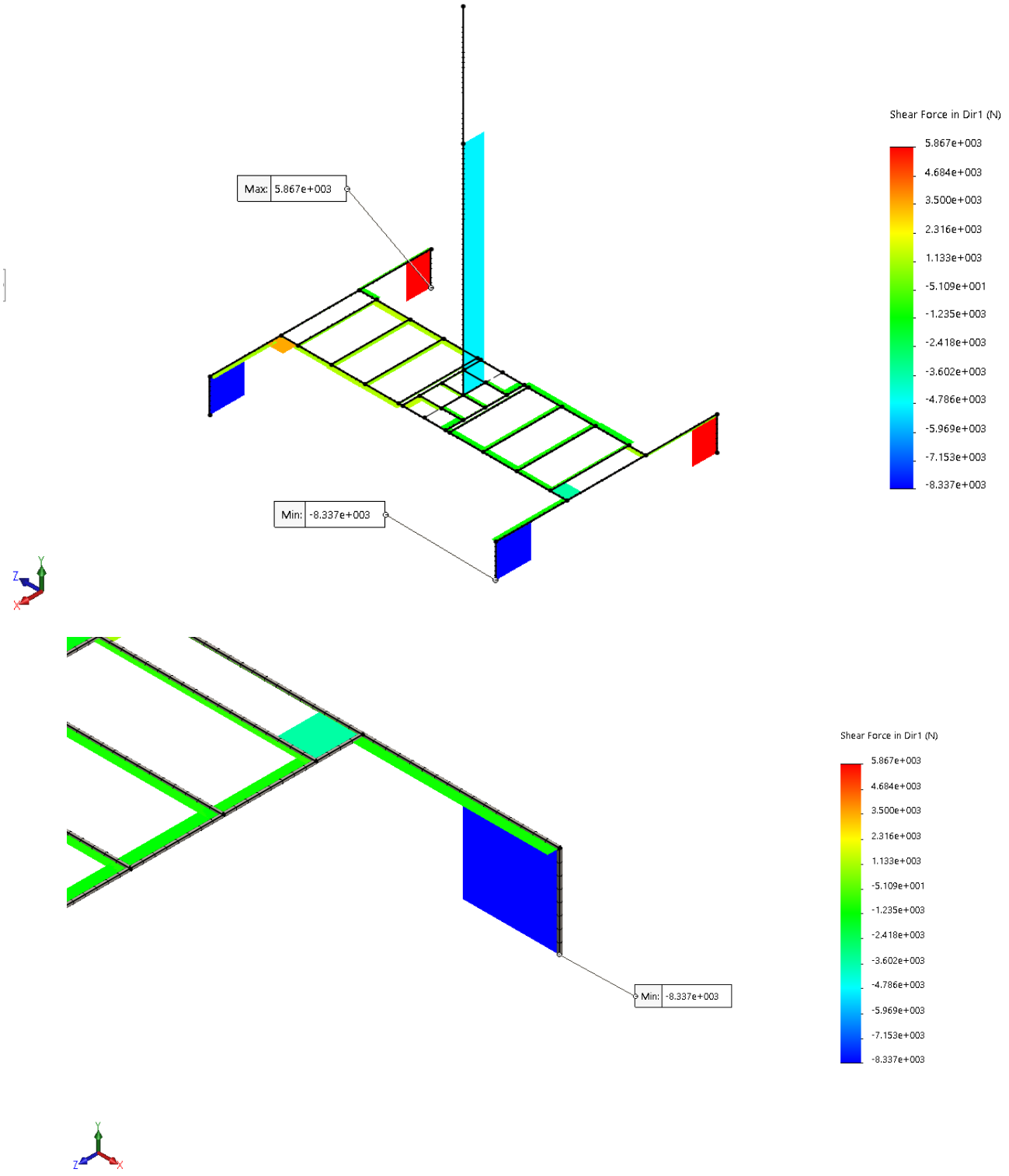
1.580e+003
6.143e+002
-3.510e+002
-1.316e+003
-2.282e+003
-3.247e+003
Max: 8.337e+003
Y
Z
X


Max: 5.867e+003
Min: -8.337e+003
Shear Force in Dir1 (N)
5.867e+003
4.684e+003
3.500e+003
2.316e+003
1.133e+003
-5.109e+001
-1.235e+003
-2.418e+003
-3.602e+003
-4.786e+003
-5.969e+003
-7.153e+003
-8.337e+003
Min: -8.337e+003
Shear Force in Dir1 (N)
5.867e+003
4.684e+003
3.500e+003
2.316e+003
1.133e+003
-5.109e+001
-1.235e+003
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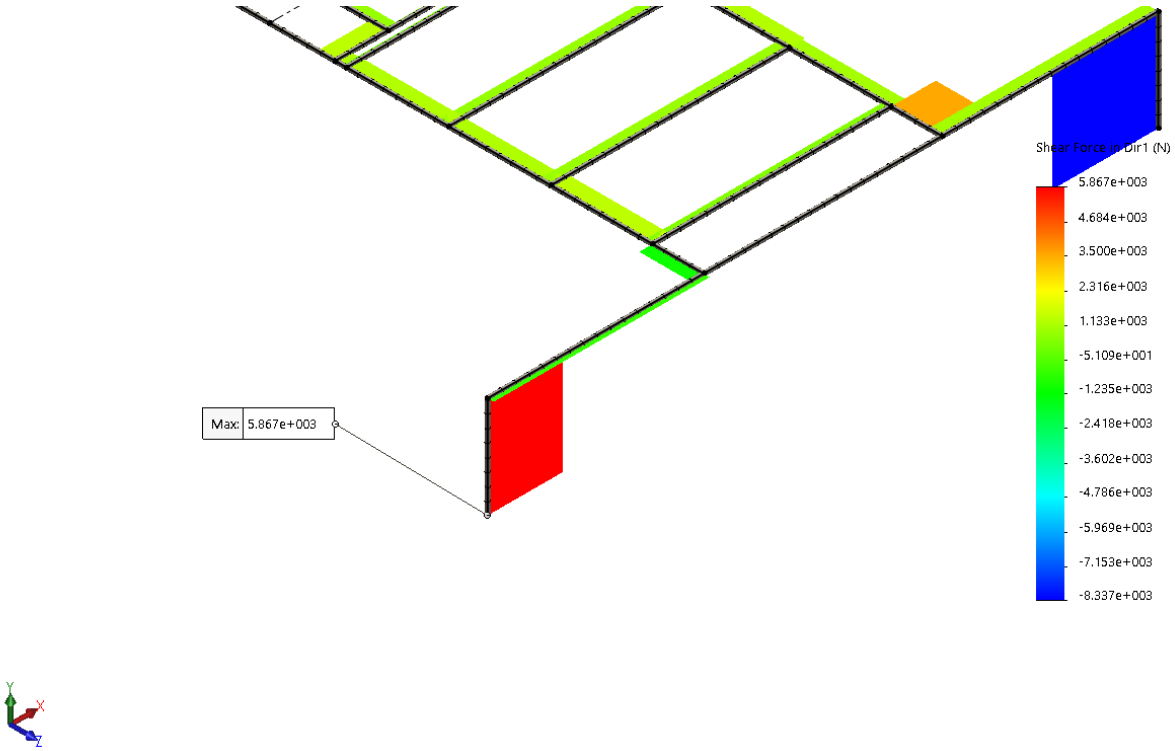
Shear Force in Dir1 (N)
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3.500e+003
2.316e+003
1.133e+003
-5.109e+001
-1.235e+003
-2.418e+003
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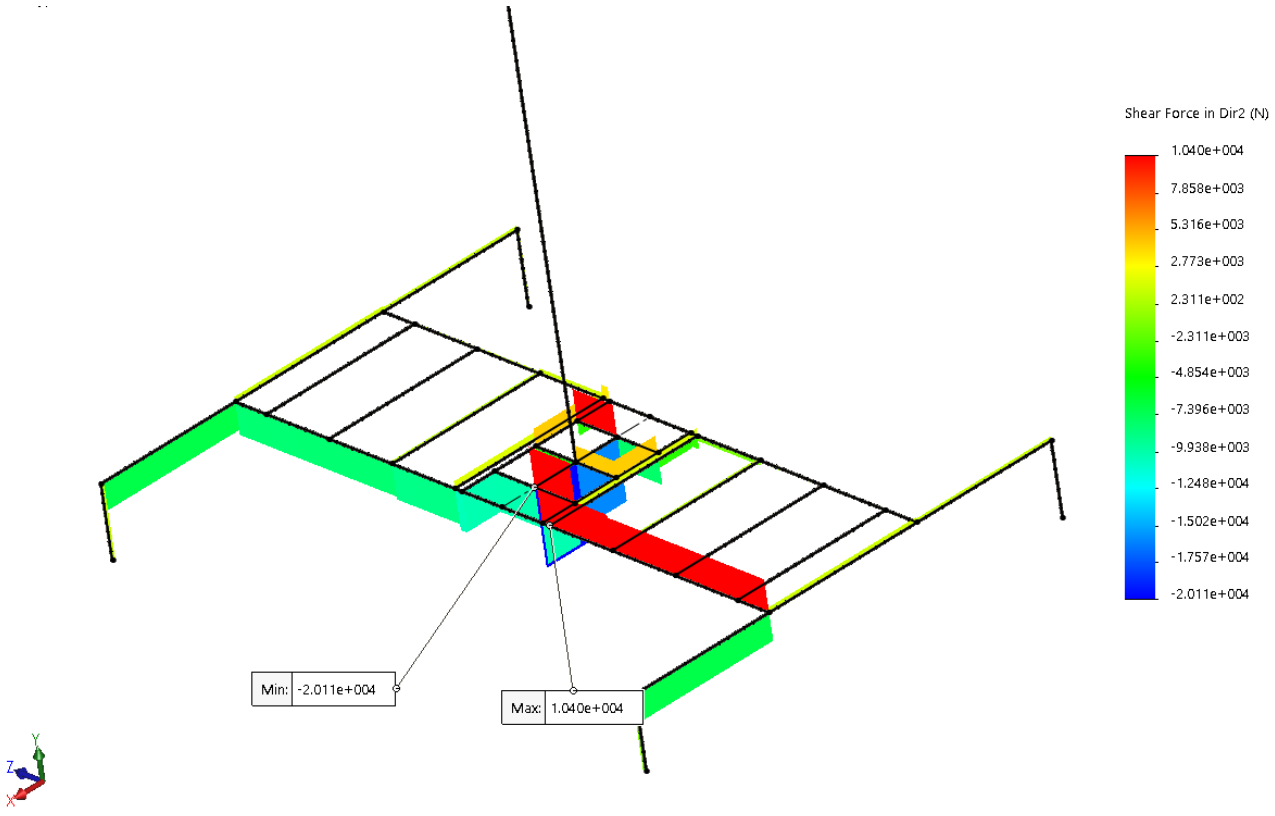
-7.153e+003
-8.337e+003
Max: 5.867e+003


Shear Force in Dir2 (N)
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7.858e+003
5.316e+003
2.773e+003
2.311e+002
-2.311e+003
-4.854e+003
-7.396e+003
-9.938e+003
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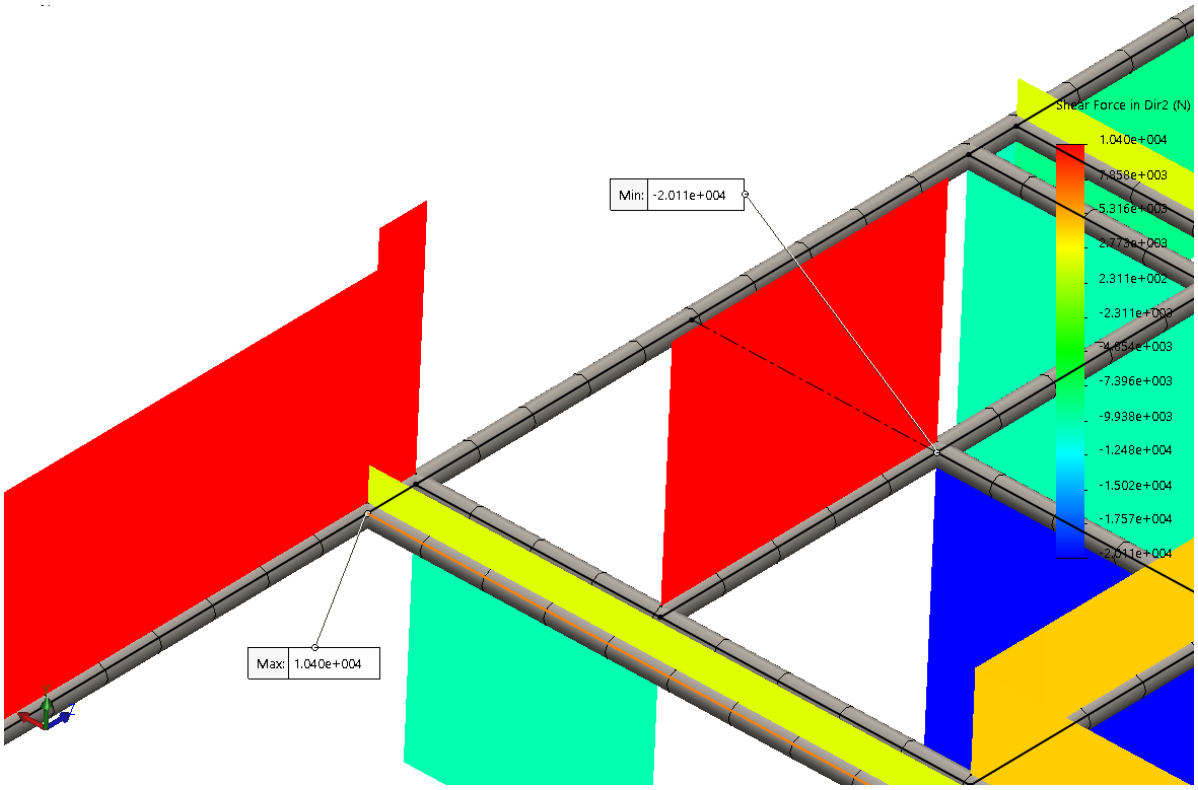
Max: 1.040e+004


Shear Force in Dir2 (N)
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7.858e+003
5.316e+003
2.773e+003
2.311e+002
-2.311e+003
-4.854e+003
-7.396e+003
-9.938e+003
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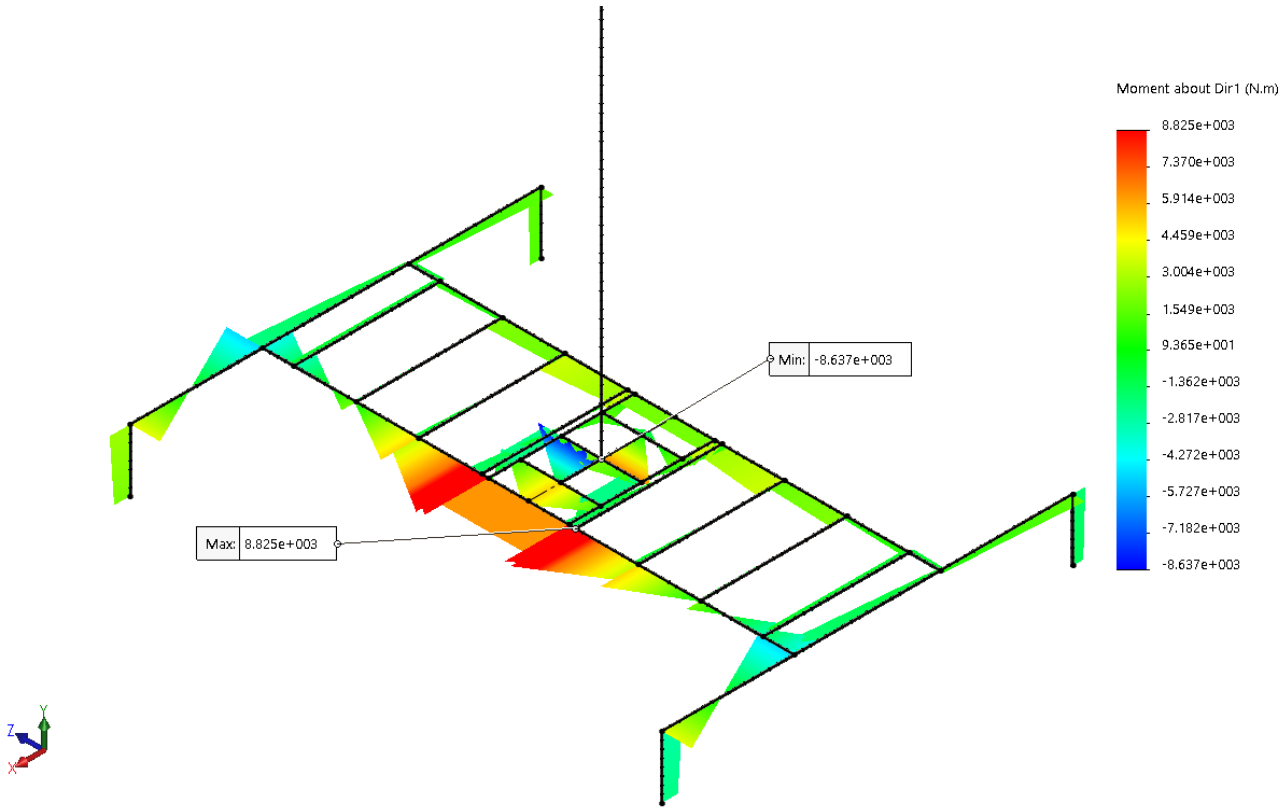
-1.502e+004
-1.757e+004
-2.011e+004
Min: -2.011e+004
Max: 1.040e+004


Moment about Dir1 (N.m)
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7.370e+003
5.914e+003
4.459e+003
3.004e+003
1.549e+003
9.365e+001
-1.362e+003
-2.817e+003
-4.272e+003
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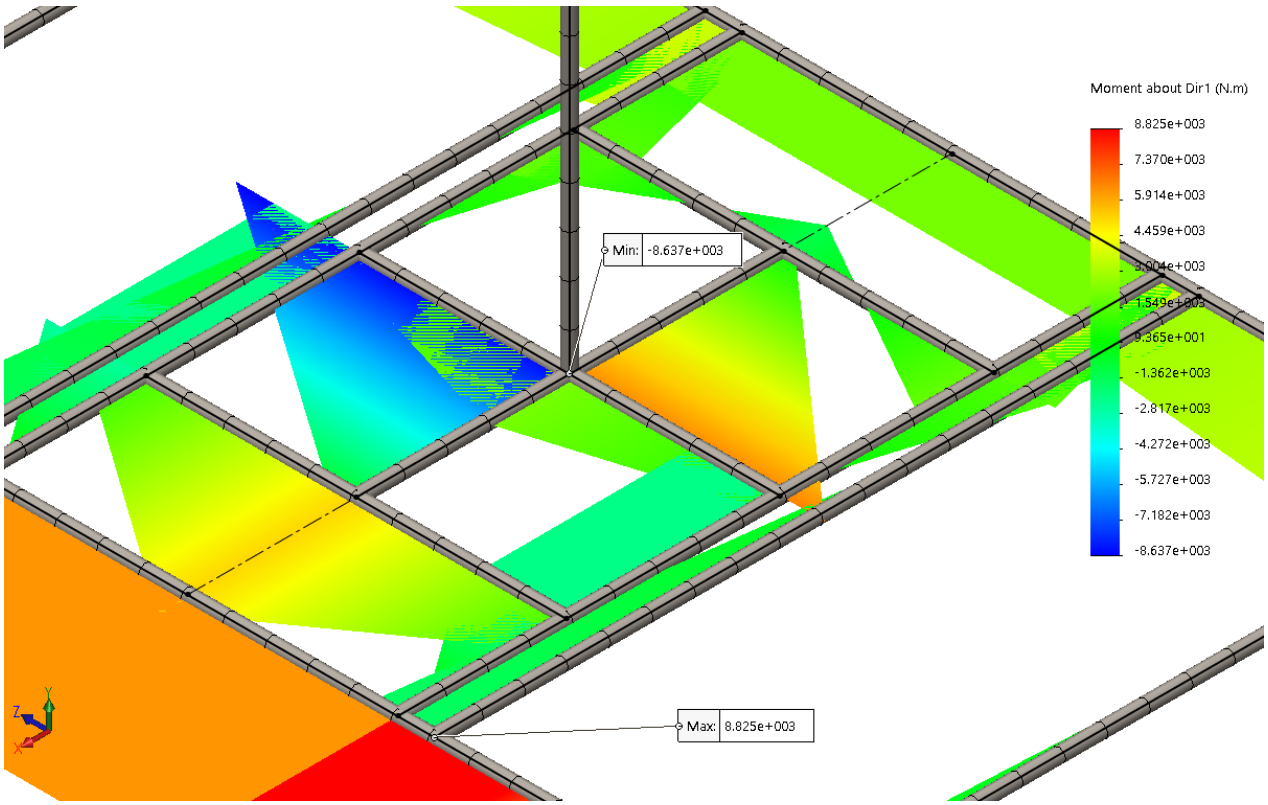
Max: 8.825e+003
Z
X


Moment about Dir1 (N.m)
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7.370e+003
5.914e+003
4.459e+003
3.004e+003
1.549e+003
9.365e+001
-1.362e+003
-2.817e+003
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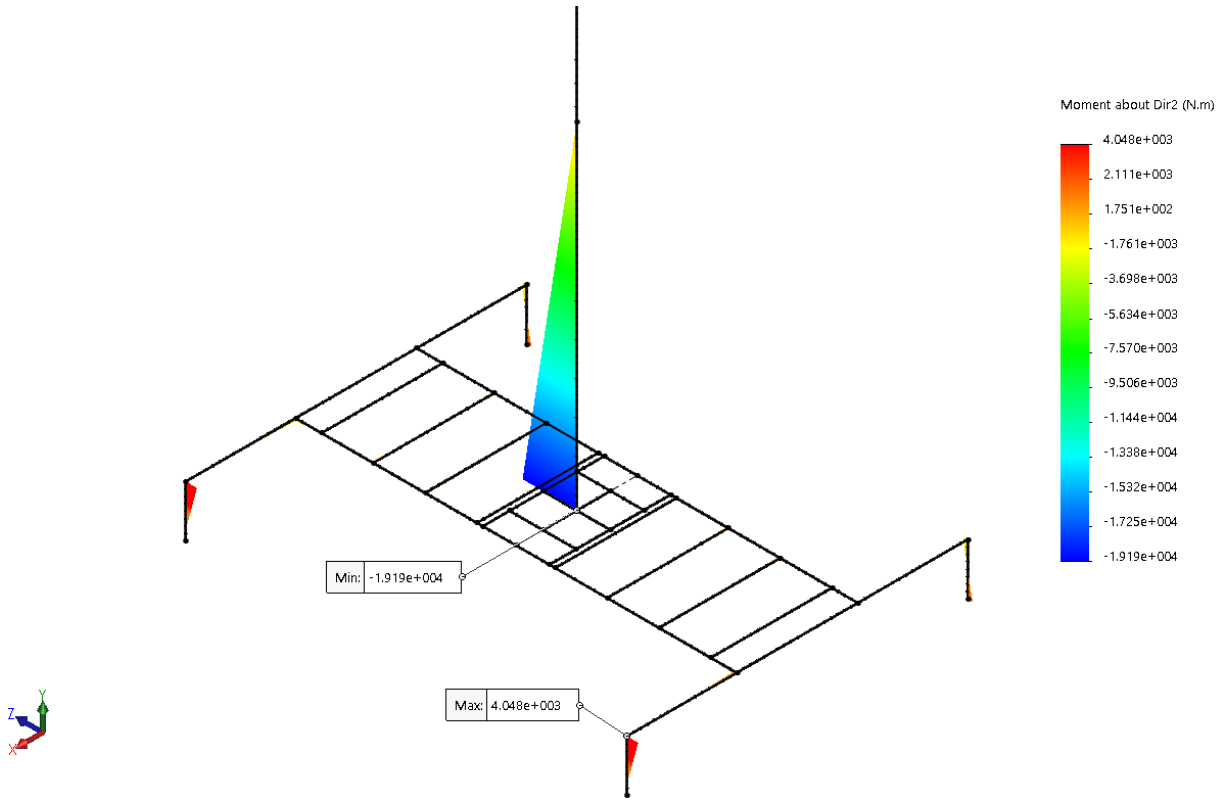
-8.637e+003
Min: -8.637e+003
Max: 8.825e+003
Z
X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-5.634e+003
-7.570e+003
-9.506e+003
-1.144e+004
-1.338e+004
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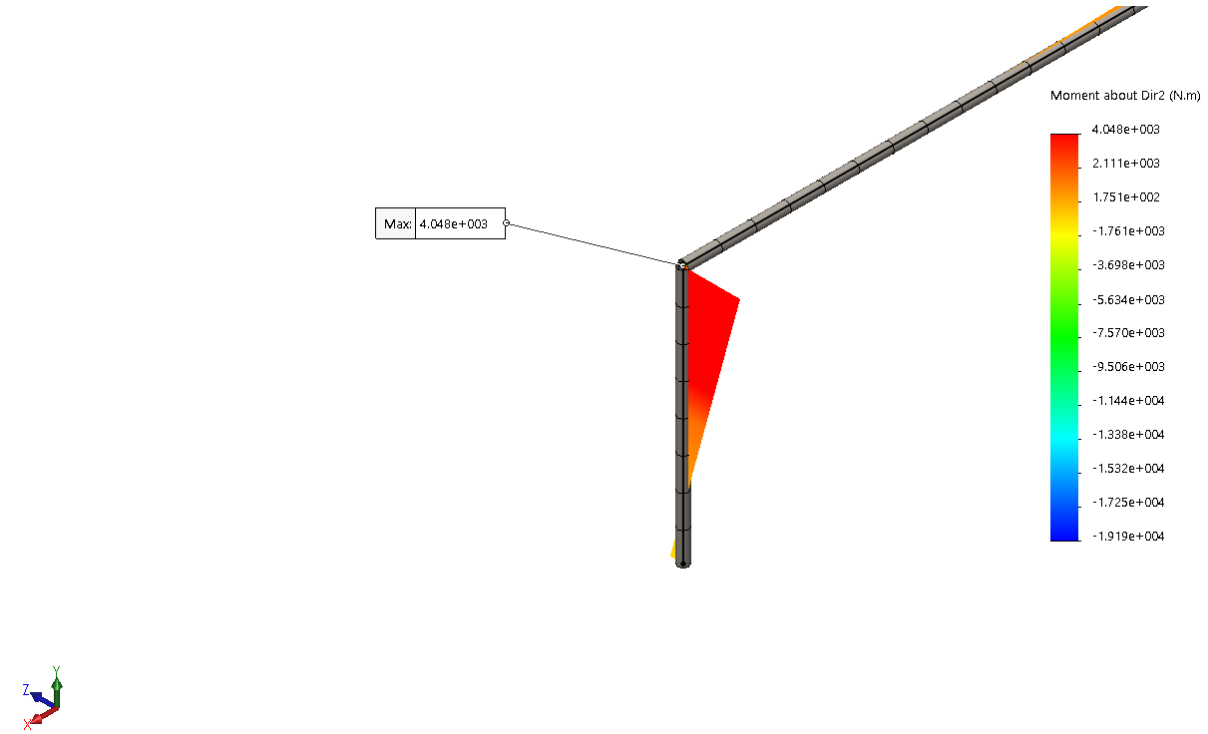
Min: -1.919e+004
Max: 4.048e+003
Z
X


Moment about Dir2 (N.m)
4.048e+003
2.111e+003
1.751e+002
-1.761e+003
-3.698e+003
-5.634e+003
-7.570e+003
-9.506e+003
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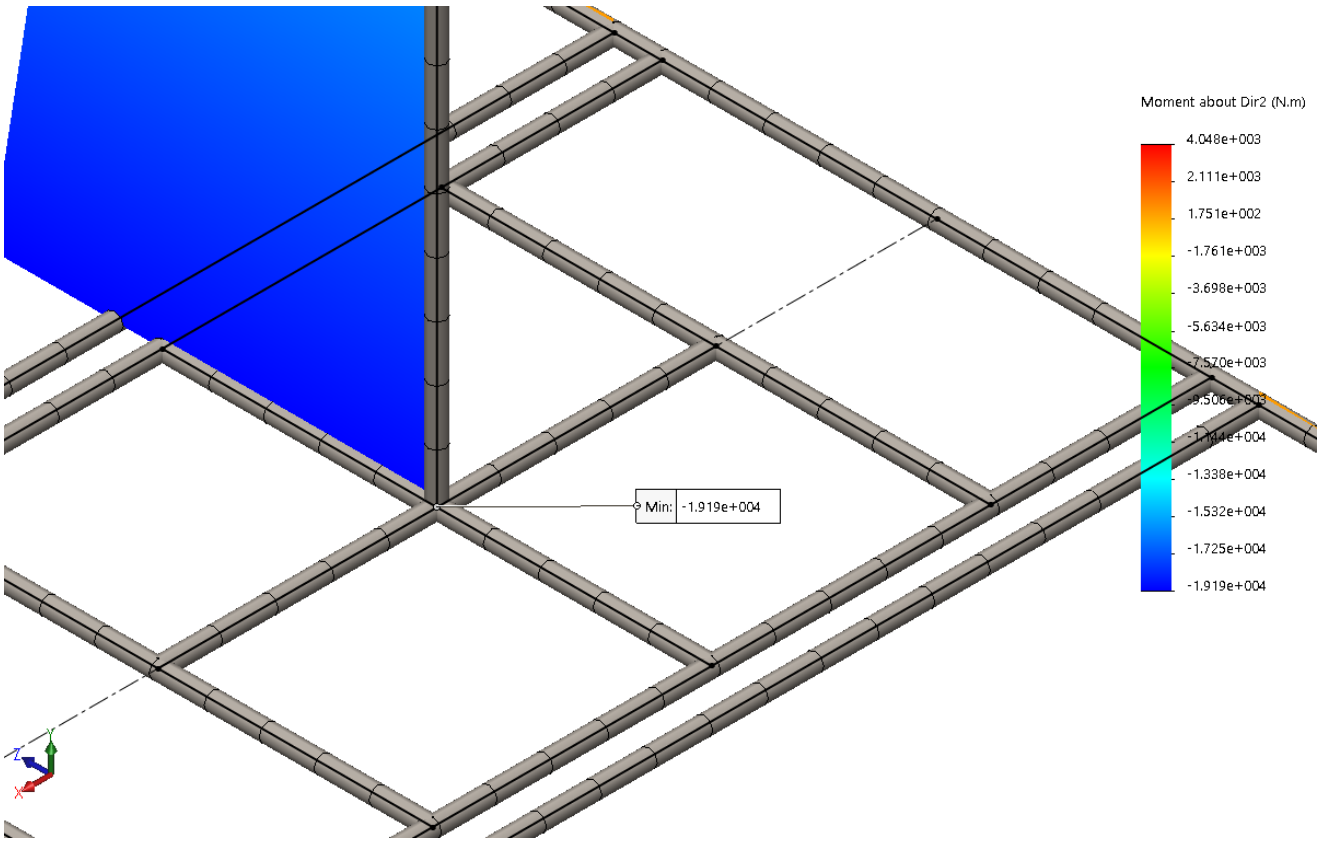
-1.919e+004
Max: 4.048e+003
Z
X


Moment about Dir2 (N.m)
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2.111e+003
1.751e+002
-1.761e+003
-3.698e+003
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-7.570e+003
-9.506e+003
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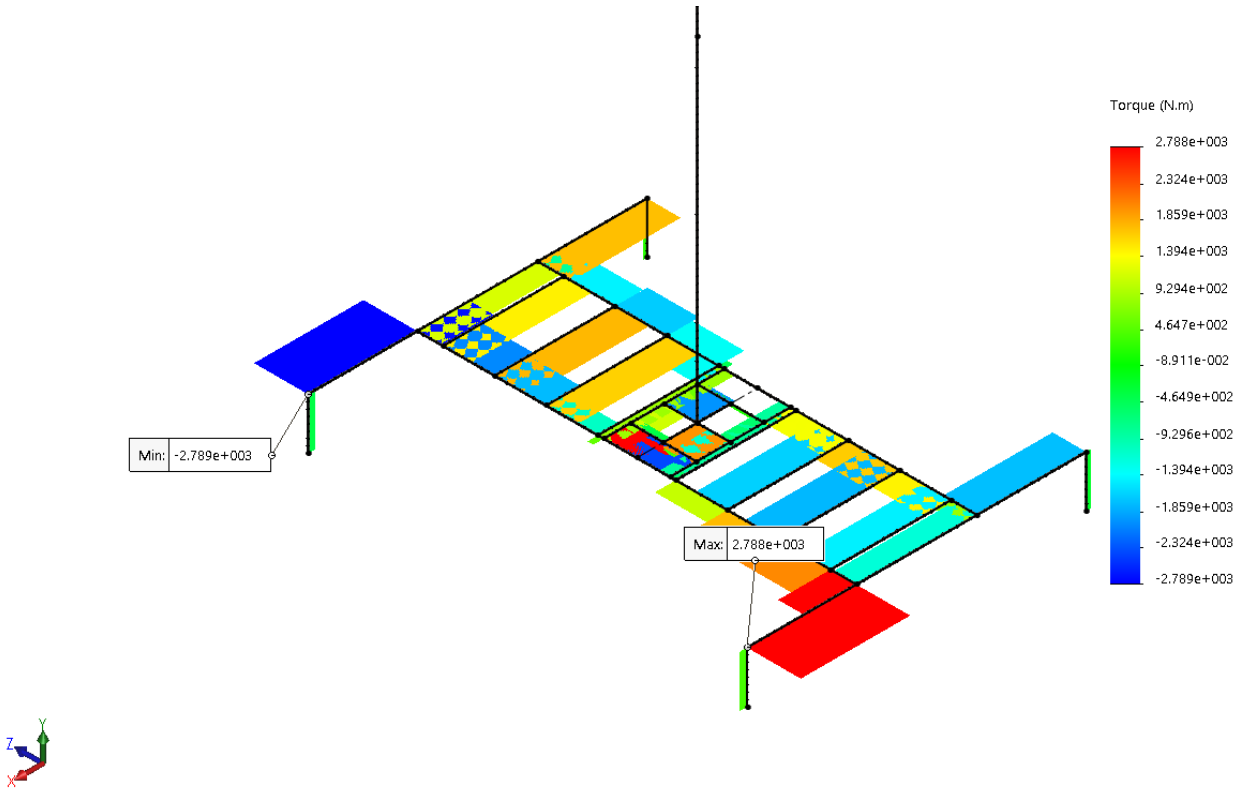
-1.919e+004
Min: -1.919e+004


Torque (N.m)
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2.324e+003
1.859e+003
1.394e+003
9.294e+002
4.647e+002
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-4.649e+002
-9.296e+002
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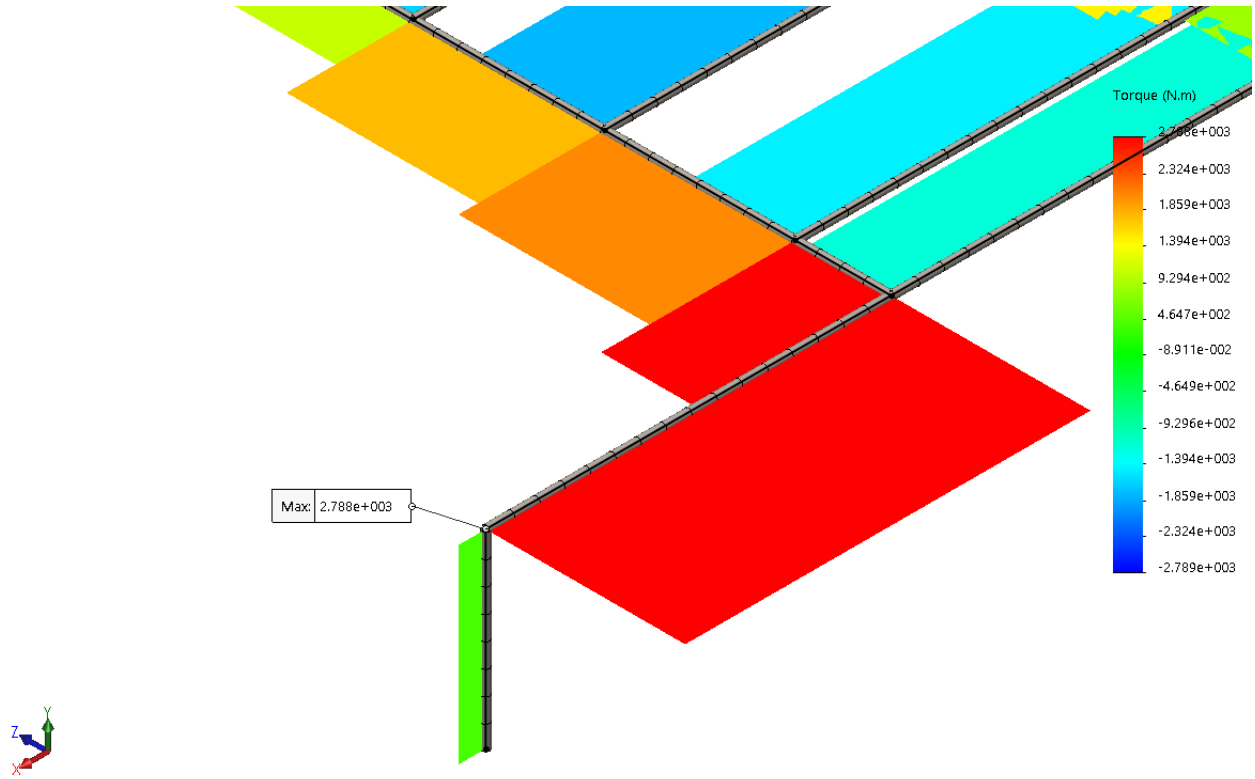
Max: 2.788e+003


Torque (N.m)
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1.394e+003
9.294e+002
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-8.911e-002
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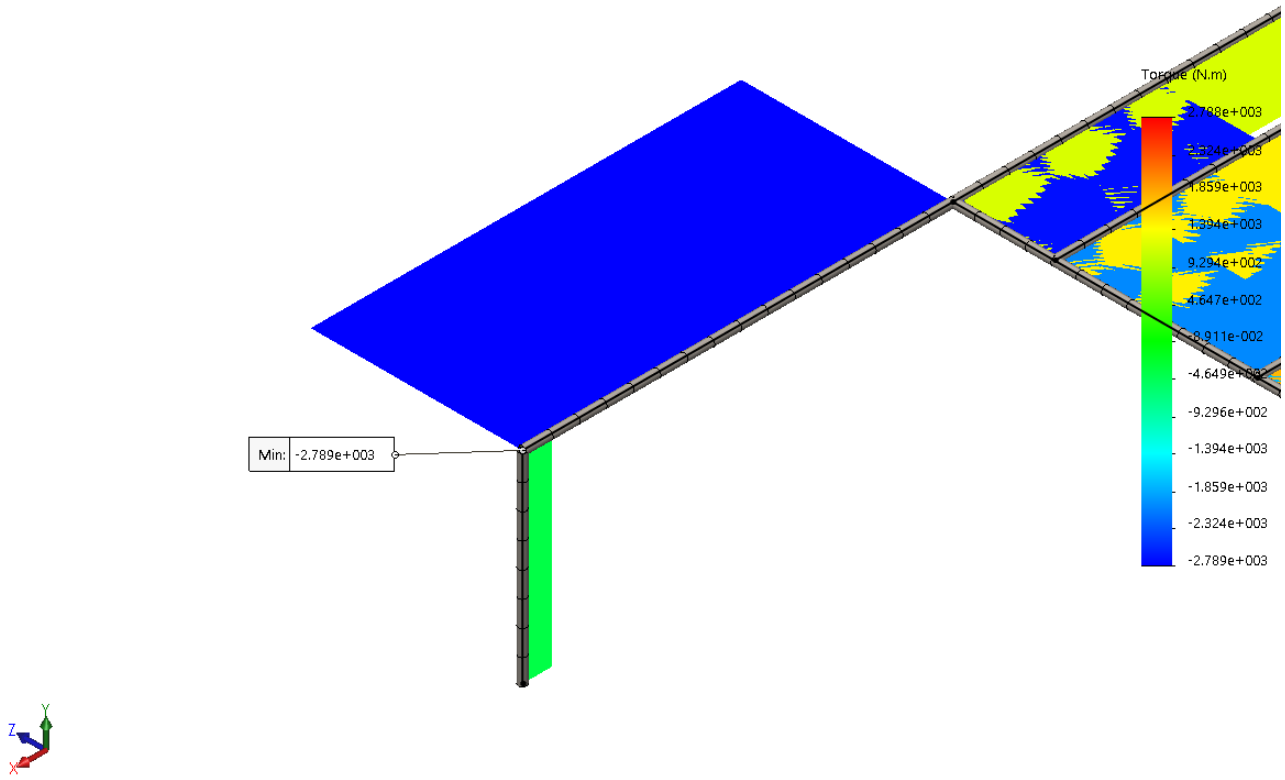
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-1.394e+003
-1.859e+003
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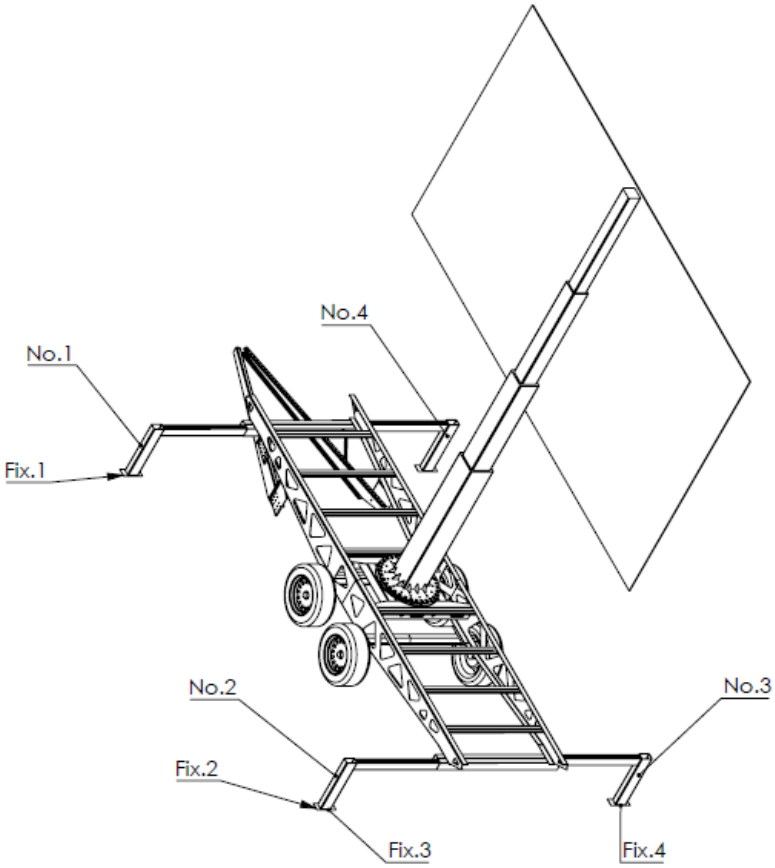
-2.789e+003
Min: -2.789e+003
Y
Z
X

2.3. STRUCTURE ROLLING OVER POSSIBILITY



To imitate rolling over possibility advanced fixtures were used.

Fix.1 and Fix.2 was fixed on supporting legs edges. These fixtures constrained movement along X axis but allowed rolling about Z axis.

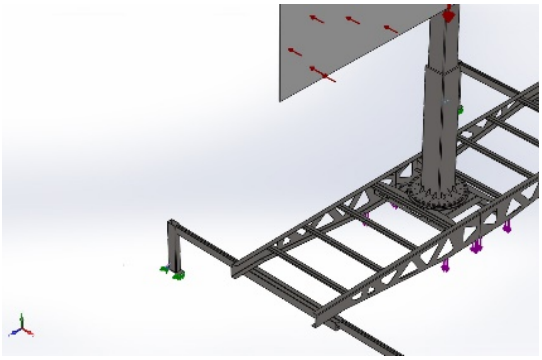
Fix.3 and Fix.4 was fixed on supporting legs faces. These fixtures constrained movement along Z axis.

Legs No.1-4 were fixed by sliders. Sliders allowed movement along X and Z axis but constrained movement along Y axis.

The method to define if trailer will roll over is based on comparison of reaction forces in supporting legs. If reaction forces in supporting legs No.1-4 has positive value that means that supporting leg is resisting force created by gravity forces of trailer elements. If reaction forces are negative that means that leg is dragged upward Y axis which means rolling over.

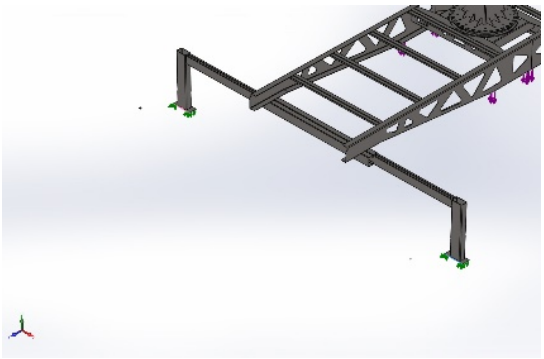
Fix.1 and Fix.2 :

Components	X	Y	Z	Resultant
Reaction force(N)	4939.78	0	0	4939.78
Reaction Moment(N.m)	0	0	0	1e-033



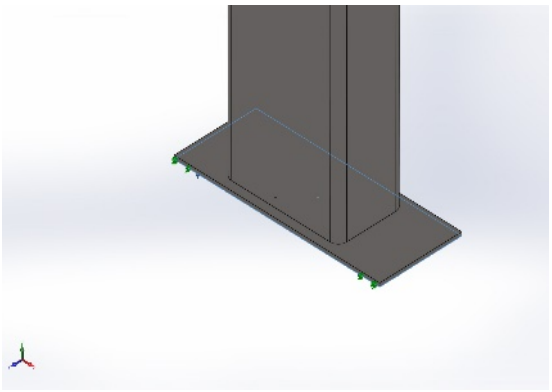
Fix.3 and Fix.4 :

Components	X	Y	Z	Resultant
Reaction force(N)	0	0	9.91821e-005	9.91821e-005
Reaction Moment(N.m)	0	0	0	1e-033



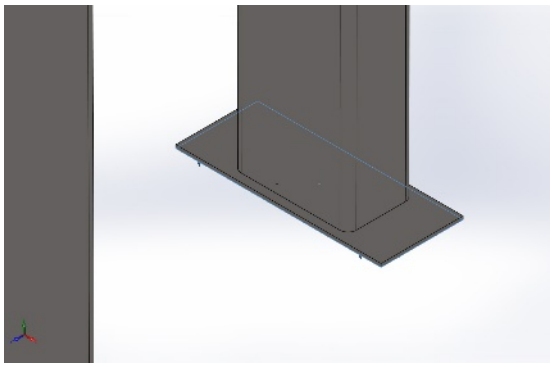
Reactions in No.1 supporting leg:

Components	X	Y	Z	Resultant
Reaction force(N)	2472.68	7326.13	-56.1063	7732.37
Reaction Moment(N.m)	0	0	0	1e-033



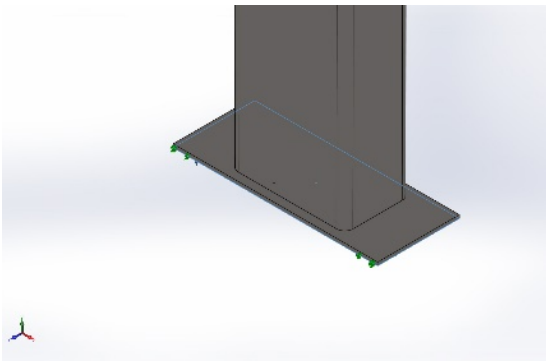
Reactions in No.2 supporting leg:

Components	X	Y	Z	Resultant
Reaction force(N)	2467.1	7376.77	0	7778.38
Reaction Moment(N.m)	0	0	0	1e-033



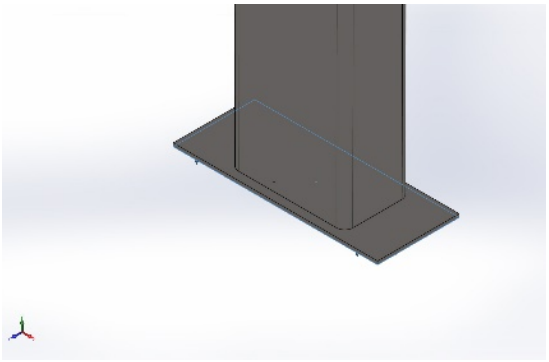
Reactions in No.3 supporting leg:

Components	X	Y	Z	Resultant
Reaction force(N)	0	465.074	56.1064	468.446
Reaction Moment(N.m)	0	0	0	1e-033



Reactions in No.4 supporting leg:

Components	X	Y	Z	Resultant
Reaction force(N)	0	491.786	0	491.786
Reaction Moment(N.m)	0	0	0	1e-033



Sum forces:

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	4939.78	15659.8	9.91821e-005	16420.4

Sum moments:

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	1e-033

2.4. STRESS ANALYSIS

Mesh information:

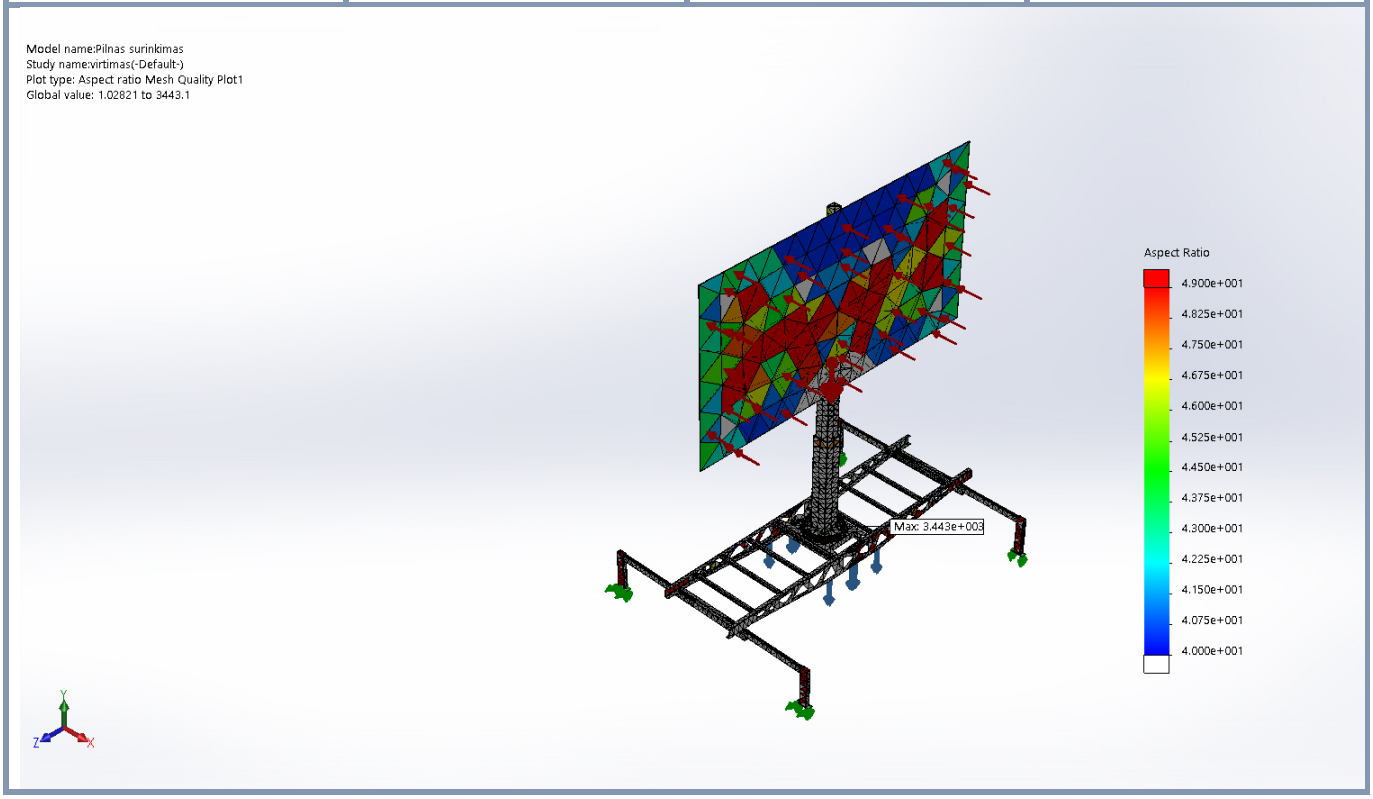
Mesh type	Mixed Mesh
Mesher Used:	Blended curvature-based mesh
Jacobian points	4 Points
Jacobian check for shell	On
Maximum element size	500 mm
Minimum element size	100 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	On

Mesh information – Details:

Total Nodes	44313
Total Elements	21188

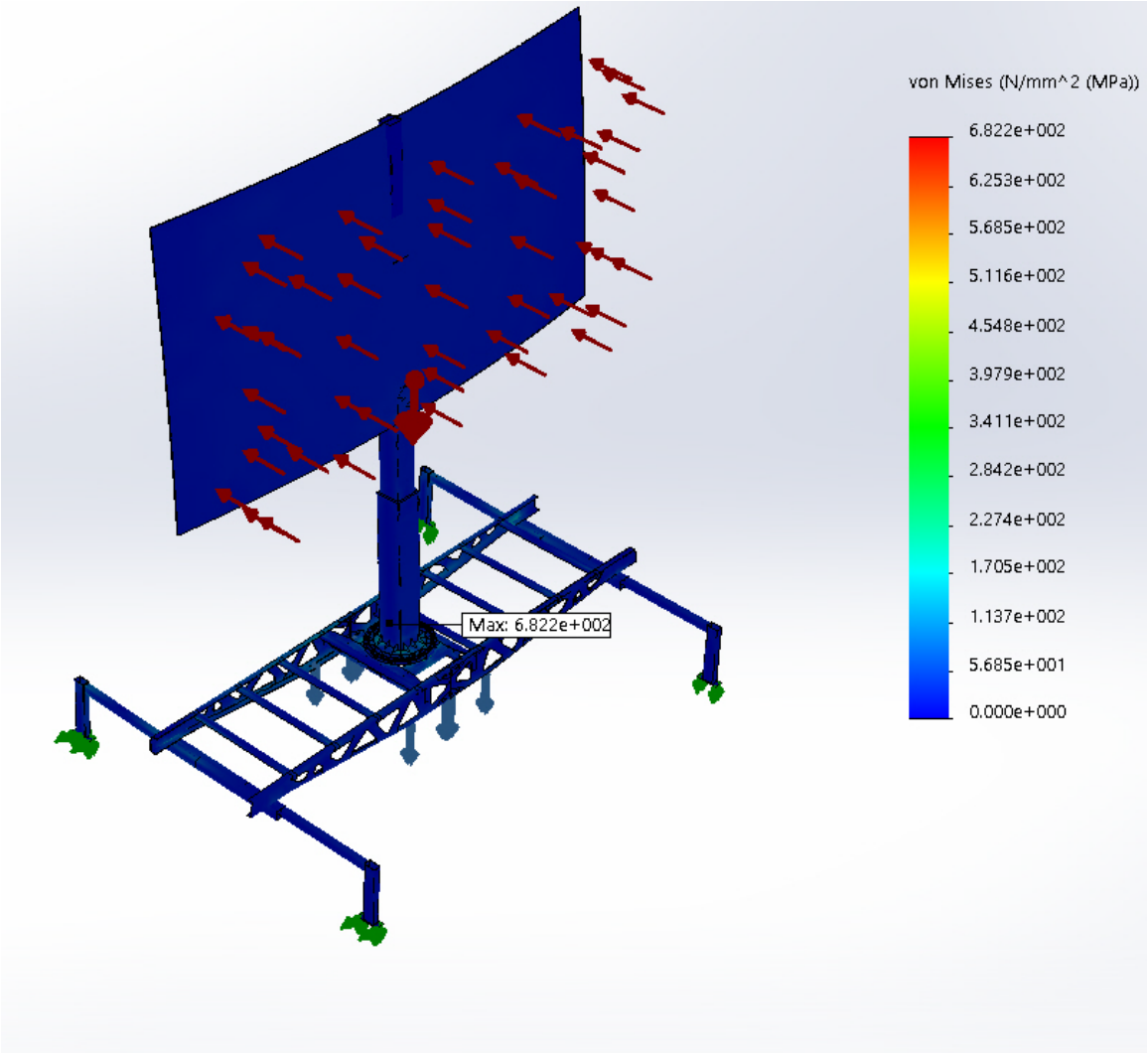
Mesh quality plots:

Name	Type	Min	Max
Mesh Quality Plot1	Aspect Ratio	1.028e+000 Element: 401	3.443e+003 Element: 20402

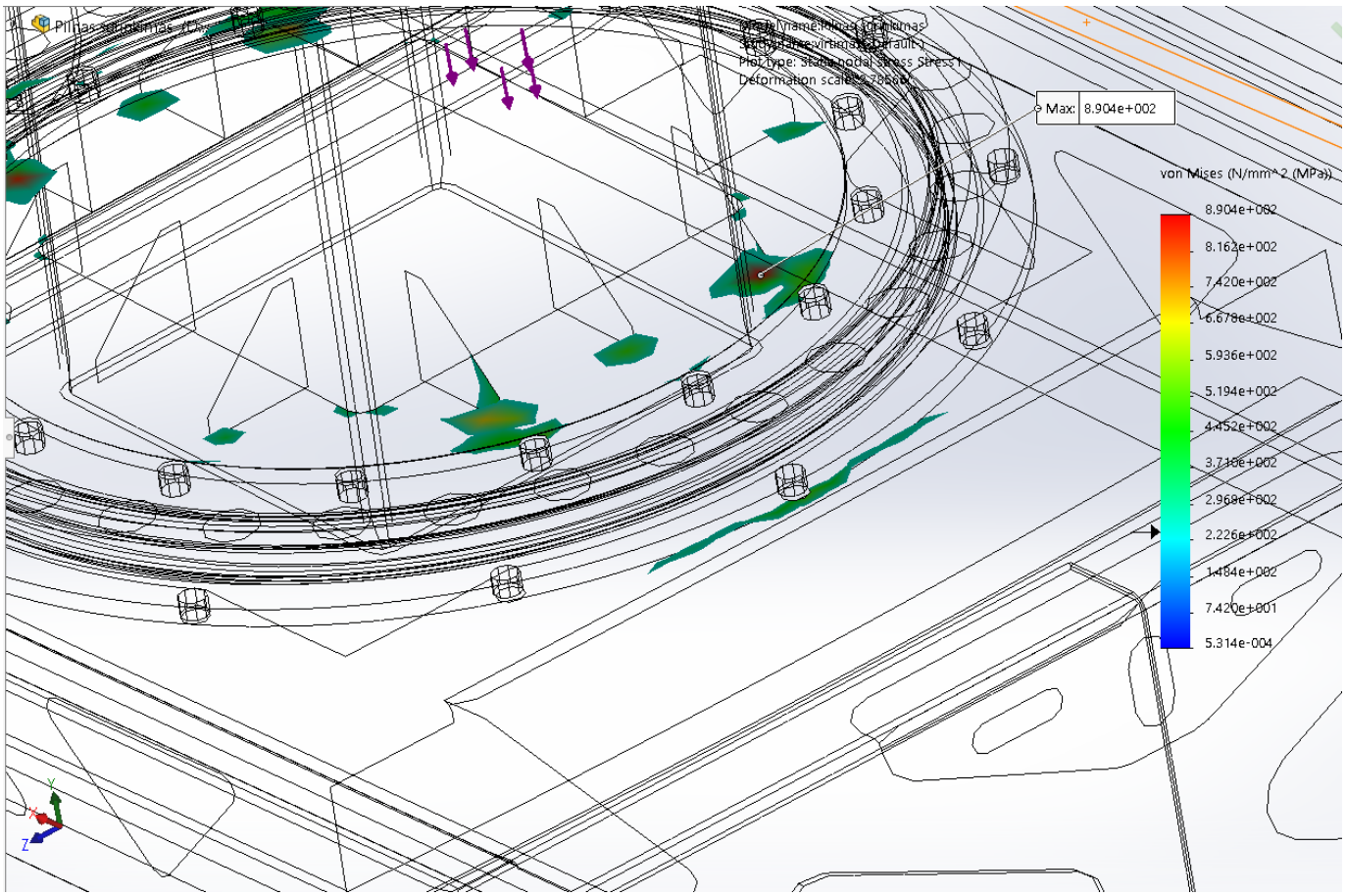


Safety factor on truss: 1,50

$$\sigma_{all} = \frac{\sigma_y}{SF} = \frac{355}{1{,}50} = 237\ MPa$$



Stress singularities over 240 MPa:



2.5. PROOF OF BEARING

In trailer used bearing is: SD.750.20.00.C