Base Load Power Hub (BLPH)

B-300 STRUCTURAL CALCULATION - E&I SHELTERS

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ALEXSISTEMI s.p.a.

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1 INTRODUCTION

1.2 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.2.1 PROJECT LOCATION

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

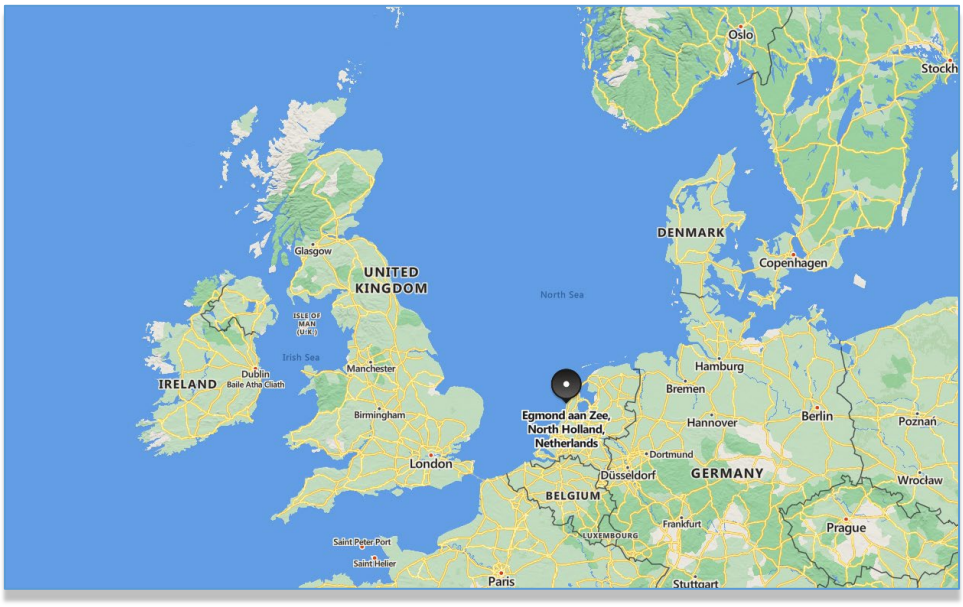


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

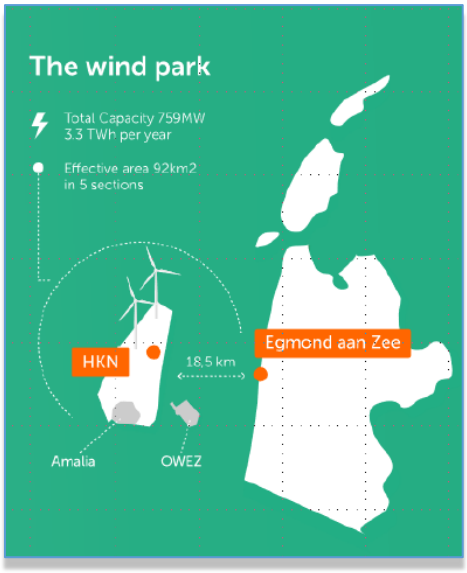


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.2.2 PROJECT CONCEPT

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

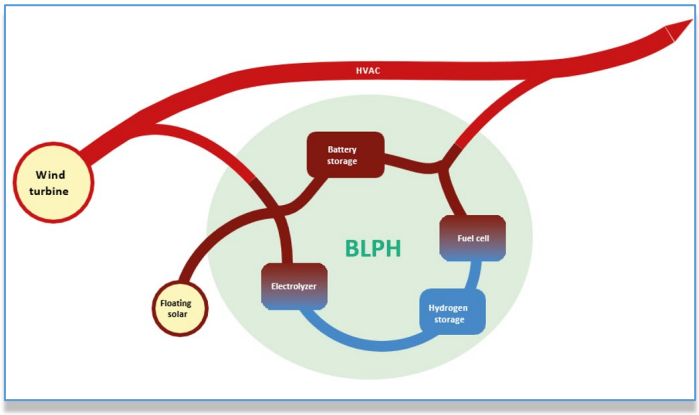


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

2 DOCUMENT SCOPE

Structural report.

2.2 REFERENCES

Doc. No.	Description
123A90-DDL-ST-SP-90017 Rev.01	Structural design basis
123A90-DDL-IN-DL-40012 Rev.01_OPEN	BLPH off-shore iter equipment layout

Table 1 - Reference Documents

2.3 DEFINITIONS AND ABBREVIATIONS

COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Table 2 - Definitions and Abbreviations

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3 PURPOSE OF WORK

The B300 (UPS equipment room), which is the object of the following report, has been design and build by Alex Sistemi S.p.A.

This calculation report describes the structural analysis of steel room, that will be placed off the coast of Netherlands near the town of Egmond aan Zee. This report summarizes the results of the analyses performed to evaluate the actual stress path and strength verification on the cabin in the worst condition among those feasible.

The following conditions have been considered for the analyses:

- Dead load;
- Live load;
- Wind load;
- Sea transport;
- Lifting.

The structure has been diagrammed so as to allow calculation by use of a computer program for finite element analysis. The structure has been calculated using SAP2000 v.25 for the finished elements (FEM) and Femap Nastran 2401 for solid models of lifting lug and corrugated panel.

1.1 CODES AND STANDARDS

For structural ULS, SLS and lifting design of has been used Eurocodes.

- EN 1993-1-1 2005 Eurocode specifications for steel building;
- 0027 ND rev. 11 Guideline for lifting Noble Denton.

1.2 UNITS

- Density [kg/m^3];
- Length [m], [mm];
- Mass [kg], [ton]= 1000 [kg];
- Force [N], [kN] = 1000 [N];
- Area Load [kN/m^2];
- Temperature [°C];
- Stress [MPa] = [N/mm^2];

1.3 MATERIALS

- Framing structure and panelling EN S355J0:
  - Modulus of elasticity E=210000 N/mm^2
  - Modulus of rigidity G=81000 N/mm^2
  - Tensile stress breakage fr>=470 N/mm^2
  - Yield stress fy=355 N/mm^2

- Ultimate elongation percentage A=22%

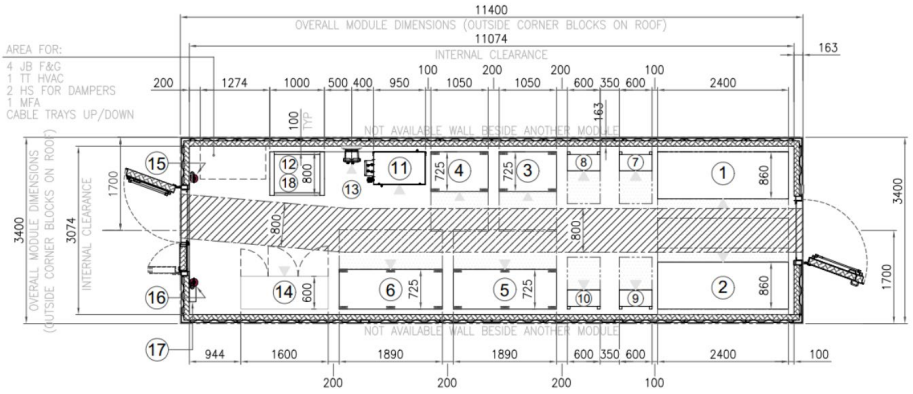
- **Welding steel dependent of welded section material:**
  - Structural steel with a yield stress of at least 300 MPa matching electrode ultimate tensile strength X_u=490 N/mm^2.

- **Bolting ASTM A325:**
  - Tensile ultimate stress fu=830 N/mm^2
  - Yield stress fy=660 N/mm^2

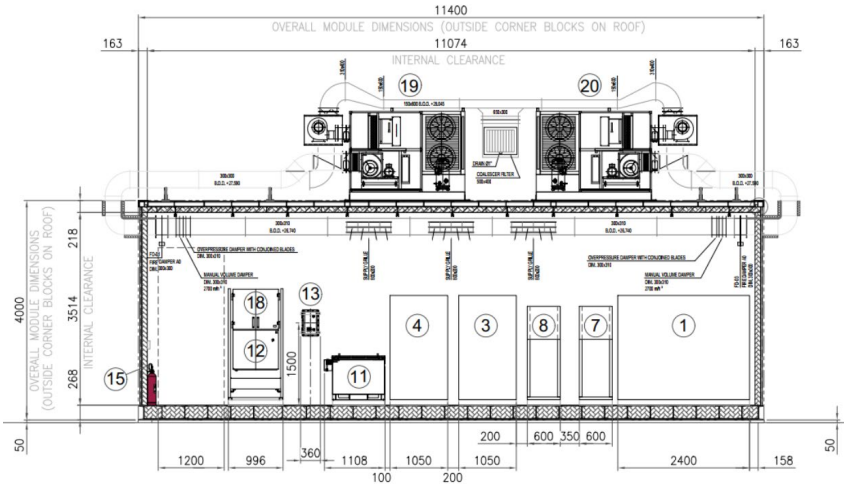
1.4 GENERAL DESCRIPTION

The structure has finished dimensions:

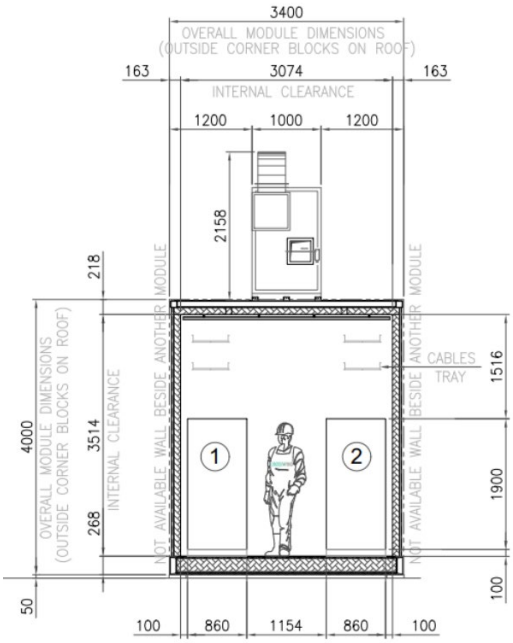
- Maximum lenght: 11400 mm;
- Maximum width: 3400 mm;
- Height: 4000 mm.



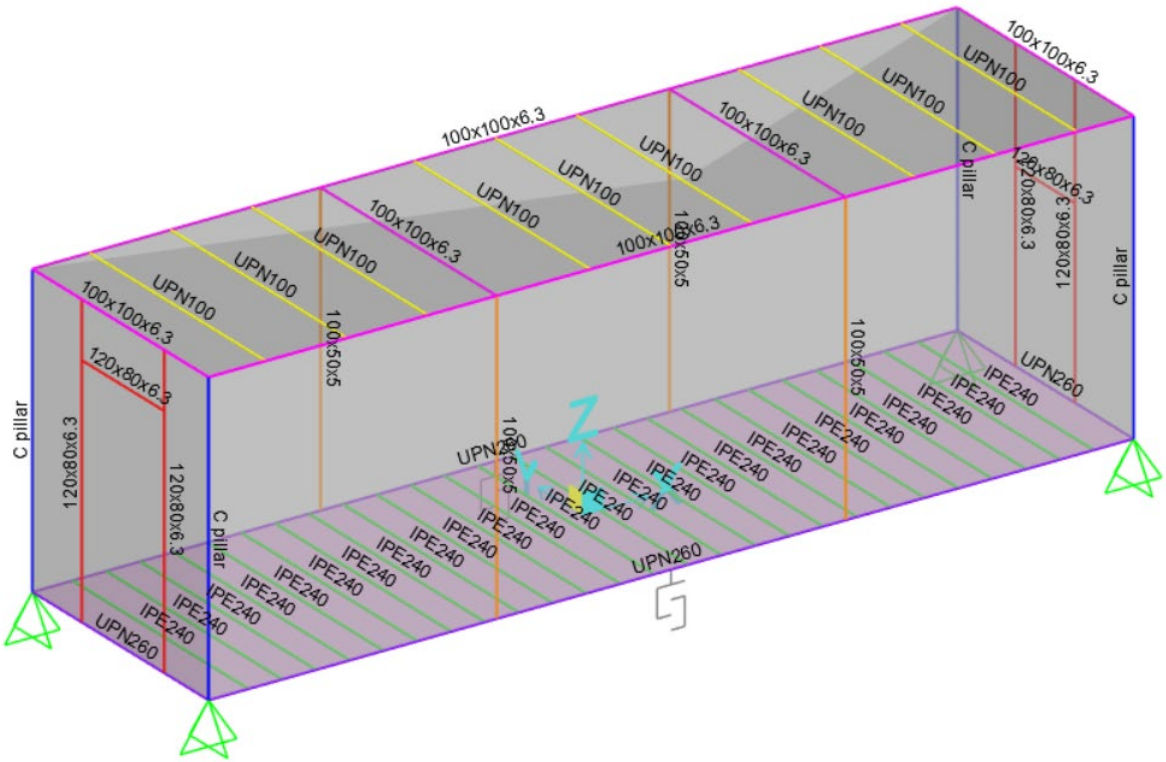
PLAN VIEW

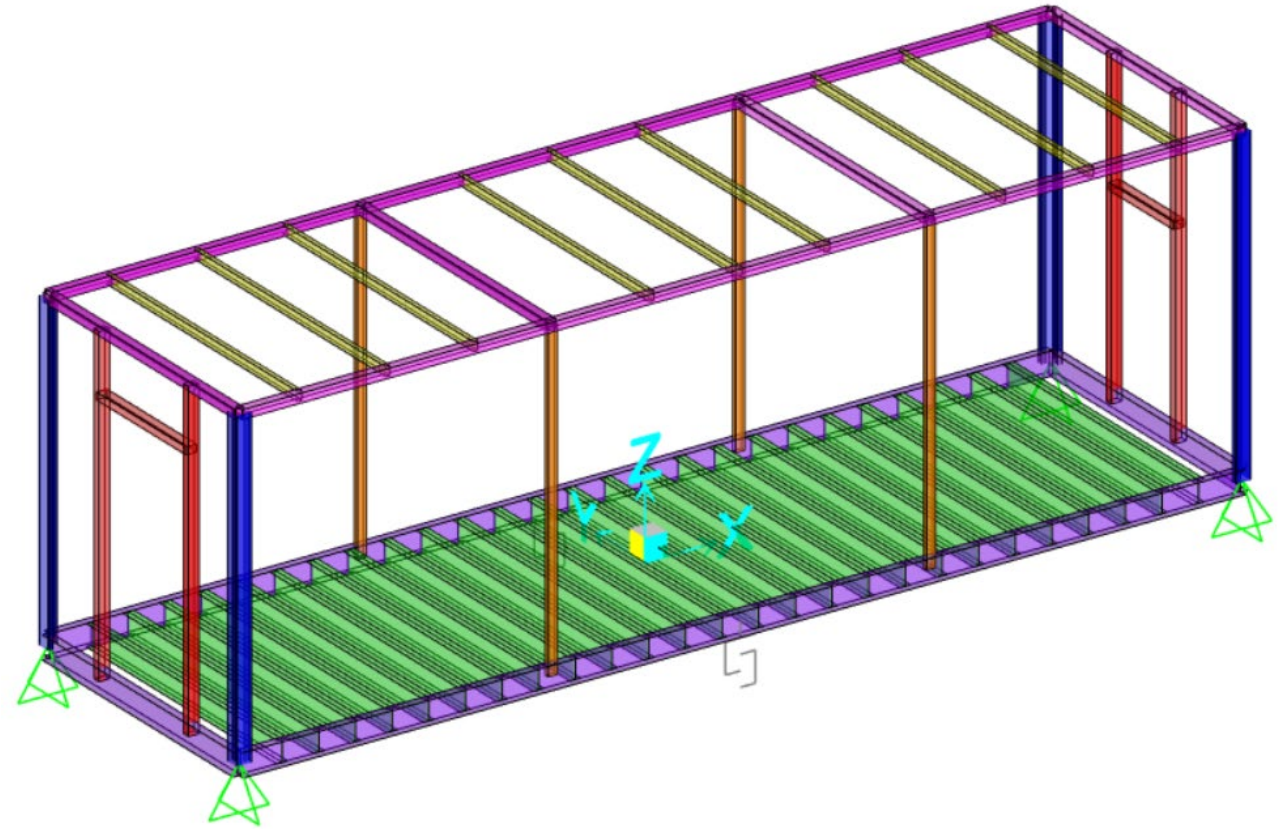


LONG SIDE VIEW



Below is shown the summary of all sections, also identified by color.





- Corrugated wall sheet thickness 3 mm;
- Roof sheet stave thickness 6 mm;
- Floor metal sheet thickness 6 mm.

TABLE: Area Section Properties

Section	Material	MatAngle	AreaType	Type	DrillDOF	Thickness	BendThick	Color	TotalWt	TotalMass
Text	Text	Degrees	Text	Text	Yes/No	m	m	Text	KN	KN-s2/m
Corrugate 3mm	S355	0	Shell	Shell-Thin	Yes	0.003	0.003	Gray	36.631	3.74
Metal sheet 6mm	S355	0	Shell	Shell-Thin	Yes	0.006	0.006	Gray	20.215	2.06
Roof stave 6mm	S355	0	Shell	Shell-Thin	Yes	0.006	0.006	Gray	21.9	2.23

TABLE: Area Section Properties

Section	F11Mod	F22Mod	F12Mod	M11Mod	M22Mod	M12Mod	V13Mod	V23Mod	MMod	WMod
Text	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless
Corrugate 3mm	1	1	1	1	261	1	1	1	1.5	1.5
Metal sheet 6mm	1	1	1	1	1	1	1	1	1.2	1.2
Roof stave 6mm	1	1	1	1	613	1	1	1	1.3	1.3

The mass and weight multiplier for the flat sheet representing the C-stave wall, is evaluated about 90% more than the equivalent flat sheet of the same thickness (4 mm of thickness) as is possible to see on the following pages.

The structural skeleton is made with combinations of different types of section, listed below:

TABLE: Frame Section Properties 01 - General

SectionName	Material	Shape	t3	t2	tf	tw	t2b	tfb	FilletRadius	Area	TorsConst
Text	Text	Text	m	m	m	m	m	m	m	m2	m4
100x100x6.3	S355	Box/Tube	0.10	0.10	0.01	0.01			0.00	0.00	0.00
100x50x5	S355	Box/Tube	0.10	0.05	0.01	0.01			0.00	0.00	0.00
120x80x6.3	S355	Box/Tube	0.12	0.08	0.01	0.01			0.00	0.00	0.00
C pillar	S355	SD Section								0.00	0.00
IPE240	S355	I/Wide Flange	0.24	0.12	0.01	0.01	0.12	0.01	0.02	0.00	0.00
UPN100	S355	Channel	0.10	0.05	0.01	0.01			0.01	0.00	0.00
UPN260	S355	Channel	0.26	0.09	0.01	0.01			0.01	0.00	0.00

TABLE: Frame Section Properties 01 - General

SectionName	I33	I22	I23	AS2	AS3	S33Top	S33Bot	S22Left	S22Right	Z33	Z22
Text	m4	m4	m4	m2	m2	m3	m3	m3	m3	m3	m3
100x100x6.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100x50x5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120x80x6.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C pillar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IPE240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UPN100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UPN260	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE: Frame Section Properties 01 - General

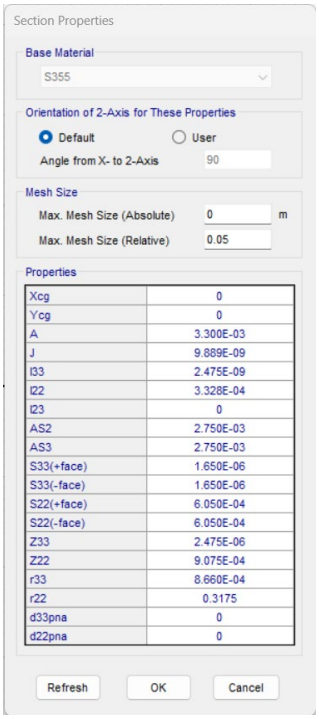
SectionName	R33	R22	CGOffset3	CGOffset2	EccV2	EccV3	Cw	IncludeSCAn	ConcCol	ConcBeam	Color
Text	m	m	m	m	m	m	m6	Yes/No	Yes/No	Yes/No	Text
100x100x6.3	0.04	0.04	0.00	0.00	0.00	0.00	0.00		No	No	Magenta
100x50x5	0.04	0.02	0.00	0.00	0.00	0.00	0.00		No	No	Orange
120x80x6.3	0.04	0.03	0.00	0.00	0.00	0.00	0.00		No	No	Red
C pillar	0.06	0.06	0.02	0.02	0.00	0.00	0.00		No	No	Blue
IPE240	0.10	0.03	0.00	0.00	0.00	0.00	0.00		No	No	Green
UPN100	0.04	0.01	0.01	0.00	0.03	0.00	0.00	Yes	No	No	Yellow
UPN260	0.10	0.03	0.02	0.00	0.05	0.00	0.00	Yes	No	No	Purple

TABLE: Frame Section Properties 01 - General

SectionName	TotalWt	TotalMass	FromFile	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod	MMod	WMod
Text	KN	KN-s2/m	Yes/No	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless	Unitless
100x100x6.3	6.47	0.66	No	1	1	1	1	1	1	1	1
100x50x5	1.561	0.16	No	1	1	1	1	1	1	1	1
120x80x6.3	3.102	0.32	No	1	1	1	1	1	1	1	1
C pillar	3.202	0.33	No	1	1	1	1	1	1	1	1
IPE240	25.039	2.55	Yes	1	1	1	1	1	1	1	1
UPN100	2.984	0.3	Yes	1	1	1	1	1	1	1	1
UPN260	10.848	1.11	Yes	1	1	1	1	1	1	1	1

The roof and wall assembly C profile modules is modelled with a flat plate with flexural stiffness calibrated on a specific FEM comparative model and consequently increased weight by a multiplier in the property (see column MMOD and WMOD in the previous tables → I33 ration between the real section and flat section).

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Section Properties

Base Material: S355

Orientation of 2-Axis for These Properties: Default / User; Angle from X- to 2-Axis: 90

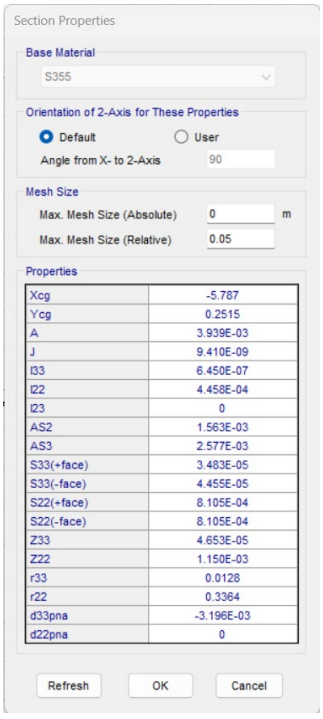
Mesh Size: Max. Mesh Size (Absolute): 0 m; Max. Mesh Size (Relative): 0.05

Properties

Xcg	0
Ycg	0
A	3.300E-03
J	9.889E-09
I33	2.475E-09
I22	3.328E-04
I23	0
AS2	2.750E-03
AS3	2.750E-03
S33(+face)	1.650E-06
S33(-face)	1.650E-06
S22(+face)	6.050E-04
S22(-face)	6.050E-04
Z33	2.475E-06
Z22	9.075E-04
r33	8.660E-04
r22	0.3175
d33pna	0
d22pna	0

Refresh / OK / Cancel

REAL MODELS FOR WALL


Section Properties

Base Material: S355

Orientation of 2-Axis for These Properties: Default / User; Angle from X- to 2-Axis: 90

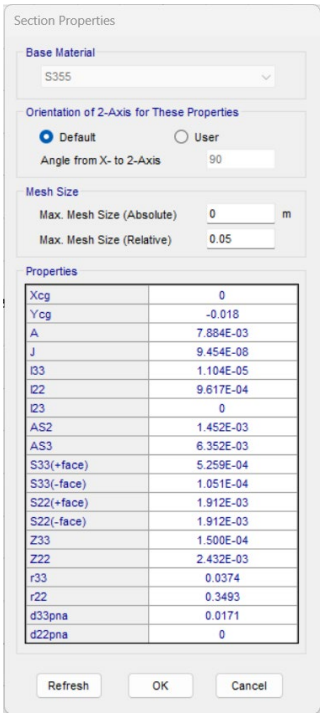
Mesh Size: Max. Mesh Size (Absolute): 0 m; Max. Mesh Size (Relative): 0.05

Properties

Xcg	-5.787
Ycg	0.2515
A	3.939E-03
J	9.410E-09
I33	6.450E-07
I22	4.458E-04
I23	0
AS2	1.563E-03
AS3	2.577E-03
S33(+face)	3.483E-05
S33(-face)	4.455E-05
S22(+face)	8.105E-04
S22(-face)	8.105E-04
Z33	4.653E-05
Z22	1.150E-03
r33	0.0128
r22	0.3364
d33pna	-3.196E-03
d22pna	0

Refresh / OK / Cancel

CALIBRATED MODELS FOR WALL


Section Properties

Base Material: S355

Orientation of 2-Axis for These Properties: Default / User; Angle from X- to 2-Axis: 90

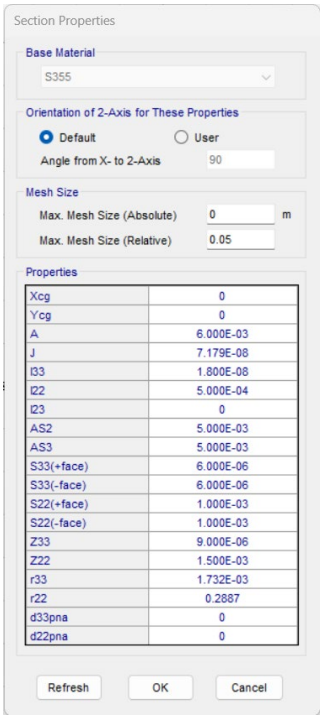
Mesh Size: Max. Mesh Size (Absolute): 0 m; Max. Mesh Size (Relative): 0.05

Properties

Xcg	0
Ycg	-0.018
A	7.884E-03
J	9.454E-08
I33	1.104E-05
I22	9.617E-04
I23	0
AS2	1.452E-03
AS3	6.352E-03
S33(+face)	5.259E-04
S33(-face)	1.051E-04
S22(+face)	1.912E-03
S22(-face)	1.912E-03
Z33	1.500E-04
Z22	2.432E-03
r33	0.0374
r22	0.3493
d33pna	0.0171
d22pna	0

Refresh / OK / Cancel

REAL MODELS FOR ROOF


Section Properties

Base Material: S355

Orientation of 2-Axis for These Properties: Default / User; Angle from X- to 2-Axis: 90

Mesh Size: Max. Mesh Size (Absolute): 0 m; Max. Mesh Size (Relative): 0.05

Properties

Xcg	0
Ycg	0
A	6.000E-03
J	7.179E-08
I33	1.800E-08
I22	5.000E-04
I23	0
AS2	5.000E-03
AS3	5.000E-03
S33(+face)	6.000E-06
S33(-face)	6.000E-06
S22(+face)	1.000E-03
S22(-face)	1.000E-03
Z33	9.000E-06
Z22	1.500E-03
r33	1.732E-03
r22	0.2887
d33pna	0
d22pna	0

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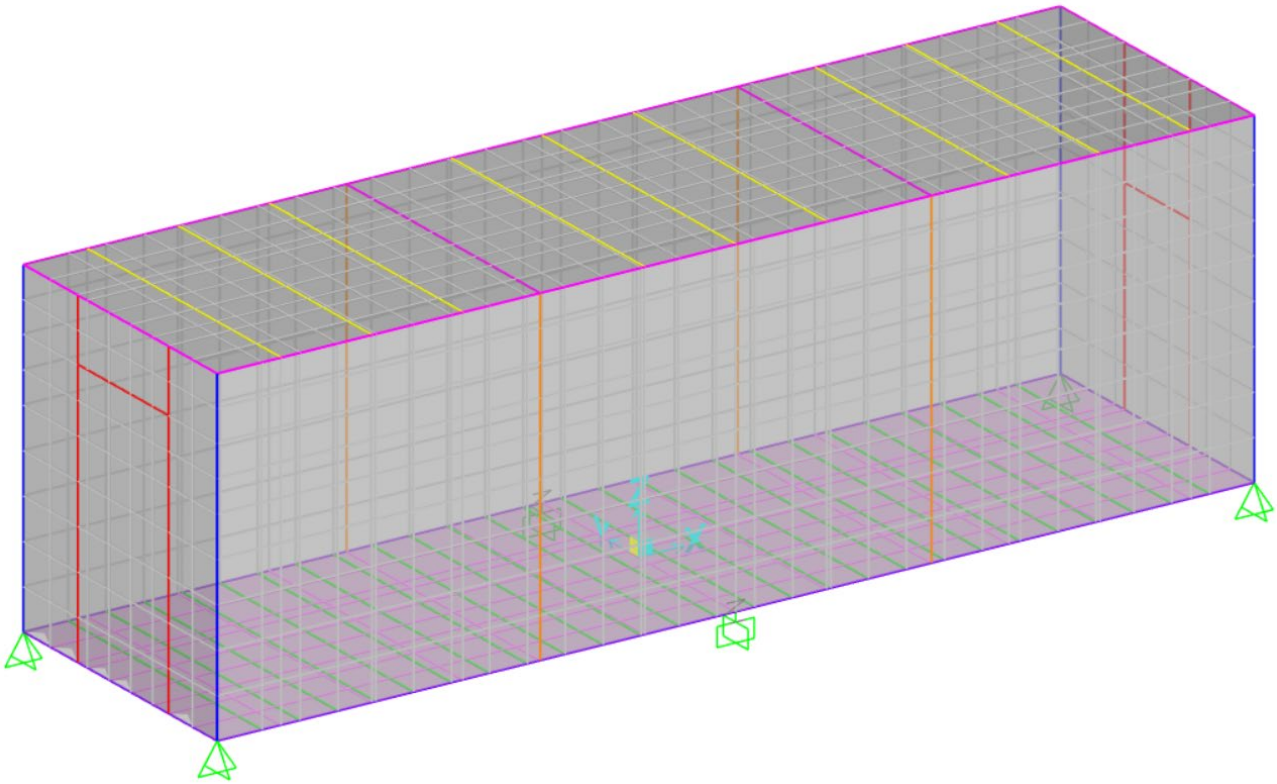
CALIBRATED MODELS FOR ROOF

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4 NUMERICAL MODEL

The analyses were performed using SAP2000 v25 Advanced.

Mono-dimensional (beam) and bi-dimensional (shell) elements were used to create the model.



ANALYSIS MESHED MODEL

The model was developed to analyse the components of steel structure, in particular:

- The C module panel sheet was modelled as equivalent shell with specific stiffness;
- The frame was modelled using mono-dimensional elements with cross section.

The wall and roof sheet forming the cover, is simplified as element flat shell but was given a stiffness, in the direction of the warping of the ribs, equivalent to the ratio between the inertia of the real section and the inertia of flat sheet. In this way it was possible to obtain a realistic displacement of the material under loads. In tensional terms it was necessary to evaluate the effective bound (considered by the software on the inertia of the flat section) as the ratio between the moment on linear meter, agent in the warping direction of the rib and the section modulus W of the real section, obtaining a maximum bound in line with the results of the software tension for orthogonal plate direction (Jcorrugated/Jflat). This aspect can be bypassed by analyzing detailed models for walls and cover including ribs. This approach also allows to consider the structural behavior of the wall together with the elements constituting the frame like a sort of compound section.

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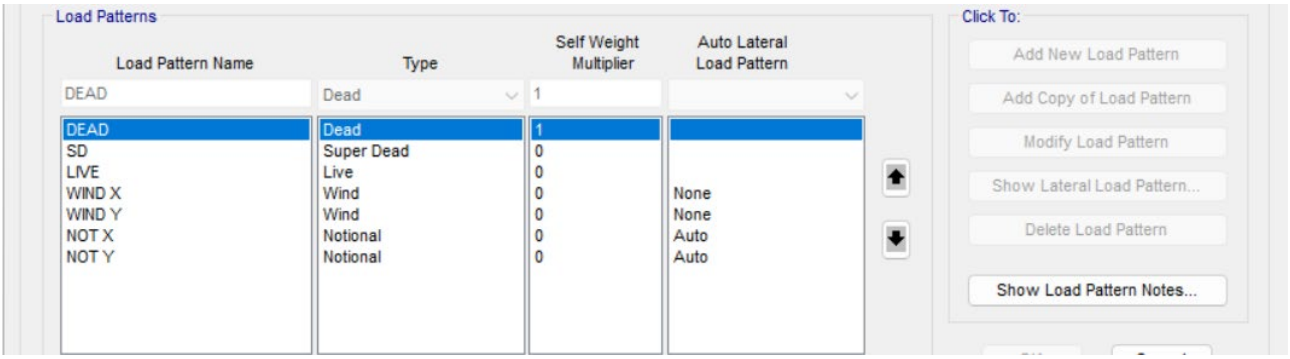
In order to apply the increase of stiffness on the shells so that it can be correctly distributed also on the surrounding frames, it is necessary to discretize the flat elements with a certain mesh and Sap will provide appropriate automation for the frames. The loads are applied as uniform to shell (meshed) for panels with structural function in order to also consider the contribution of the latter in the distribution and as uniform to frames for floor and deck where the plate area have only function as load distributors.

As regards the middle supports for perimeter beam UPN260, they are represented with GAP links and therefore all load combinations are converted into non-linear in order to take into account the contribution to only compression given from them (non-linear geometry analysis).

4.2 DESIGN LOADING

4.2.1 Dead load

The DEAD LOADS or permanent structural loads of steel FAR are calculated automatically (is considered an additional 3% for connections and NOTIONAL as 0.002 ratio of DEAD).



4.2.2 Super dead load

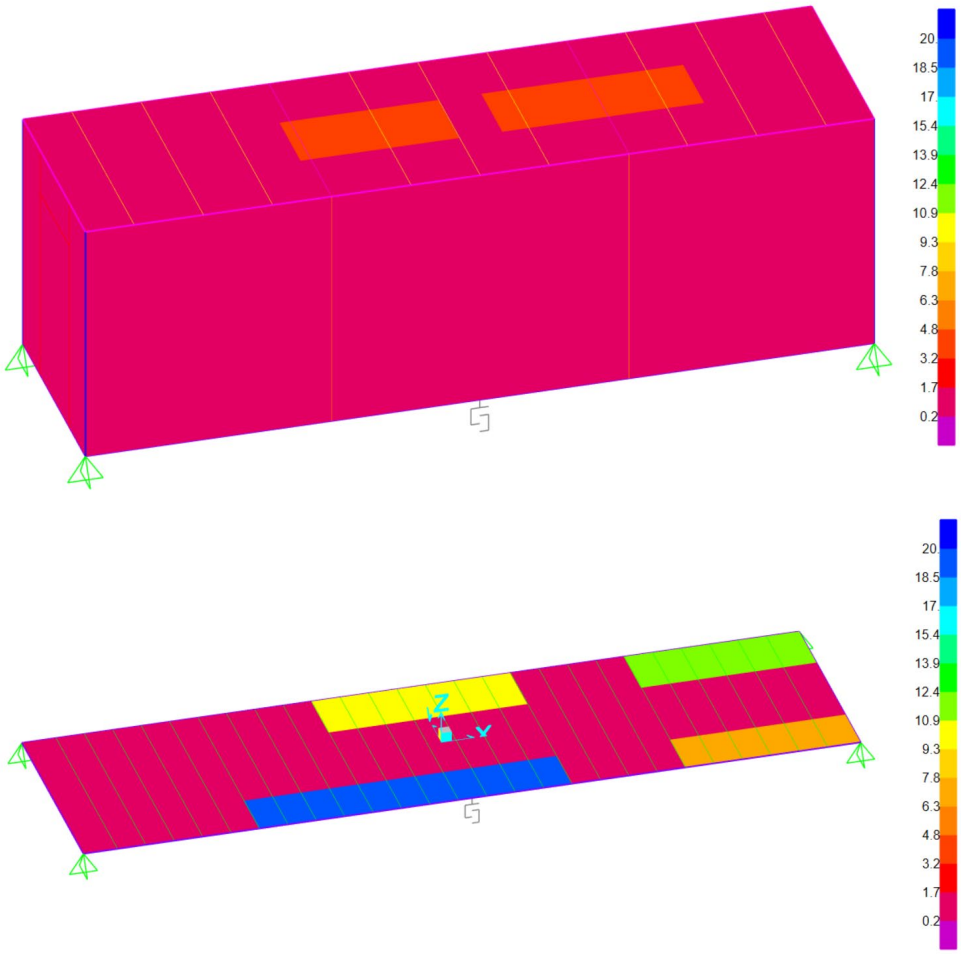
All non structural or SUPER DEAD LOADS on walls 20 kg/m² on roof 50 kg/m² load and floor 50 kg/m².

The weight of internal racks is calculated by data provided by customer and their overall dimensions, therefore simplified in favor of safety with a loading area in the model. The relevant equipments are switchgear and its GIS for two imprint respectively 9.4 m² and 7.4 m² for two distributed loads 8 kN/m² for switchgear and 3.5 kN/m² for GIS. For other equipment is in favor of safety to consider the live load instead of SD load.

In particular for HVAC units of roof, considering the worst condition 4 kN/m² for the foot-print 2 m² and 1 kN/m² for the conducts in extra areas. In these areas isn't applied live load.

	B300 [kg]
Metal structure	13518
Insulating panels wall roof	2947
Insulating panels floor	685
Insulating door A5	23
Insulating door A6	/
Insulating door C4	41
Insulating door D4	/
Total DEAD + INSULATION	**17215**

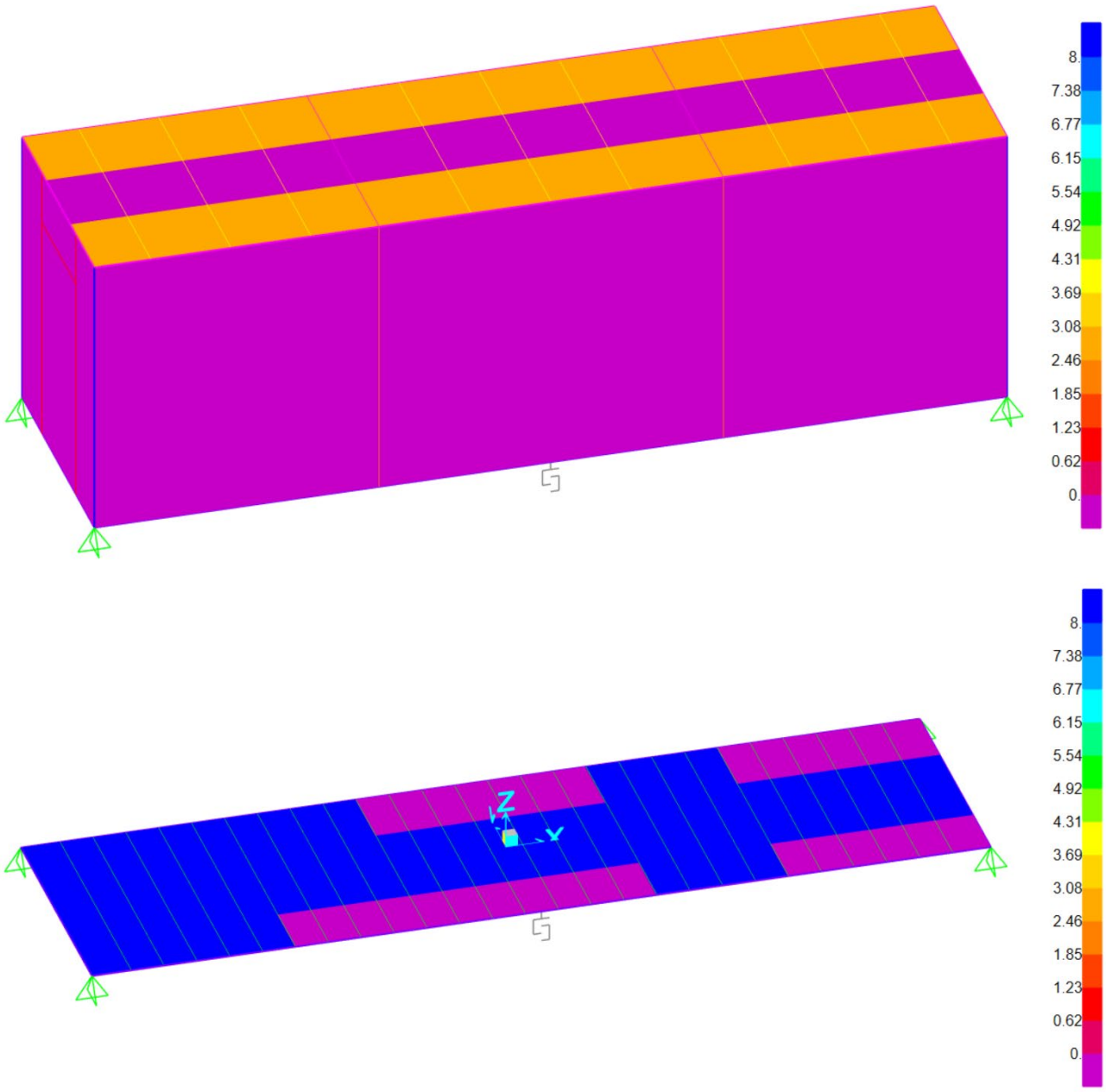
EQUIPMENT LIST						
REF.	TAG No.	DESCRIPTION	LENGTH (mm)	WIDTH (mm)	HEIGHT (mm)	WEIGHT (Kg)
	UP-200F3	AC UPS 35kVA	2400	860	1915	2258
2	UP-200F4	AC UPS 15kVA	2400	860	1915	1530
3	BA-200F3A	BATTERY RACK GEL VRLA 7y AC UPS 35kVA	1050	725	1272	914
4	BA-200F3B	BATTERY RACK GEL VRLA 7y AC UPS 35kVA	1050	725	1272	914
5	BA-200F4A	BATTERY RACK GEL VRLA 7y AC UPS 15kVA	1890	725	1761	3429
6	BA-200F4B	BATTERY RACK GEL VRLA 7y AC UPS 15kVA	1890	725	1761	3429
7	CB-200F3A	ISOLATOR BOX AC UPS 35kVA	600	300	800	100
8	CB-200F3B	ISOLATOR BOX AC UPS 35kVA	600	300	800	100
9	CB-200F4A	ISOLATOR BOX AC UPS 15kVA	600	300	800	100
10	CB-200F4B	ISOLATOR BOX AC UPS 15kVA	600	300	800	100
11	NC-200F2	NAVAID PANEL	1180	810	675	500
12	BA-200F2	BATTERY BOX NAVAID	1000	500	1135	325
13	CB-200F2	ISOLATOR BOX NAVAID	500	400	765	70
14	B3000-HSB-001	DISTRIBUTION & HVAC PANEL - AC/UPS ROOM	1600	600	2300	350
15	-	EYE WASH STATION	228	80	290	5
16	-	PORTABLE EXTINGUISHER (CO2) 5 Kg.	150	150	750	20
17	-	PORTABLE EXTINGUISHER (CO2) 5 Kg.	150	150	750	20
18	BC-200F2	BATTERY CHARGER NAVAID	607	607	2157	500
19	HHU-77003A	AIR HANDLING UNIT A	2100	1000	2158	840
20	HHU-77003B	AIR HANDLING UNIT B	2100	1000	2158	840



SUPER DEAD LOADS APPLIED IN MODEL [kN/m²]

4.2.3 Live load

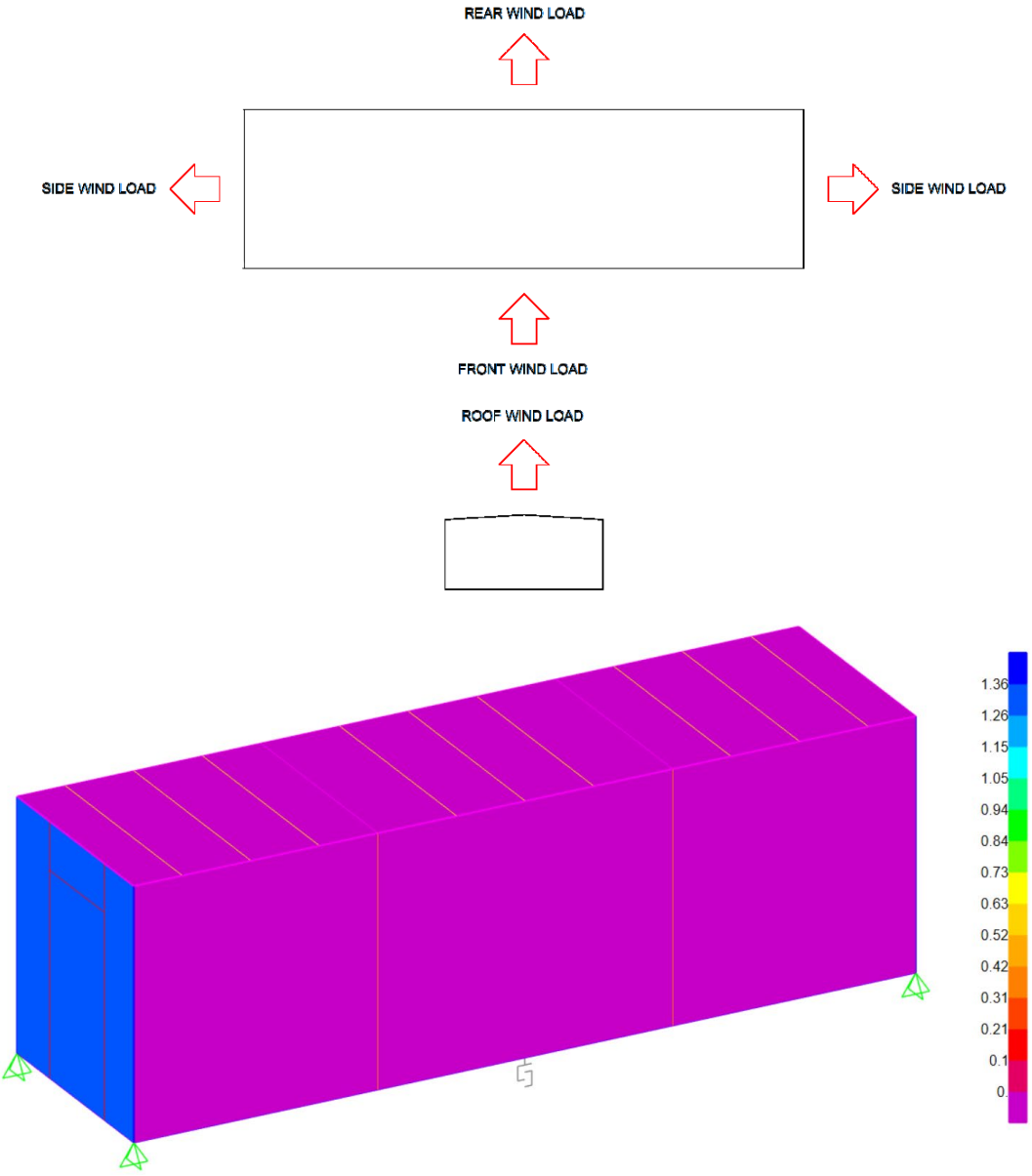
The LIVE LOADS are distributed in areas not loaded with cabinets or internal components. All loads are rounded up and equal to 2.5 kN/m^2 for roof and 8 kN/m^2 for internal floor.



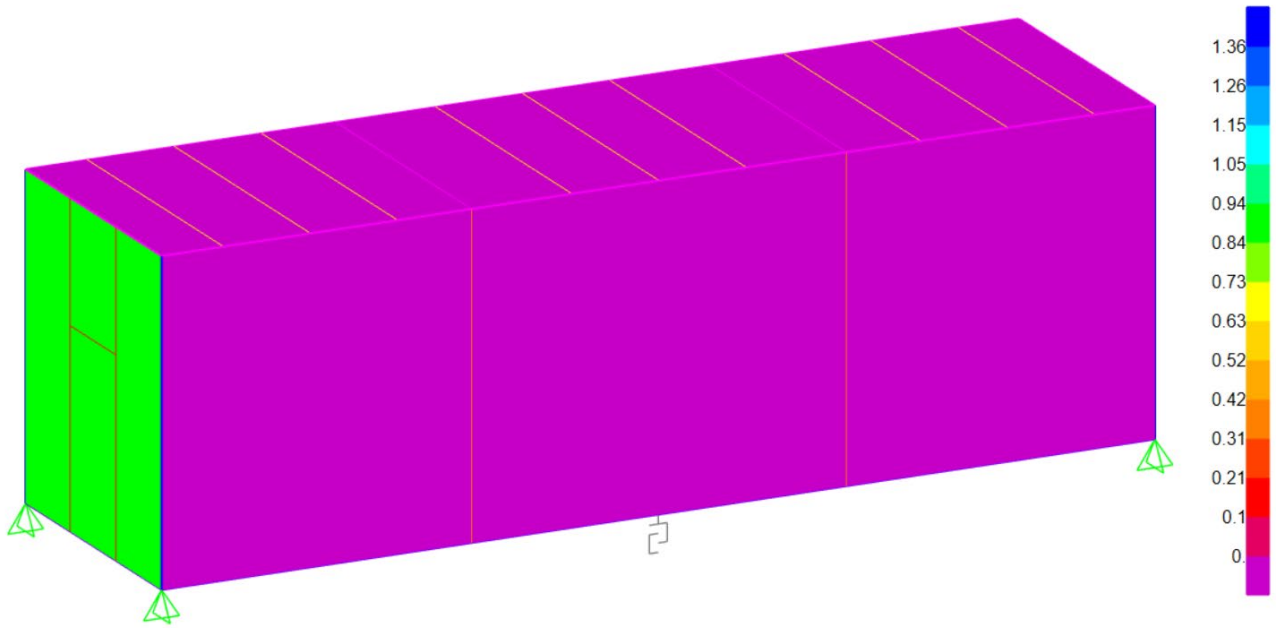
LIVE LOAD APPLIED IN MODEL [kN/m^2]

4.2.4 Wind load

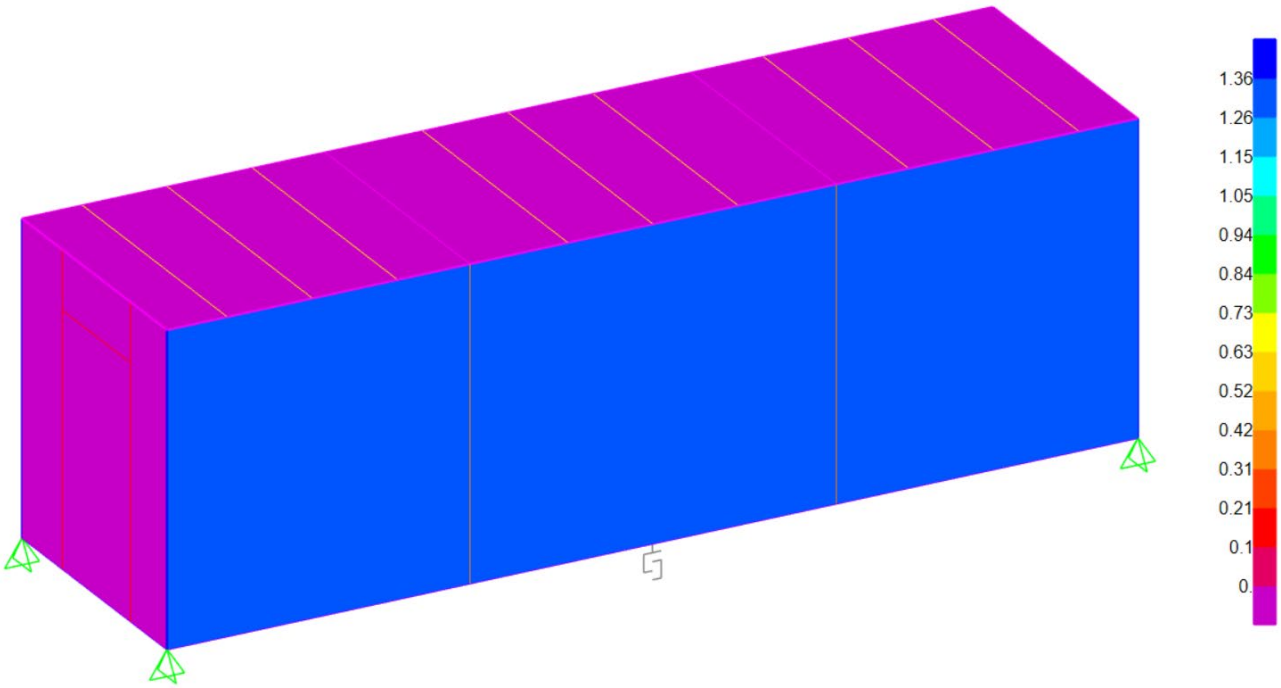
The design wind loads shall be automatically calculated for the worst condition of wind speed 41 m/s and exposure category D with importance factor 1.15 (Eurocode's worst condition for off-shore and in accordance with the specifics of customer WIND TABLE). The actions on walls and roof are automatically calculated by Sap by setting the parameters and applying the appropriate exposure coefficient to the plate elements (peak velocity pressure 1.69 kN/m^2 → pressure coefficient Cp front 0.8, Cp side, rear and roof 0.5).



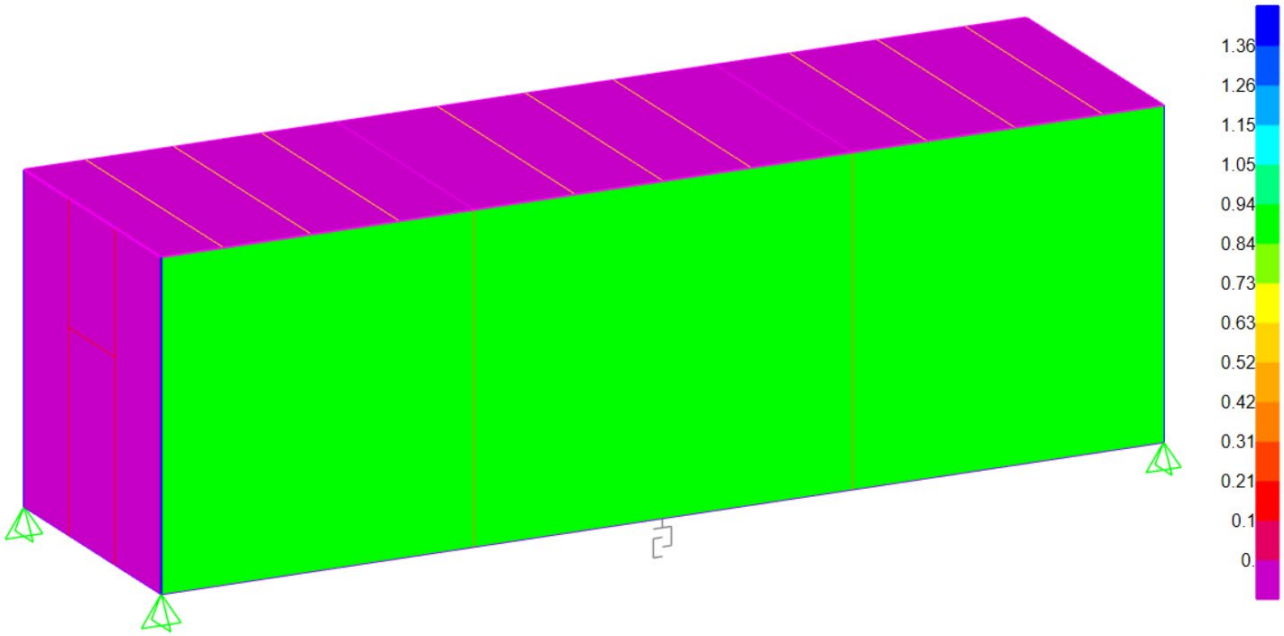
WIND X PRESSURE FRONT [kN/m^2]



WIND X PRESSURE REAR [kN/m²]



WIND Y PRESSURE FRONT [kN/m²]



WIND Y PRESSURE REAR [kN/m^2]

4.3 LOAD COMBINATIONS

TABLE: Combination Definitions						
ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
Text	Text	Yes/No	Text	Text	Unitless	Text
ULS LIVE	Linear Add	No	NonLin Static	DEAD	1.3	Strength
			NonLin Static	SD	1.5	
			NonLin Static	LIVE	1.5	
			NonLin Static	NOT X	1.3	
			NonLin Static	NOT Y	1.3	
ULS WIND X	Linear Add	No	NonLin Static	DEAD	1.3	Strength
			NonLin Static	SD	1.5	
			NonLin Static	LIVE	1.05	
			NonLin Static	WIND X	1.5	
			NonLin Static	WIND Y	0.3	
			NonLin Static	NOT X	1.3	
			NonLin Static	NOT Y	1.3	
ULS WIND Y	Linear Add	No	NonLin Static	DEAD	1.3	Strength
			NonLin Static	SD	1.5	
			NonLin Static	LIVE	1.05	
			NonLin Static	WIND X	0.3	
			NonLin Static	WIND Y	1.5	
			NonLin Static	NOT X	1.3	
			NonLin Static	NOT Y	1.3	
SLS LIVE	Linear Add	No	NonLin Static	DEAD	1	Deflection
			NonLin Static	SD	1	
			NonLin Static	LIVE	1	
			NonLin Static	NOT X	1	
			NonLin Static	NOT Y	1	
SLS WIND X	Linear Add	No	NonLin Static	DEAD	1	Deflection
			NonLin Static	SD	1	
			NonLin Static	WIND X	1	
			NonLin Static	WIND Y	0.3	
			NonLin Static	NOT X	1	
			NonLin Static	NOT Y	1	
SLS WIND Y	Linear Add	No	NonLin Static	DEAD	1	Deflection
			NonLin Static	SD	1	
			NonLin Static	WIND X	0.3	
			NonLin Static	WIND Y	1	
			NonLin Static	NOT X	1	
			NonLin Static	NOT Y	1	
LLC2 lifting	Linear Add	No	NonLin Static	DEAD	1.5	Strength
			NonLin Static	SD	1.5	
LLC3 lifting	Linear Add	No	NonLin Static	DEAD	2	Lifting point
			NonLin Static	SD	2	

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TABLE: Combination Definitions

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
Text	Text	Yes/No	Text	Text	Unitless	Text
SEA COMB 1	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SURGE	1	
			NonLin Static	HEAVE	1	
SEA COMB 2	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SURGE	-1	
			NonLin Static	HEAVE	1	
SEA COMB 3	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SURGE	1	
			NonLin Static	HEAVE	-1	
SEA COMB 4	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SURGE	-1	
			NonLin Static	HEAVE	-1	
SEA COMB 5	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SWAY	1	
			NonLin Static	HEAVE	1	
SEA COMB 6	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SWAY	-1	
			NonLin Static	HEAVE	1	
SEA COMB 7	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SWAY	1	
			NonLin Static	HEAVE	-1	
SEA COMB 8	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND X	1	
			NonLin Static	SWAY	-1	
			NonLin Static	HEAVE	-1	

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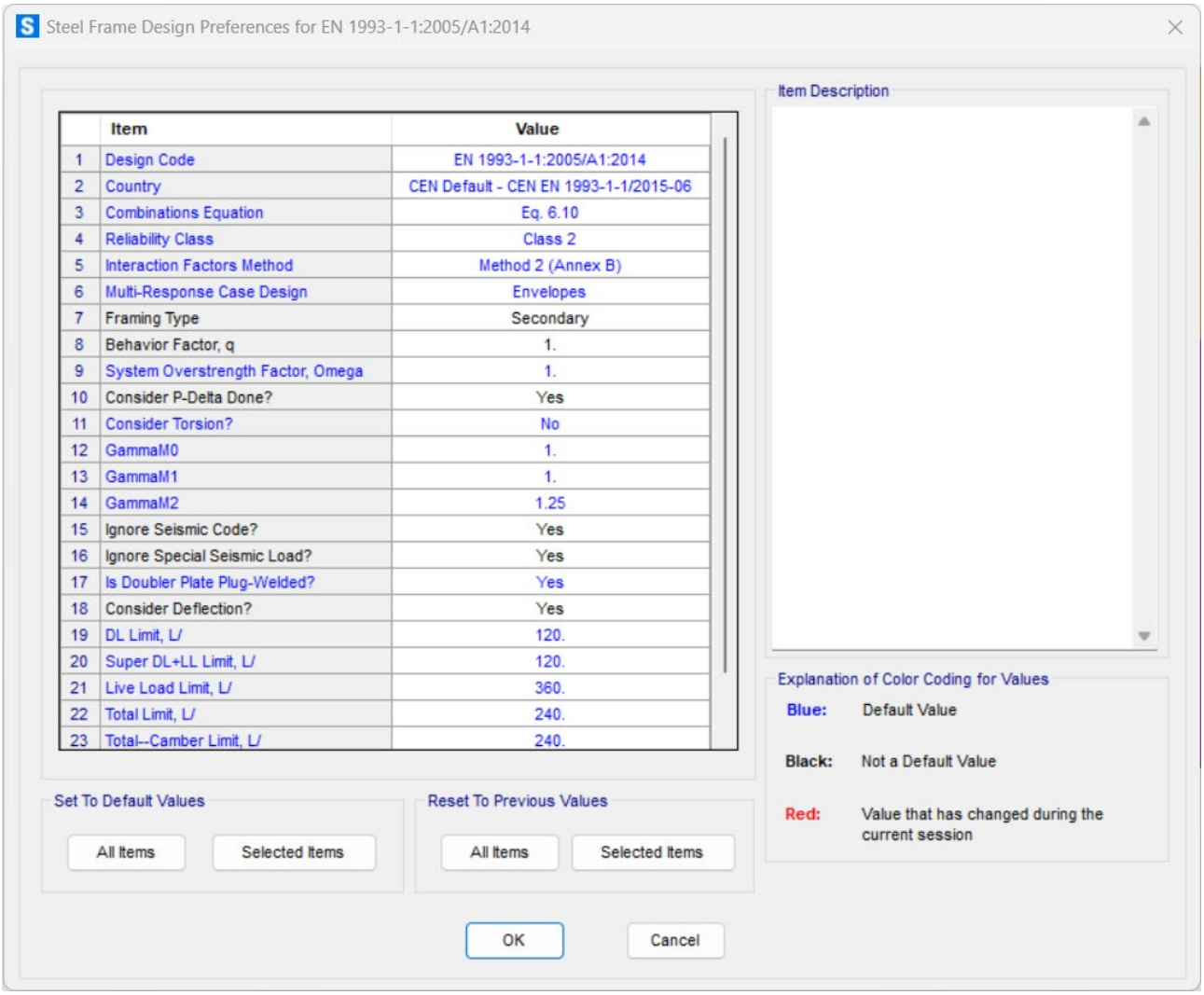
TABLE: Combination Definitions

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
Text	Text	Yes/No	Text	Text	Unitless	Text
SEA COMB 9	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SURGE	1	
			NonLin Static	HEAVE	1	
SEA COMB 10	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SURGE	-1	
			NonLin Static	HEAVE	1	
SEA COMB 11	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SURGE	1	
			NonLin Static	HEAVE	-1	
SEA COMB 12	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SURGE	-1	
			NonLin Static	HEAVE	-1	
SEA COMB 13	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SWAY	1	
			NonLin Static	HEAVE	1	
SEA COMB 14	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SWAY	-1	
			NonLin Static	HEAVE	1	
SEA COMB 15	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SWAY	1	
			NonLin Static	HEAVE	-1	
SEA COMB 16	Linear Add	No	NonLin Static	DEAD	1.1	Strength
			NonLin Static	SD	1.1	
			NonLin Static	WIND Y	1	
			NonLin Static	SWAY	-1	
			NonLin Static	HEAVE	-1	

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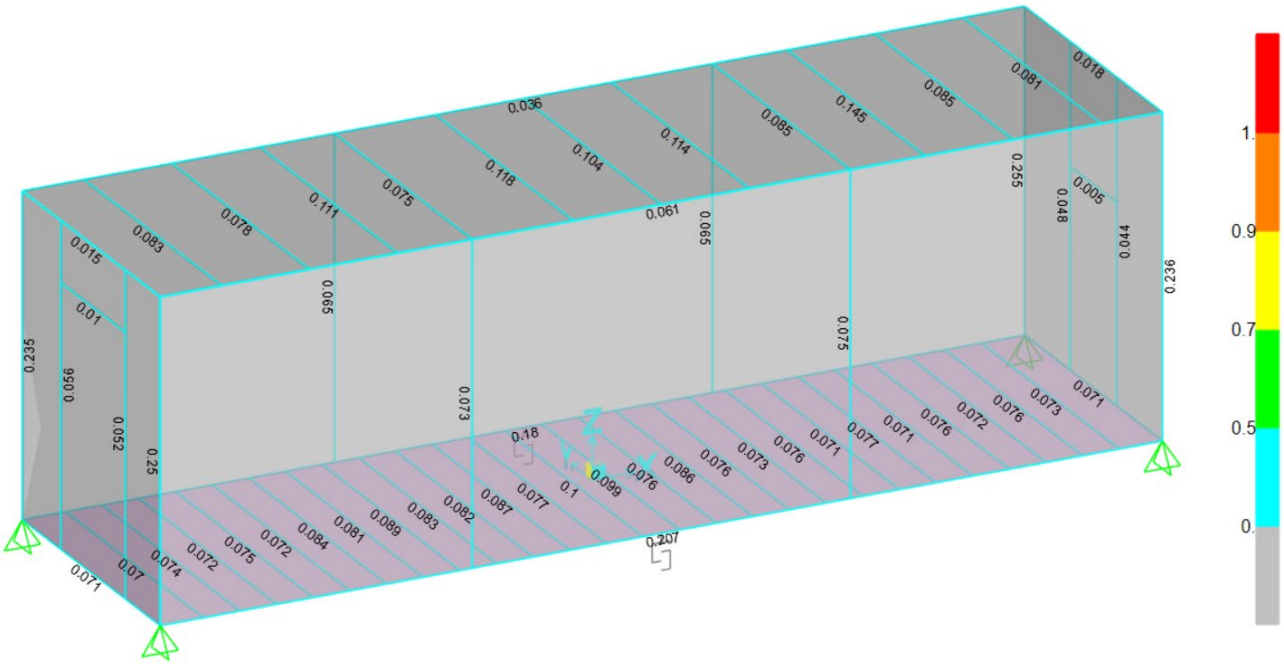
4.4 STRESS CHECK IN PLACE

All sections are check and verified in according with EN 1993 combinations ULS LIVE and WIND, SLS LIVE and WIND. Showed below the detailed printout for each type of section in its combination of maximum stress and the force diagrams with values for roof frames.



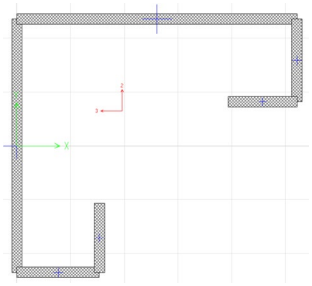
	Item	Value
1	Design Code	EN 1993-1-1:2005/A1:2014
2	Country	CEN Default - CEN EN 1993-1-1/2015-06
3	Combinations Equation	Eq. 6.10
4	Reliability Class	Class 2
5	Interaction Factors Method	Method 2 (Annex B)
6	Multi-Response Case Design	Envelopes
7	Framing Type	Secondary
8	Behavior Factor, q	1.
9	System Overstrength Factor, Omega	1.
10	Consider P-Delta Done?	Yes
11	Consider Torsion?	No
12	GammaM0	1.
13	GammaM1	1.
14	GammaM2	1.25
15	Ignore Seismic Code?	Yes
16	Ignore Special Seismic Load?	Yes
17	Is Doubler Plate Plug-Welded?	Yes
18	Consider Deflection?	Yes
19	DL Limit, L/	120.
20	Super DL+LL Limit, L/	120.
21	Live Load Limit, L/	360.
22	Total Limit, L/	240.
23	Total--Camber Limit, L/	240.

For in-place condition is automatically calculated also the relative deflection and compared with the limite L/240 (for beams). For beams in compression is calculated the lateral torsion buckling limit from code.



CHECK DESIGN FOR ULS LOADS (ORANGE < 1 RATIO)

4.4.1 C PILLAR



```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  190      X Mid:  -5.7      Combo:  ULS LIVE       Design Type:  Column
Length:  3.622    Y Mid:  -1.6      Shape:  C pillar       Frame Type:  Secndry
Loc   :  3.622    Z Mid:  1.811     Class:  Class 3        Rolled : No

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2                Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                    Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75        D/C Lim=0.95        Prin. Axis Angle = 90.
deg

Aeff=0.003        Av,2=0.001        Av,3=0.001       eNy=0.              eNz=0.
A=0.003           Iy=8.703E-06      iy=0.055         Wel,y=8.999E-05     Weff,y=8.999E-05
It=3.406E-08      Iz=1.075E-05      iz=0.061         Wel,z=1.027E-04     Weff,z=1.027E-04
Iw=0.             Iyz=0.            h=0.153          Wpl,y=1.342E-04
E=210000000.      fy=355000.        fu=510000.       Wpl,z=1.489E-04


STRESS CHECK FORCES & MOMENTS
    Location          Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    3.622          -73.52       0.269       2.009       0.845        4.77          0.

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.3.1.1(1)-6.46)
    D/C Ratio:      0.25 = 0.25   <         0.95          OK
                         = (NEd/Nb,Rd)       (EC3 6.3.1.1(1)-6.46)

AXIAL FORCE DESIGN
                        NEd       Nc,Rd       Nt,Rd
                      Force    Capacity    Capacity
    Axial           -73.52    1019.205    1019.205

                     Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                   1019.205    1054.231     406.117     406.117          1.

              Curve    Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y           c     0.49     1374.92       0.861       1.033       0.624     635.963
    Y-Y Braced    c     0.49     2771.045      0.606       0.783       0.782     796.553
    Z-Z           c     0.49     1697.891      0.775       0.941       0.678     691.019
```

Z-Z Braced	c	0.49	2449.451	0.645	0.817	0.758	772.934
Torsional TF	c	0.49	406.117	1.584	2.094	0.289	294.293

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	0.269	0.269	31.947	31.947	31.947	23.736
Z-Z	2.009	2.009	36.446	36.446	36.446	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	0.552	0.786	0.743	0.	104.807

Factors	kw	C1	C2	C3		
	1.	2.711	0.43	1.12		
	za	zs	zg	zz	zj	
	0.056	0.	0.056	0.	0.	

	kyy	kyz	kzy	kzz
Factors	0.413	0.415	0.98	0.415

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	0.845	249.477	0.003	1.
3-Axis	4.77	259.256	0.018	1.

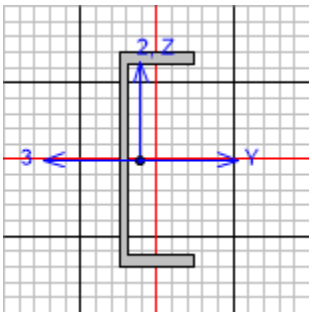
SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	0.845	0.	249.477	0.003	OK
3-Axis	4.77	0.	259.256	0.018	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	249.477	1.2	0.	1.
3-Axis	259.256	1.2	0.	1.

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4.4.2 UPN260




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  215      X Mid:  -4.441E-15Combo:  ULS LIVE        Design Type:  Beam
Length:  11.399   Y Mid:  -1.6      Shape:  UPN260          Frame Type:  Secndry
Loc   :  5.7      Z Mid:  1.404E-07 Class:  Class 1         Rolled : Yes

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2                Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                    Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75         D/C Lim=0.95       Prin. Axis Angle = 0. deg

Aeff=0.005        Av,2=0.003        Av,3=0.003        eNy=0.             eNz=0.
A=0.005           Iy=4.821E-05      iy=0.1            Wel,y=3.708E-04    Weff,y=3.708E-04
It=2.420E-07      Iz=3.178E-06      iz=0.026          Wel,z=4.784E-05    Weff,z=4.784E-05
Iw=3.850E-08      Iyz=0.            h=0.26            Wpl,y=4.531E-04
E=210000000.      fy=355000.        fu=510000.        Wpl,z=1.025E-04


STRESS CHECK FORCES & MOMENTS
    Location            Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    5.7              -39.953     -16.451       2.972      58.627      24.188         0.1

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.2.1(7))
    D/C Ratio:     0.207 = 0.023 + 0.102 + 0.082   <         0.95          OK
                         = (NEd/NRd) + (My,Ed/My,Rd) + (Mz,Ed/Mz,Rd)       (EC3 6.2.1(7))

AXIAL FORCE DESIGN
                          NEd       Nc,Rd       Nt,Rd
                        Force    Capacity    Capacity
    Axial            -39.953    1713.585    1713.585

                       Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                     1713.585    1772.474   35722.072    5219.656          1.

                Curve   Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y             c    0.49    5404.043       0.563       0.748       0.807    1382.911
    Y-Y Braced      c    0.49    5404.043       0.563       0.748       0.807    1382.911
    Z-Z             c    0.49   37939.914       0.213       0.526       0.994    1702.647
```

Z-Z Braced	c	0.49	37939.914	0.213	0.526	0.994	1702.647
Torsional TF	c	0.49	5219.656	0.573	0.756	0.801	1373.074

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	-16.451	-16.451	160.851	160.851	160.851	156.082
Z-Z	2.972	2.974	36.388	36.388	36.388	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	0.238	0.543	0.97	3.850E-08	2839.869

Factors	kw	C1	C2	C3		
	1.	1.217	0.553	1.73		
	za	zs	zg	zz	zj	
	0.13	0.	0.13	-6.539E-18	6.539E-18	

	kyy	kyz	kzy	kzz
Factors	0.909	0.498	0.813	0.83

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	58.627	541.707	0.108	1.
3-Axis	24.188	513.833	0.047	1.

SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	58.627	0.1	541.707	0.108	OK
3-Axis	24.188	0.1	513.833	0.047	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	541.707	1.2	0.33	1.2
3-Axis	513.833	1.2	0.	1.

CONNECTION SHEAR FORCES FOR BEAMS

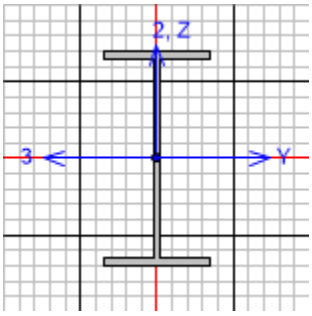
	V2 Left	V2 Right
2-2 (V2)	13.093	13.617

DEFLECTION CHECK (ComboSLS LIVE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	0.003	0.095	0.031	OK
Super DL+LL	Yes	0.003	0.095	0.031	OK
Live Load	Yes	0.003	0.032	0.091	OK
Total Load	Yes	0.003	0.047	0.063	OK
Total-Camber	Yes	0.003	0.047	0.063	OK

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4.4.3 IPE240




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  32       X Mid:  -0.208    Combo:  ULS LIVE        Design Type:  Beam
Length:  3.2      Y Mid:  0.        Shape:  IPE240          Frame Type:  Secndry
Loc   :  2.75     Z Mid:  1.404E-07 Class:  Class 1         Rolled : Yes

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2                Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                    Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75         D/C Lim=0.95       Prin. Axis Angle = 0. deg

Aeff=0.004        Av,2=0.002        Av,3=0.003        eNy=0.             eNz=0.
A=0.004           Iy=3.892E-05      iy=0.1            Wel,y=3.243E-04    Weff,y=3.243E-04
It=1.300E-07      Iz=2.840E-06      iz=0.027          Wel,z=4.733E-05    Weff,z=4.733E-05
Iw=3.739E-08      Iyz=0.            h=0.24            Wpl,y=3.670E-04
E=210000000.      fy=355000.        fu=510000.        Wpl,z=7.390E-05


STRESS CHECK FORCES & MOMENTS
    Location            Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    2.75             21.878        5.92      -0.647       7.903       1.294       0.006

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.3.3(4)-6.62)
    D/C Ratio:       0.1 = 0. + 0.09 + 0.01   <         0.95          OK
                       = NEd/(Chi_z NRk/GammaM1) + kzy (My,Ed+NEd eNy)/(Chi_LT My,Rk/GammaM1)
                           + kzz (Mz,Ed+NEd eNz)/(Mz,Rk/GammaM1)       (EC3 6.3.3(4)-6.62)

AXIAL FORCE DESIGN
                         NEd       Nc,Rd       Nt,Rd
                       Force    Capacity    Capacity
    Axial             21.878     1388.05     1388.05

                      Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                     1388.05    1435.752    1691.785    1691.785          1.

                Curve   Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y             a    0.21    7878.247        0.42       0.611       0.948    1315.195
    Y-Y Braced      a    0.21    7878.247        0.42       0.611       0.948    1315.195
    Z-Z             b    0.34     574.877       1.554       1.937       0.323      448.54
    Z-Z Braced      b    0.34     574.877       1.554       1.937       0.323      448.54
```

Torsional TF	b	0.34	1691.785	0.906	1.03	0.657	912.581

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	2.346	5.92	130.285	130.285	130.285	65.738
Z-Z	-0.284	-0.647	26.235	26.235	26.235	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	a	0.21	1.241	1.38	0.505	3.739E-08	84.57

Factors	kw	C1	C2	C3		
	1.	1.106	0.43	1.12		
	za	zs	zg	zz	zj	
	0.12	0.	0.12	0.	0.	

	kyy	kyz	kzy	kzz
Factors	0.882	0.24	1.	0.4

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	7.903	392.038	0.02	1.
3-Axis	1.294	521.318	0.002	1.

SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	7.903	0.006	392.038	0.02	OK
3-Axis	1.294	0.006	521.318	0.002	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	392.038	1.2	0.506	1.2
3-Axis	521.318	1.2	0.	1.

CONNECTION SHEAR FORCES FOR BEAMS

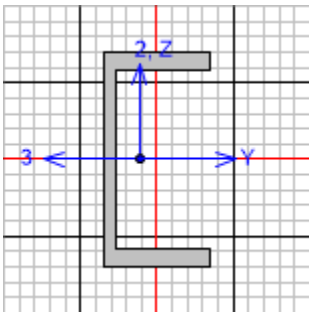
	V2 Left	V2 Right
2-2 (V2)	12.632	9.955

DEFLECTION CHECK (ComboSLS LIVE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	2.894E-04	0.027	0.011	OK
Super DL+LL	Yes	4.671E-04	0.027	0.018	OK
Live Load	Yes	2.380E-04	0.009	0.027	OK
Total Load	Yes	5.274E-04	0.013	0.04	OK
Total-Camber	Yes	5.274E-04	0.013	0.04	OK

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4.4.4 UPN100




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  129      X Mid:  -1.      Combo:  ULS LIVE      Design Type:  Beam
Length:  3.2      Y Mid:  0.       Shape:  UPN100        Frame Type:  Secndry
Loc   :  2.75     Z Mid:  3.622    Class:  Class 1       Rolled : Yes

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2              Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                  Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75        D/C Lim=0.95      Prin. Axis Angle = 0. deg

Aeff=0.001        Av,2=6.193E-04    Av,3=8.480E-04   eNy=0.            eNz=0.
A=0.001           Iy=2.053E-06      iy=0.039         Wel,y=4.106E-05   Weff,y=4.106E-05
It=2.645E-08      Iz=2.929E-07      iz=0.015         Wel,z=8.478E-06   Weff,z=8.478E-06
Iw=4.853E-10      Iyz=0.            h=0.1            Wpl,y=5.033E-05
E=210000000.      fy=355000.        fu=510000.       Wpl,z=1.800E-05


STRESS CHECK FORCES & MOMENTS
    Location          Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    2.75            7.018       0.757      -0.018       0.585       0.047       0.007

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.3.3(4)-6.62)
    D/C Ratio:     0.118 = 0. + 0.116 + 0.001   <         0.95          OK
                         = NEd/(Chi_z NRk/GammaM1) + kzy (My,Ed+NEd eNy)/(Chi_LT My,Rk/GammaM1)
                             + kzz (Mz,Ed+NEd eNz)/(Mz,Rk/GammaM1)       (EC3 6.3.3(4)-6.62)

AXIAL FORCE DESIGN
                          NEd       Nc,Rd       Nt,Rd
                       Force    Capacity    Capacity
    Axial              7.018      477.83      477.83

                     Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                     477.83     494.251     788.427     326.619          1.

                Curve   Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y             c    0.49     415.571       1.072       1.289       0.499     238.525
    Y-Y Braced      c    0.49     415.571       1.072       1.289       0.499     238.525
```

Z-Z	c	0.49	59.289	2.839	5.176	0.105	50.275
Z-Z Braced	c	0.49	59.289	2.839	5.176	0.105	50.275
Torsional TF	c	0.49	326.619	1.21	1.479	0.429	205.108

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	0.412	0.757	17.867	17.867	17.867	6.498
Z-Z	-0.009	-0.018	6.39	6.39	6.39	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	1.232	1.651	0.364	4.853E-10	11.775

Factors	kw	C1	C2	C3		
	1.	1.143	0.43	1.12		
	za	zs	zg	zz	zj	
	0.05	0.	0.05	1.598E-18	-1.598E-18	

	kyy	kyz	kzy	kzz
Factors	0.909	0.24	1.	0.4

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	0.585	126.921	0.005	1.
3-Axis	0.047	173.805	2.720E-04	1.

SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	0.585	0.007	126.921	0.005	OK
3-Axis	0.047	0.007	173.805	0.	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	126.921	1.2	0.197	1.2
3-Axis	173.805	1.2	0.	1.

CONNECTION SHEAR FORCES FOR BEAMS

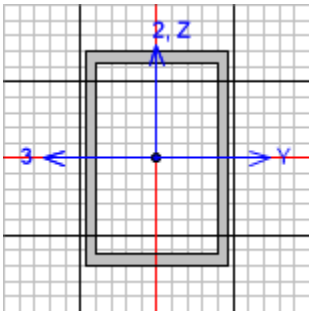
	V2 Left	V2 Right
2-2 (V2)	0.906	0.987

DEFLECTION CHECK (ComboSLS LIVE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	8.816E-04	0.027	0.033	OK
Super DL+LL	Yes	0.001	0.027	0.038	OK
Live Load	Yes	3.720E-04	0.009	0.042	OK
Total Load	Yes	0.001	0.013	0.094	OK
Total-Camber	Yes	0.001	0.013	0.094	OK

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4.4.5 120x80x6.3




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  192      X Mid:  -5.7      Combo:  ULS WIND X      Design Type:  Column
Length:  3.622    Y Mid:  -0.8      Shape:  120x80x6.3      Frame Type:  Secndry
Loc   :  2.278    Z Mid:  1.811     Class:  Class 1         Rolled : No

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2                Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                    Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75        D/C Lim=0.95        Prin. Axis Angle = 0. deg

Aeff=0.002        Av,2=0.002        Av,3=0.001       eNy=0.              eNz=0.
A=0.002           Iy=4.562E-06      iy=0.044         Wel,y=7.603E-05     Weff,y=7.603E-05
It=4.721E-06      Iz=2.380E-06      iz=0.032         Wel,z=5.949E-05     Weff,z=5.949E-05
Iw=0.             Iyz=0.            h=0.12           Wpl,y=9.364E-05
E=210000000.      fy=355000.        fu=510000.       Wpl,z=7.003E-05


STRESS CHECK FORCES & MOMENTS
    Location          Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    2.278          -3.249      -1.629       0.174       0.942       0.002       0.044

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.3.3(4)-6.61)
    D/C Ratio:     0.052 = 0.008 + 0.042 + 0.002   <         0.95          OK
                         = NEd/(Chi_y NRk/GammaM1) + kyy (My,Ed+NEd eNy)/(Chi_LT My,Rk/GammaM1)
                             + kyz (Mz,Ed+NEd eNz)/(Mz,Rk/GammaM1)     (EC3 6.3.3(4)-6.61)

AXIAL FORCE DESIGN
                          NEd       Nc,Rd       Nt,Rd
                       Force    Capacity    Capacity
    Axial             -3.249      838.24      838.24

                      Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                      838.24     867.047  129713.748     570.612          1.

                Curve   Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y             c    0.49     720.719       1.078       1.297       0.496     415.624
    Y-Y Braced      c    0.49     720.719       1.078       1.297       0.496     415.624
```

Z-Z	c	0.49	570.612	1.212	1.482	0.428	358.824
Z-Z Braced	c	0.49	570.612	1.212	1.482	0.428	358.824
Torsional TF	c	0.49	570.612	1.212	1.482	0.428	358.824

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	-1.231	-1.629	33.242	33.242	33.242	33.242
Z-Z	0.002	0.174	24.86	24.86	24.86	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	0.236	0.542	0.972	0.	595.242

Factors	kw	C1	C2	C3		
	1.	1.32	0.459	0.525		
	za	zs	zg	zz	zj	
	0.06	0.	0.06	0.	0.	

	kyy	kyz	kzy	kzz
Factors	0.842	0.242	0.505	0.403

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	0.942	332.831	0.003	1.
3-Axis	0.002	206.599	8.334E-06	1.

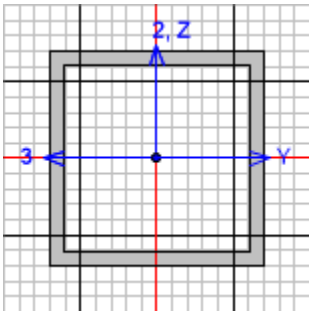
SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	0.942	0.044	332.831	0.003	OK
3-Axis	0.002	0.044	206.599	8.334E-06	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	332.831	1.2	0.243	1.2
3-Axis	206.599	1.2	0.	1.

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4.4.6 100x100x6.3




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  128      X Mid:  2.15     Combo:  ULS LIVE       Design Type:  Beam
Length:  3.2      Y Mid:  0.       Shape:  100x100x6.3    Frame Type:  Secndry
Loc   :  1.42     Z Mid:  3.622    Class:  Class 1        Rolled : No

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10             Reliability = Class 2              Interaction = Method 2
(Annex B)
MultiResponse = Envelopes          P-Delta Done? Yes                  Consider Torsion? No

GammaM0=1.        GammaM1=1.       GammaM2=1.25
An/Ag=1.          RLLF=1.          PLLF=0.75        D/C Lim=0.95      Prin. Axis Angle = 0. deg

Aeff=0.002        Av,2=0.001       Av,3=0.001       eNy=0.            eNz=0.
A=0.002           Iy=3.471E-06     iy=0.038         Wel,y=6.942E-05   Weff,y=6.942E-05
It=5.183E-06      Iz=3.471E-06     iz=0.038         Wel,z=6.942E-05   Weff,z=6.942E-05
Iw=0.             Iyz=0.           h=0.1            Wpl,y=8.309E-05
E=210000000.      fy=355000.       fu=510000.       Wpl,z=8.309E-05


STRESS CHECK FORCES & MOMENTS
    Location          Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    1.42           26.512       1.165      -0.003       0.284       0.038       0.006

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.2.9.1(6y))
    D/C Ratio:      0.04 = 0.04   <         0.95          OK
                         = (My,Ed/Mn,y,Rd)       (EC3 6.2.9.1(6y))

AXIAL FORCE DESIGN
                        NEd       Nc,Rd       Nt,Rd
                     Force    Capacity    Capacity
    Axial           26.512      838.24      838.24

                    Npl,Rd       Nu,Rd       Ncr,T      Ncr,TF       An/Ag
                    838.24     867.047  142392.944      702.56          1.

              Curve   Alpha         Ncr   LambdaBar         Phi         Chi       Nb,Rd
    Y-Y           c    0.49      702.56       1.092       1.315       0.488     409.361
    Y-Y Braced    c    0.49      702.56       1.092       1.315       0.488     409.361
    Z-Z           c    0.49      702.56       1.092       1.315       0.488     409.361
```

Z-Z Braced	c	0.49	702.56	1.092	1.315	0.488	409.361
Torsional TF	c	0.49	702.56	1.092	1.315	0.488	409.361

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	1.165	1.165	29.498	29.498	29.498	29.498
Z-Z	-0.003	-0.019	29.498	29.498	29.498	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	0.22	0.532	0.984	0.	608.982

Factors	kw	C1	C2	C3		
	1.	1.155	0.43	1.12		
	za	zs	zg	zz	zj	
	0.05	0.	0.05	0.	0.	

	kyy	kyz	kzy	kzz
Factors	0.904	0.24	0.542	0.4

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	0.284	270.851	0.001	1.
3-Axis	0.038	258.249	1.460E-04	1.

SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	0.284	0.006	270.851	0.001	OK
3-Axis	0.038	0.006	258.249	0.	OK

	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	270.851	1.2	0.197	1.2
3-Axis	258.249	1.2	0.	1.

CONNECTION SHEAR FORCES FOR BEAMS

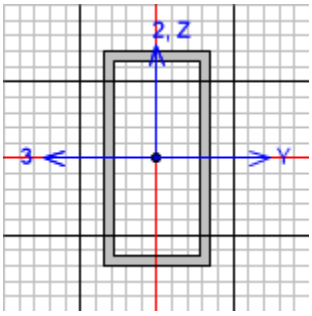
	V2 Left	V2 Right
2-2 (V2)	1.726	1.787

DEFLECTION CHECK (ComboSLS LIVE)

Type	Consider	Deflection	Limit	Ratio	Status
Dead Load	Yes	8.150E-04	0.027	0.031	OK
Super DL+LL	Yes	9.097E-04	0.027	0.034	OK
Live Load	Yes	3.143E-04	0.009	0.035	OK
Total Load	Yes	0.001	0.013	0.085	OK
Total-Camber	Yes	0.001	0.013	0.085	OK

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4.4.7 100x50x5




```
EN 1993-1-1:2005/A1:2014 STEEL SECTION CHECK  (Summary for Combo and Station)
Units  : KN, m, C

Frame :  216      X Mid:  2.15      Combo:  ULS WIND Y      Design Type:  Column
Length:  3.622    Y Mid:  -1.6      Shape:  100x50x5        Frame Type:  Secndry
Loc   :  0.       Z Mid:  1.811     Class:  Class 1         Rolled : No

Country = CEN Default - CEN EN 1993-1-1/2015-06
Combination = Eq. 6.10              Reliability = Class 2                Interaction = Method 2
(Annex B)
MultiResponse = Envelopes           P-Delta Done? Yes                    Consider Torsion? No

GammaM0=1.        GammaM1=1.        GammaM2=1.25
An/Ag=1.          RLLF=1.           PLLF=0.75         D/C Lim=0.95       Prin. Axis Angle = 0. deg

Aeff=0.001        Av,2=0.001        Av,3=5.000E-04    eNy=0.             eNz=0.
A=0.001           Iy=1.737E-06      iy=0.035          Wel,y=3.473E-05    Weff,y=3.473E-05
It=1.305E-06      Iz=5.617E-07      iz=0.02           Wel,z=2.247E-05    Weff,z=2.247E-05
Iw=0.             Iyz=0.            h=0.1             Wpl,y=4.400E-05
E=210000000.      fy=355000.        fu=510000.        Wpl,z=2.650E-05


STRESS CHECK FORCES & MOMENTS
    Location            Ned       My,Ed       Mz,Ed       V2,Ed       V3,Ed         TEd
    0.                -0.521      0.024      -0.706       0.107       0.921       0.006

PMM DEMAND/CAPACITY RATIO   (Governing Equation EC3 6.2.9.1(6z))
    D/C Ratio:     0.075 = 0.075   <         0.95          OK
                         = (Mz,Ed/Mn,z,Rd)       (EC3 6.2.9.1(6z))

AXIAL FORCE DESIGN
                          NEd       Nc,Rd       Nt,Rd
                        Force    Capacity    Capacity
    Axial             -0.521        497.        497.

                      Npl,Rd       Nu,Rd       Ncr,T       Ncr,TF       An/Ag
                        497.      514.08   64225.156       88.736          1.

                Curve   Alpha         Ncr   LambdaBar          Phi          Chi       Nb,Rd
    Y-Y             c    0.49     274.371       1.346        1.686         0.37     183.892
    Y-Y Braced      c    0.49     274.371       1.346        1.686         0.37     183.892
    Z-Z             c    0.49      88.736       2.367        3.831        0.146      72.616
```

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Z-Z Braced	c	0.49	159.991	1.763	2.436	0.243	120.701
Torsional TF	c	0.49	88.736	2.367	3.831	0.146	72.616

MOMENT DESIGN

	MEd Moment	MEd,span Moment	Mc,Rd Capacity	Mv,Rd Capacity	Mn,Rd Capacity	Mb,Rd Capacity
Y-Y	0.024	0.026	15.62	15.62	15.62	15.62
Z-Z	-0.706	-0.706	9.408	9.408	9.408	

	Curve	AlphaLT	LambdaBarLT	PhiLT	ChiLT	Iw	Mcr
LTB	d	0.76	0.306	0.587	0.919	0.	166.8

Factors	kw	C1	C2	C3		
	1.	1.759	0.43	1.12		
	za	zs	zg	zz	zj	
	0.05	0.	0.05	0.	0.	

	kyy	kyz	kzy	kzz
Factors	0.53	0.241	0.318	0.401

	VEd Force	Vpl,Rd Capacity	Ved/Vpl.Rd Ratio	rho Factor
2-Axis	0.107	221.356	4.830E-04	1.
3-Axis	0.921	102.48	0.009	1.

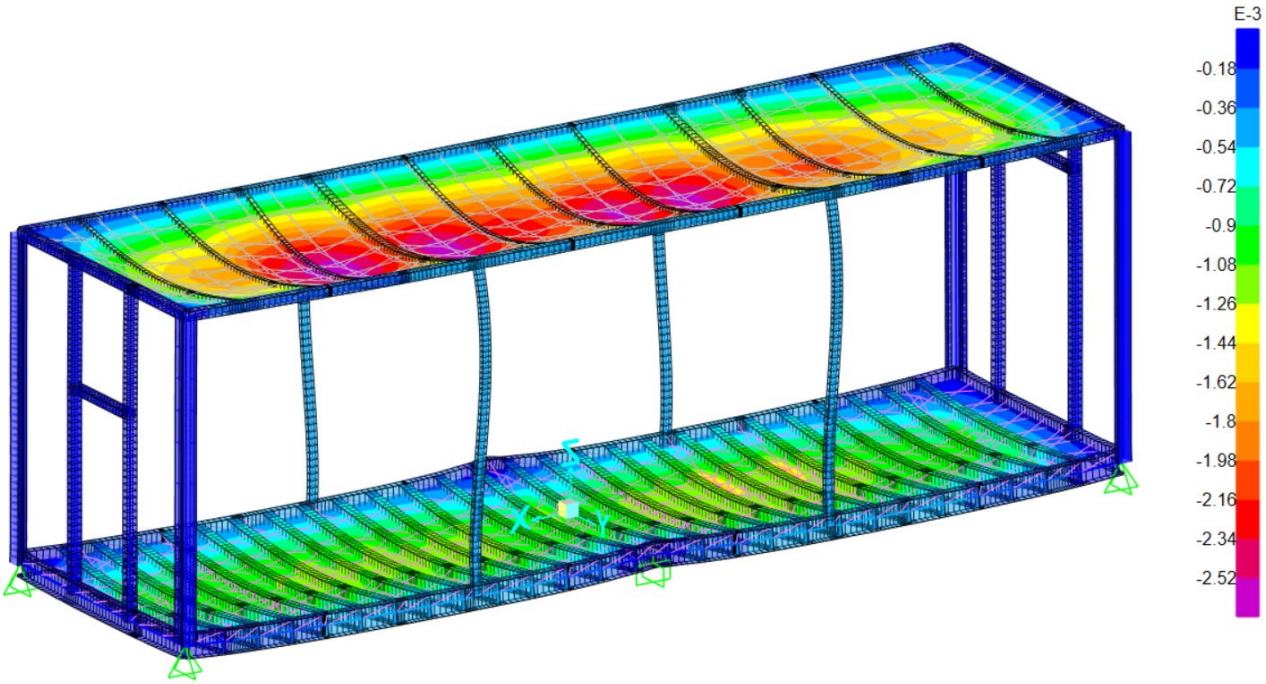
SHEAR DESIGN

	VEd Force	TEd Torsion	Vc,Rd Capacity	Stress Ratio	Status Check
2-Axis	0.107	0.006	221.356	0.	OK
3-Axis	0.921	0.006	102.48	0.009	OK

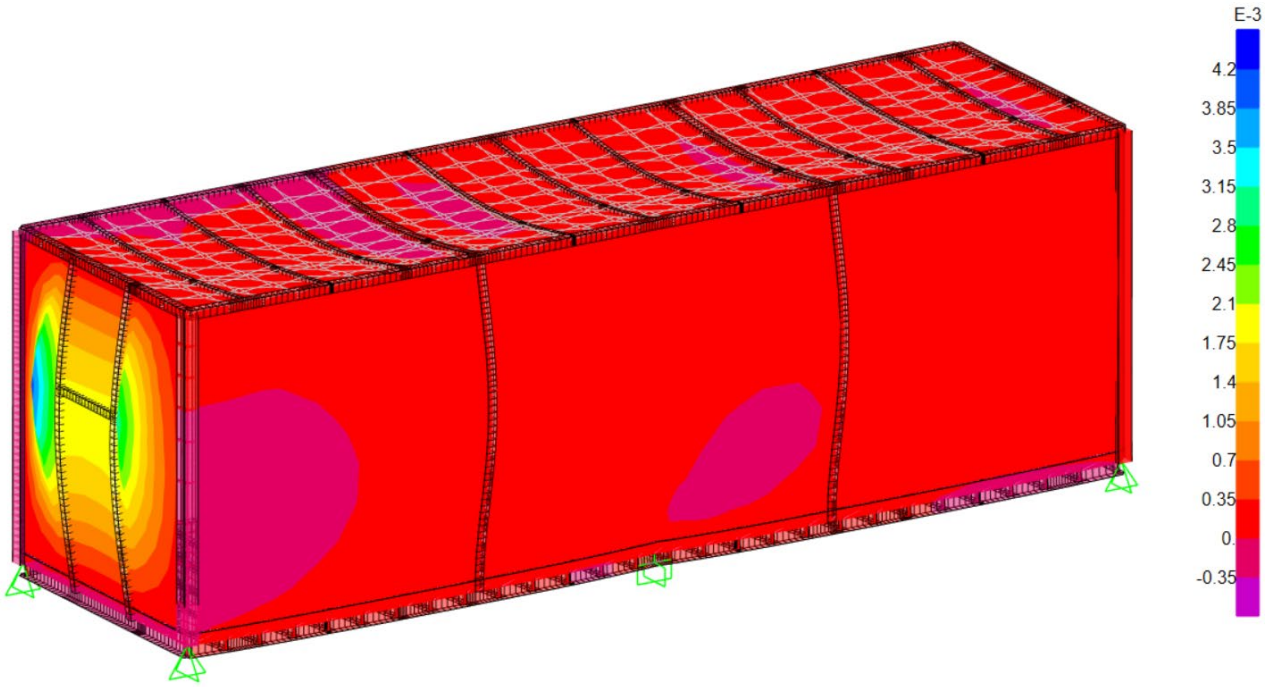
	Vpl,Rd Capacity	Eta Factor	Lambdabar Ratio	Chi Factor
2-Axis	221.356	1.2	0.256	1.2
3-Axis	102.48	1.2	0.	1.

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5 DISPLACEMENT CHECK

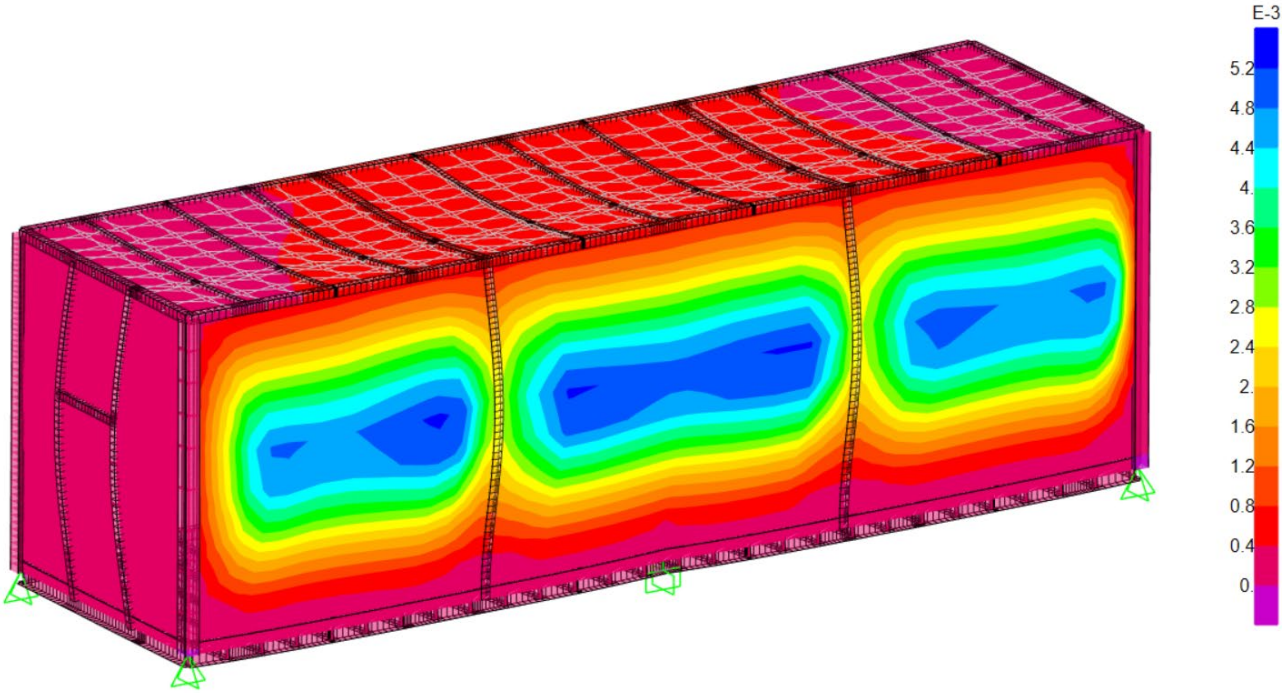


Uz SLS LIVE = 1.7 mm < 4500/240 = 18.75 mm



Ux SLS WIND X = 5.2mm < 4500/240 = 18.75 mm

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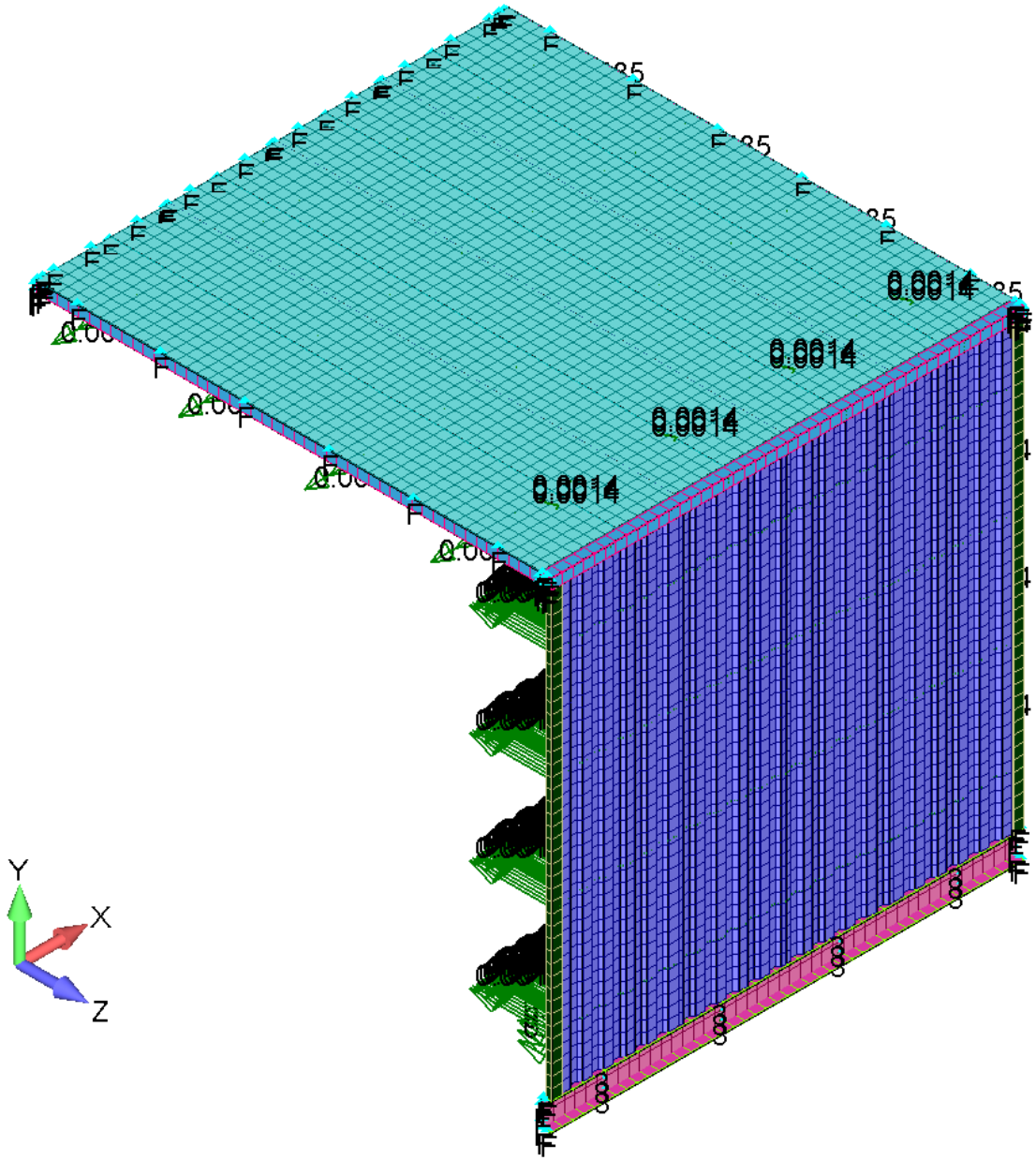
Uy SLS WIND Y = 6.5 mm < 4500/240 = 18.75 mm

6 METAL SHEET CHECK

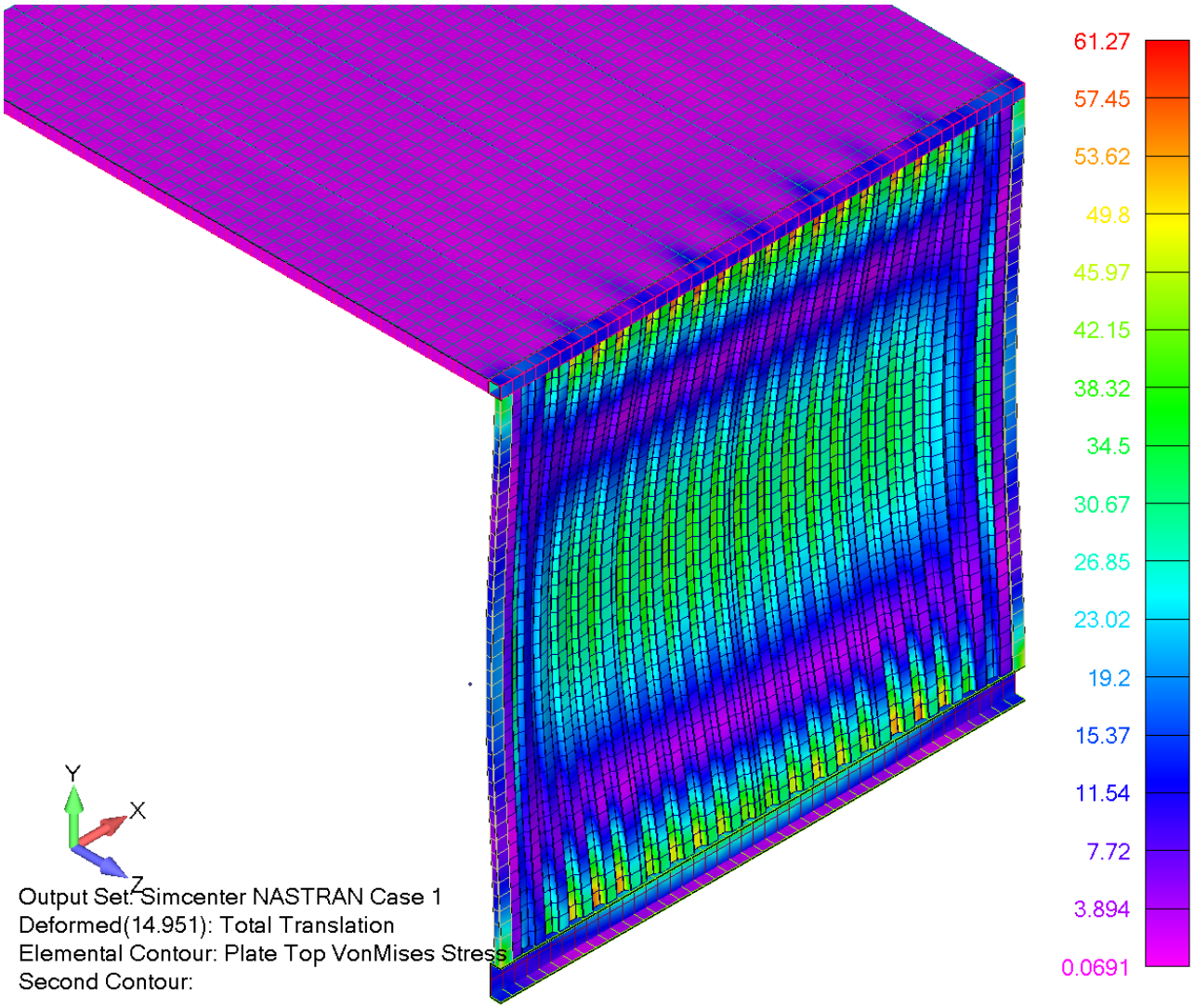
A detailed analysis of the corrugated wall and stave roof is carried out. The structure is modeled taking into account all the metal sheets constituting the geometry of metal sheet.

The front is loaded with 1.69 kN/m^2 wind pressure and Cp = 0.8. For the roof is applied 1.69 kN/m^2 with Cp = 0.5 and 45 degree (worst case).

The analysis is performed with FEMAP NASTRAN finite element software and post-processor.



MODEL WITH 8211 ELEMENTS AND 8805 NODES, LOADED AND FIXED AT THE ENDS



MAXIMUM VM STRESS 61 MPA AND 15 MM LATERAL DISPLACEMENT

Displacement value is lower than sap2000 simplified model for global analysis.

The maximum Von Mises stress is lower than yield limit reduced by safety factor 1.15 → 275/1.15 = 239 MPa.

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7 BASE REACTIONS

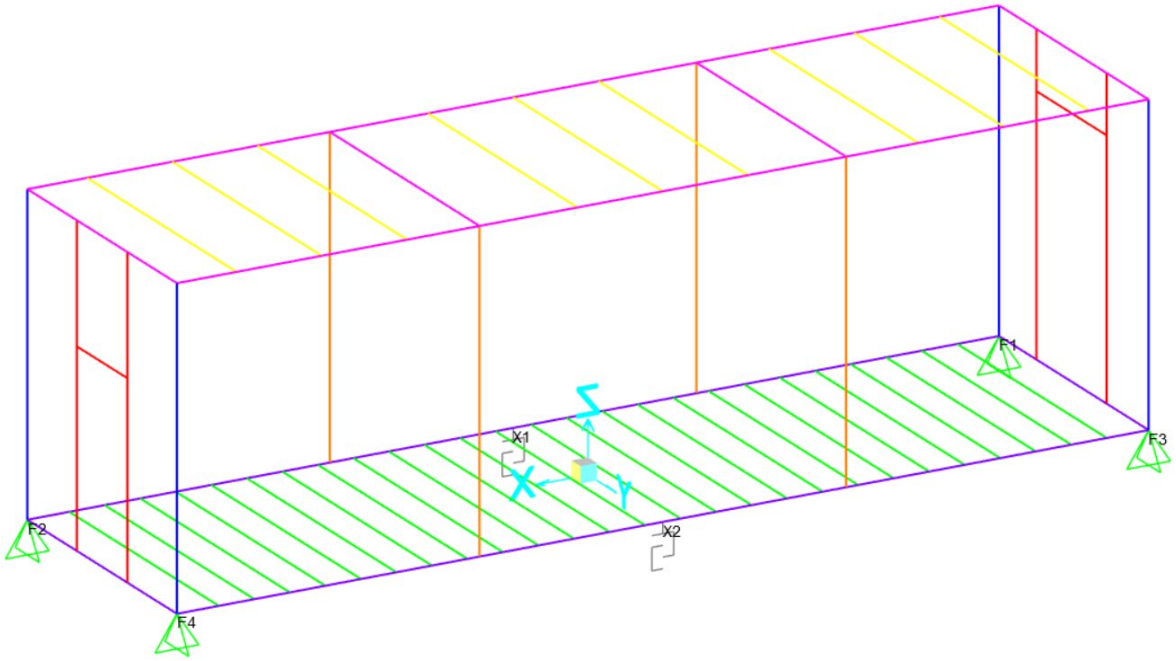


TABLE: Joint Reactions

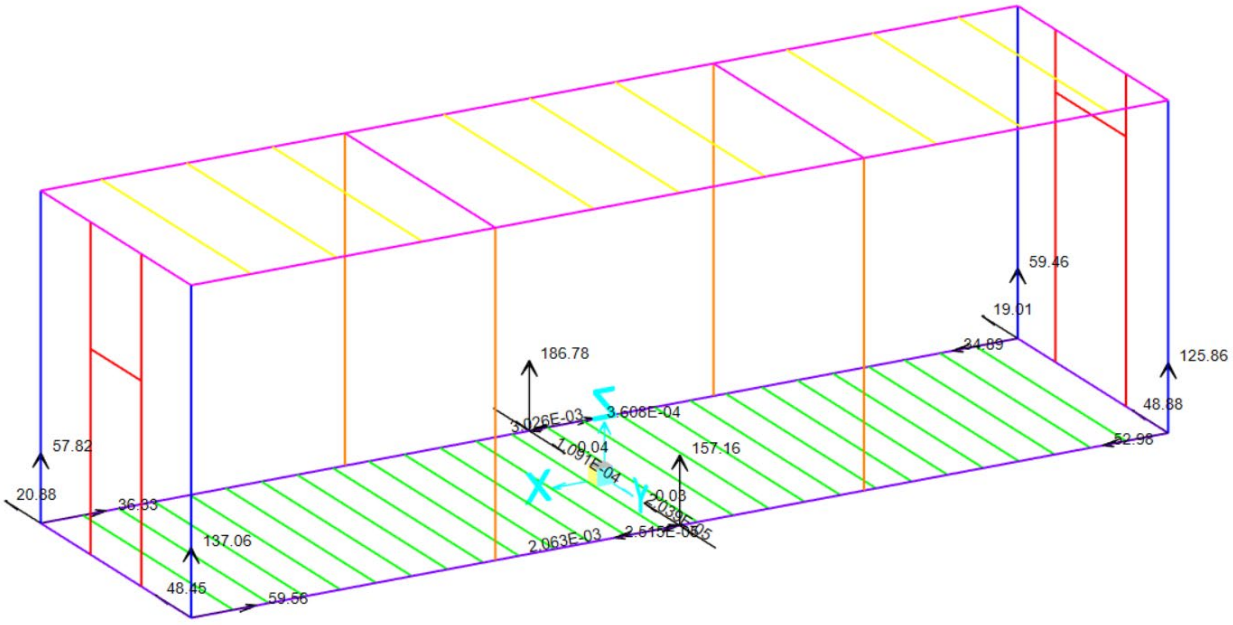
Joint	OutputCase	CaseType	StepType	Fx	Fy	Fz	Mx	My	Mz
Text	Text	Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
F1	DEAD	NonStatic	Last Step	8.15	3.98	20.56	0.00	0.00	0.00
F1	SD	NonStatic	Last Step	17.79	5.10	26.86	0.00	0.00	0.00
F1	LIVE	NonStatic	Last Step	18.94	6.80	43.72	0.00	0.00	0.00
F1	WIND X	NonStatic	Last Step	-11.64	0.34	-9.78	0.00	0.00	0.00
F1	WIND Y	NonStatic	Last Step	-12.43	-25.98	-33.62	0.00	0.00	0.00
F1	NOT X	NonStatic	Last Step	-0.07	-0.01	-0.02	0.00	0.00	0.00
F1	NOT Y	NonStatic	Last Step	-0.04	-0.07	-0.06	0.00	0.00	0.00
F1	SLU LIVE	Combination		65.55	22.92	132.49	0.00	0.00	0.00
F1	SLU WIND X	Combination		35.85	12.57	88.06	0.00	0.00	0.00
F1	SLU WIND Y	Combination		34.89	-19.01	59.46	0.00	0.00	0.00
F1	SLE LIVE	Combination		44.78	15.80	91.06	0.00	0.00	0.00
F1	SLE WIND X	Combination		10.47	1.55	27.47	0.00	0.00	0.00
F1	SLE WIND Y	Combination		9.91	-16.88	10.79	0.00	0.00	0.00
F2	DEAD	NonStatic	Last Step	-8.15	3.95	20.50	0.00	0.00	0.00
F2	SD	NonStatic	Last Step	-15.55	4.85	31.79	0.00	0.00	0.00
F2	LIVE	NonStatic	Last Step	-19.68	6.13	33.86	0.00	0.00	0.00
F2	WIND X	NonStatic	Last Step	-1.08	-2.06	-5.72	0.00	0.00	0.00
F2	WIND Y	NonStatic	Last Step	12.41	-26.02	-33.53	0.00	0.00	0.00
F2	NOT X	NonStatic	Last Step	-0.07	0.01	0.02	0.00	0.00	0.00
F2	NOT Y	NonStatic	Last Step	0.04	-0.07	-0.06	0.00	0.00	0.00
F2	SLU LIVE	Combination		-63.48	21.52	125.06	0.00	0.00	0.00
F2	SLU WIND X	Combination		-52.52	7.87	91.19	0.00	0.00	0.00
F2	SLU WIND Y	Combination		-36.33	-20.88	57.82	0.00	0.00	0.00
F2	SLE LIVE	Combination		-43.41	14.87	86.10	0.00	0.00	0.00
F2	SLE WIND X	Combination		-21.09	-1.13	36.46	0.00	0.00	0.00
F2	SLE WIND Y	Combination		-11.65	-17.90	17.00	0.00	0.00	0.00

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TABLE: Joint Reactions

Joint	OutputCase	CaseType	StepType	Fx	Fy	Fz	Mx	My	Mz
Text	Text	Text	Text	KN	KN	KN	KN-m	KN-m	KN-m
F3	DEAD	NonStatic	Last Step	8.15	-3.98	20.51	0.00	0.00	0.00
F3	SD	NonStatic	Last Step	11.42	-4.47	17.26	0.00	0.00	0.00
F3	LIVE	NonStatic	Last Step	20.70	-7.01	46.69	0.00	0.00	0.00
F3	WIND X	NonStatic	Last Step	-11.74	-0.31	-9.79	0.00	0.00	0.00
F3	WIND Y	NonStatic	Last Step	4.72	-19.65	18.12	0.00	0.00	0.00
F3	NOT X	NonStatic	Last Step	-0.07	0.01	-0.02	0.00	0.00	0.00
F3	NOT Y	NonStatic	Last Step	0.04	-0.07	0.06	0.00	0.00	0.00
F3	SLU LIVE	Combination		58.73	-22.47	122.63	0.00	0.00	0.00
F3	SLU WIND X	Combination		33.23	-25.68	92.38	0.00	0.00	0.00
F3	SLU WIND Y	Combination		52.98	-48.88	125.86	0.00	0.00	0.00
F3	SLE LIVE	Combination		40.24	-15.52	84.50	0.00	0.00	0.00
F3	SLE WIND X	Combination		9.22	-14.72	33.46	0.00	0.00	0.00
F3	SLE WIND Y	Combination		20.74	-28.25	52.99	0.00	0.00	0.00
F4	DEAD	NonStatic	Last Step	-8.15	-3.95	20.50	0.00	0.00	0.00
F4	SD	NonStatic	Last Step	-13.65	-5.48	33.05	0.00	0.00	0.00
F4	LIVE	NonStatic	Last Step	-19.97	-5.92	33.74	0.00	0.00	0.00
F4	WIND X	NonStatic	Last Step	-1.16	2.03	-5.71	0.00	0.00	0.00
F4	WIND Y	NonStatic	Last Step	-4.70	-19.60	18.02	0.00	0.00	0.00
F4	NOT X	NonStatic	Last Step	-0.07	-0.01	0.02	0.00	0.00	0.00
F4	NOT Y	NonStatic	Last Step	-0.04	-0.07	0.06	0.00	0.00	0.00
F4	SLU LIVE	Combination		-61.15	-22.33	126.93	0.00	0.00	0.00
F4	SLU WIND X	Combination		-55.32	-22.49	108.58	0.00	0.00	0.00
F4	SLU WIND Y	Combination		-59.56	-48.45	137.06	0.00	0.00	0.00
F4	SLE LIVE	Combination		-41.87	-15.42	87.36	0.00	0.00	0.00
F4	SLE WIND X	Combination		-24.48	-13.35	53.32	0.00	0.00	0.00
F4	SLE WIND Y	Combination		-26.95	-28.49	69.93	0.00	0.00	0.00
X1	DEAD	NonStatic	Last Step	0.00	0.00	24.94	0.00	0.00	0.00
X1	SD	NonStatic	Last Step	0.00	0.02	65.88	0.00	0.00	0.00
X1	LIVE	NonStatic	Last Step	0.00	0.01	52.89	0.00	0.00	0.00
X1	WIND X	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X1	WIND Y	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X1	NOT X	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X1	NOT Y	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X1	SLU LIVE	Combination		0.00	0.05	210.58	0.00	0.00	0.00
X1	SLU WIND X	Combination		0.00	0.04	186.78	0.00	0.00	0.00
X1	SLU WIND Y	Combination		0.00	0.04	186.78	0.00	0.00	0.00
X1	SLE LIVE	Combination		0.00	0.03	143.71	0.00	0.00	0.00
X1	SLE WIND X	Combination		0.00	0.02	90.82	0.00	0.00	0.00
X1	SLE WIND Y	Combination		0.00	0.02	90.82	0.00	0.00	0.00
X2	DEAD	NonStatic	Last Step	0.00	0.00	24.95	0.00	0.00	0.00
X2	SD	NonStatic	Last Step	0.00	-0.01	43.97	0.00	0.00	0.00
X2	LIVE	NonStatic	Last Step	0.00	-0.01	55.99	0.00	0.00	0.00
X2	WIND X	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X2	WIND Y	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X2	NOT X	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X2	NOT Y	NonStatic	Last Step	0.00	0.00	0.00	0.00	0.00	0.00
X2	SLU LIVE	Combination		0.00	-0.04	182.36	0.00	0.00	0.00
X2	SLU WIND X	Combination		0.00	-0.03	157.17	0.00	0.00	0.00
X2	SLU WIND Y	Combination		0.00	-0.03	157.17	0.00	0.00	0.00
X2	SLE LIVE	Combination		0.00	-0.03	124.90	0.00	0.00	0.00
X2	SLE WIND X	Combination		0.00	-0.01	68.91	0.00	0.00	0.00
X2	SLE WIND Y	Combination		0.00	-0.01	68.91	0.00	0.00	0.00

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BASE <u>REACTIONS</u> FOR WORST ULS WIND Y CASE (F1 = FX, F2 = FY and F3 = FZ)

Joint Reactions in Joint Local CoordSys

Joint Object	F4	Joint Element	F4
	1	2	3
Force	-59.56	-48.451	137.064
Moment	0.	0.	0.

MAX FY reaction (SHEAR) = 60 kN

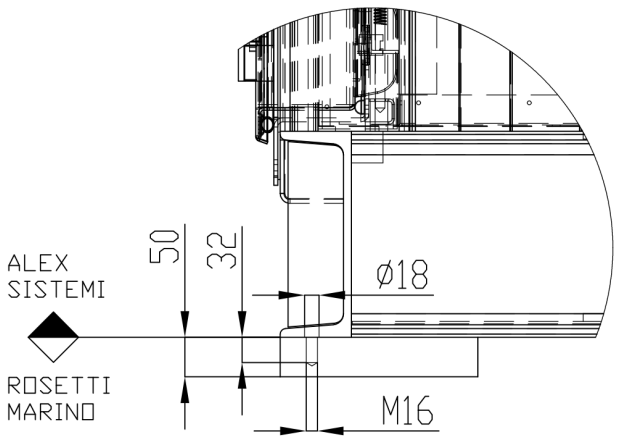
M1 and M2 in the image are values close to zero in according with the boundary conditions and concern only gaps non-linear link elements (as non-linear elements with imposed zero stiffness, the software calculate the value to the limit of zero).

For the fixing at the ground will be considered two M18 bar class 8.8 for hinge.

CORNER ANCHOR BOLT CHECK						
Nc=	0	kN				
Nt=	0	kN				
Vx=	60	kN	Vmax=(Vx^2+Vy^2)^0.5=			
Vy=	49	kN			77	kN
Φb=	18	mm				
SIF*DIF=	1					
fu=	860	Mpa				
Ω blast=	1					
Ab=(π*(Φb-3)^2)/4=		176.715	mm^2			
Abn=0.78*Ab=		137.837	mm^2			
Tension check	Nbu=Nt/2=		0.000	kN		
	Nbn=DIF*fu*Abn=		118.540	kN		
	Nbu/(Ω*Nbn)=		0.000	<1	OK	
Shear check	Vbu=Vmax/2=		38.733	kN		
	Vbn=0.6*DIF*fu*Abn=		71.124	kN		
	Vbu/(Ω*Vbn)=		0.545	<1	OK	
Combined	(Nbu/1.4/Nbn)+(Vbu/Vbn)=		0.545	<1	OK	

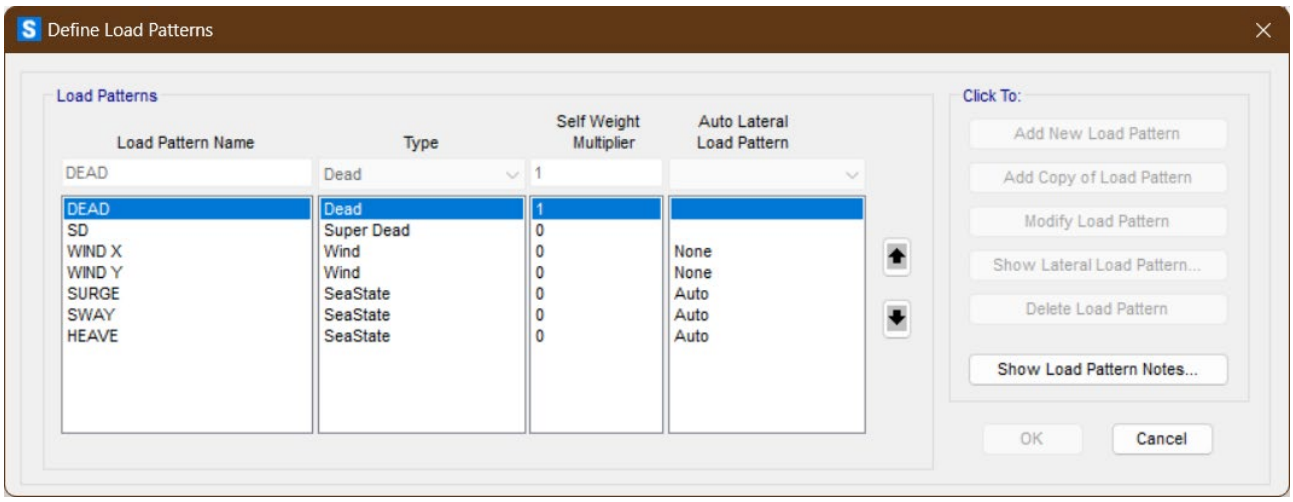
The vertical reactions in model are always compression on the ground but in favour of safety is considered tension Nt on bolt.

M18 bar verified (worst ULS WIND Y case)

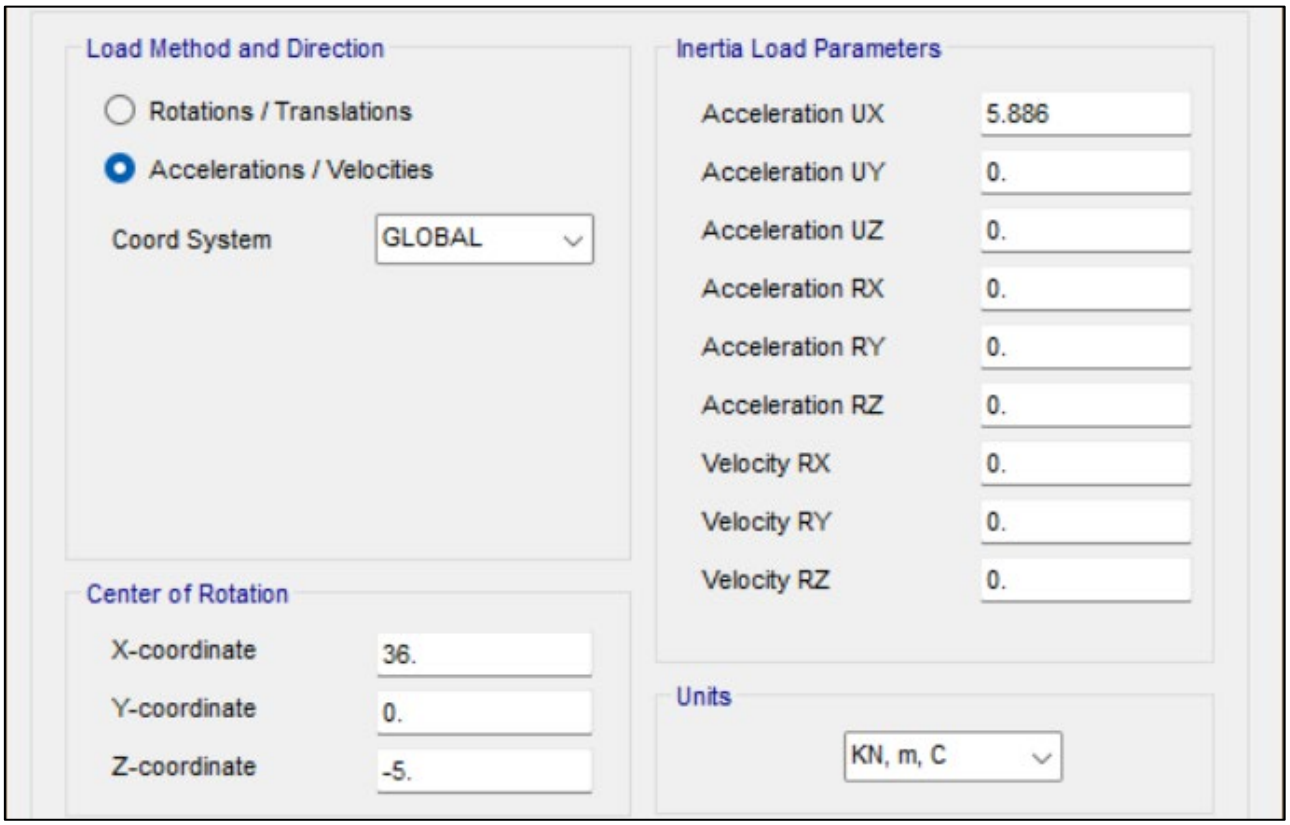


8 SEA TRANSPORT ANALYSIS

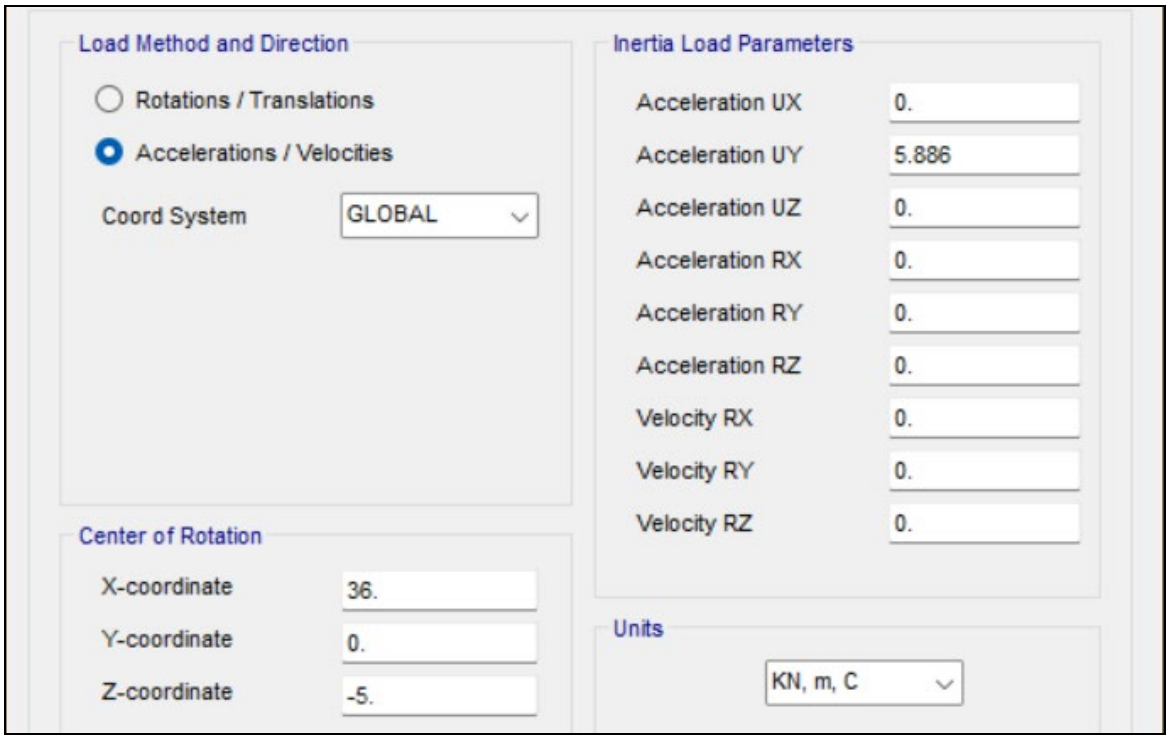
For the sea transport analysis are considered the three translational acceleration as 0.6g for Surge and Sway and 0.5g for Heave. The three accelerations are applied as sea-state loads considering also the center of rotation that is the distances between cog of structure and cog of barge.



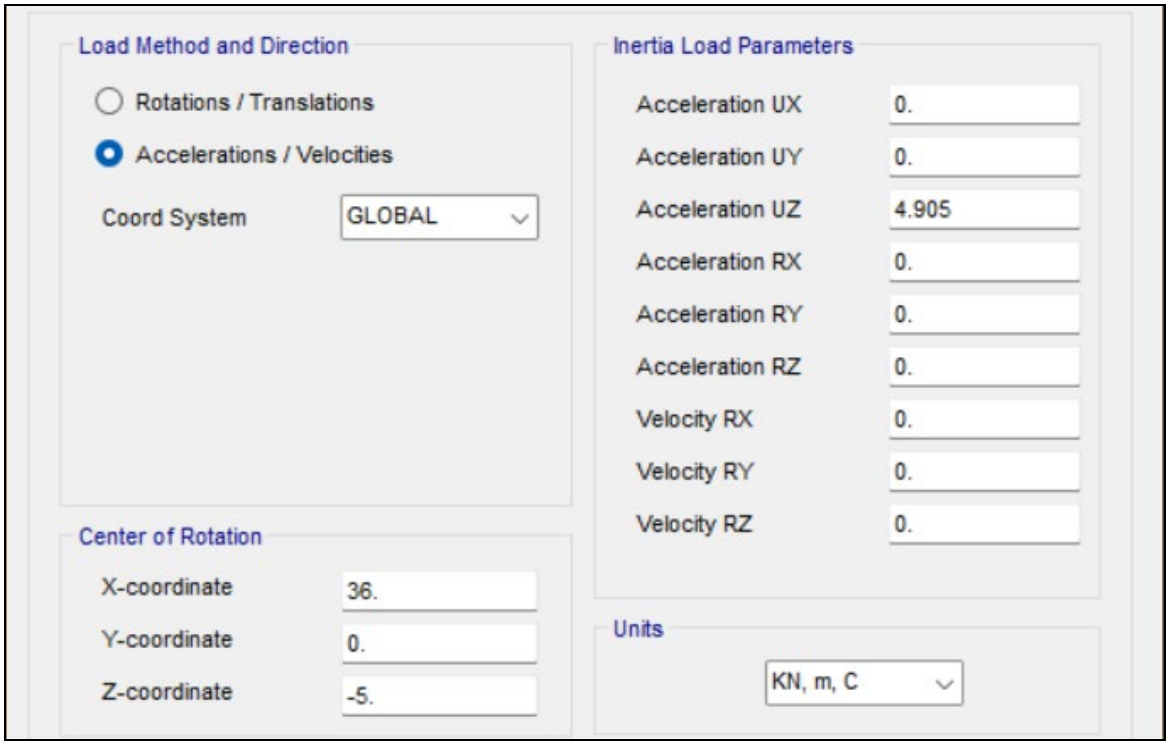
SURGE LONGITUDINAL ACCELERATION



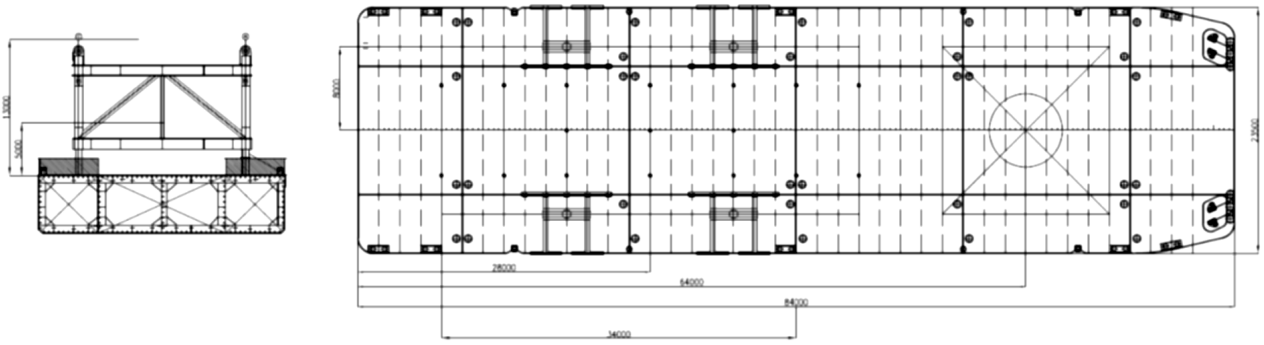
SWAY TRANSVERSAL ACCELERATION



HEAVE VERTICAL ACCELERATION

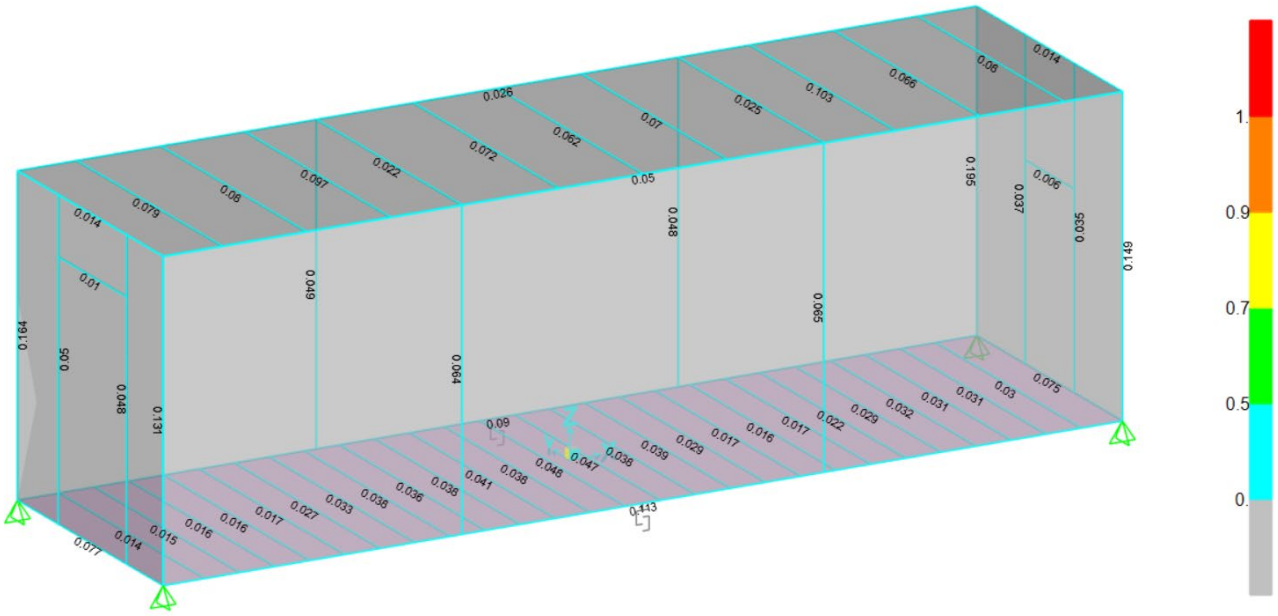


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8.2 STRESS CHECK SEA TRANSPORT

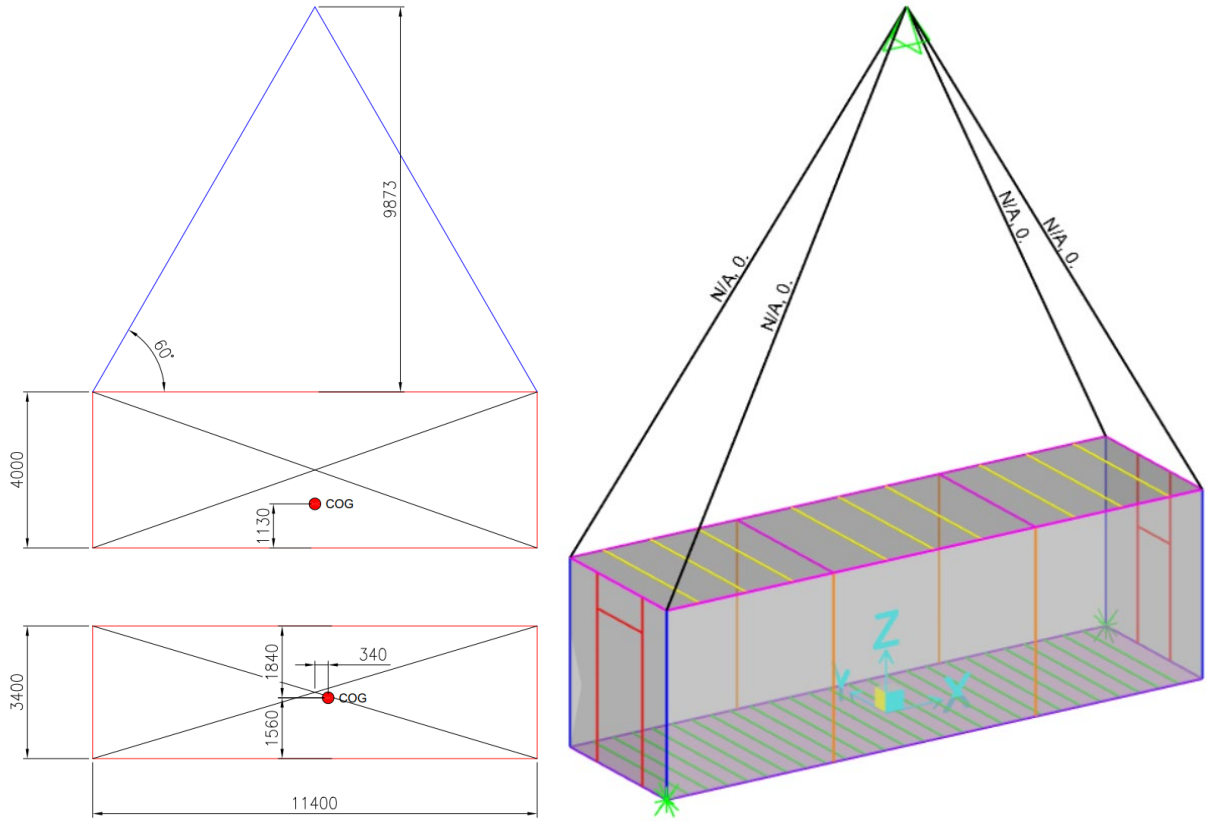
The loads are combined as explained in chapter 4.3 and verified in according with EN 1993.



9 LIFTING ANALYSIS

For lifting analysis, only the weight of shelter (DEAD LOAD AND NO STRUCTURAL LOAD SD in LLC 2 combinations) are considered.

Total weight of shelter is about 35 ton including equipment. Lifting cables are modeled with non-linear elements cables tension-only connected to the top corner points (lifting points) of model in non-linear geometry analysis.



LIFTING SCHEME AND MODEL

TABLE: Base Reactions

OutputCase	CaseType	GlobalFX	GlobalFY	GlobalFZ	GlobalMX	GlobalMY	GlobalMZ	XCentroidFZ	YCentroidFZ	ZCentroidFZ
Text	Text	KN	KN	KN	KN-m	KN-m	KN-m	m	m	m
DEAD	NonStatic	0.00	0.00	131.95	-0.08	0.44	0.00	0.00	0.00	1.48
SD	NonStatic	0.00	0.00	218.80	-48.40	-118.00	0.00	0.54	-0.22	0.93
DEAD+SD	Combination	0.00	0.00	350.75	-48.48	-117.57	0.00	0.34	-0.14	1.13

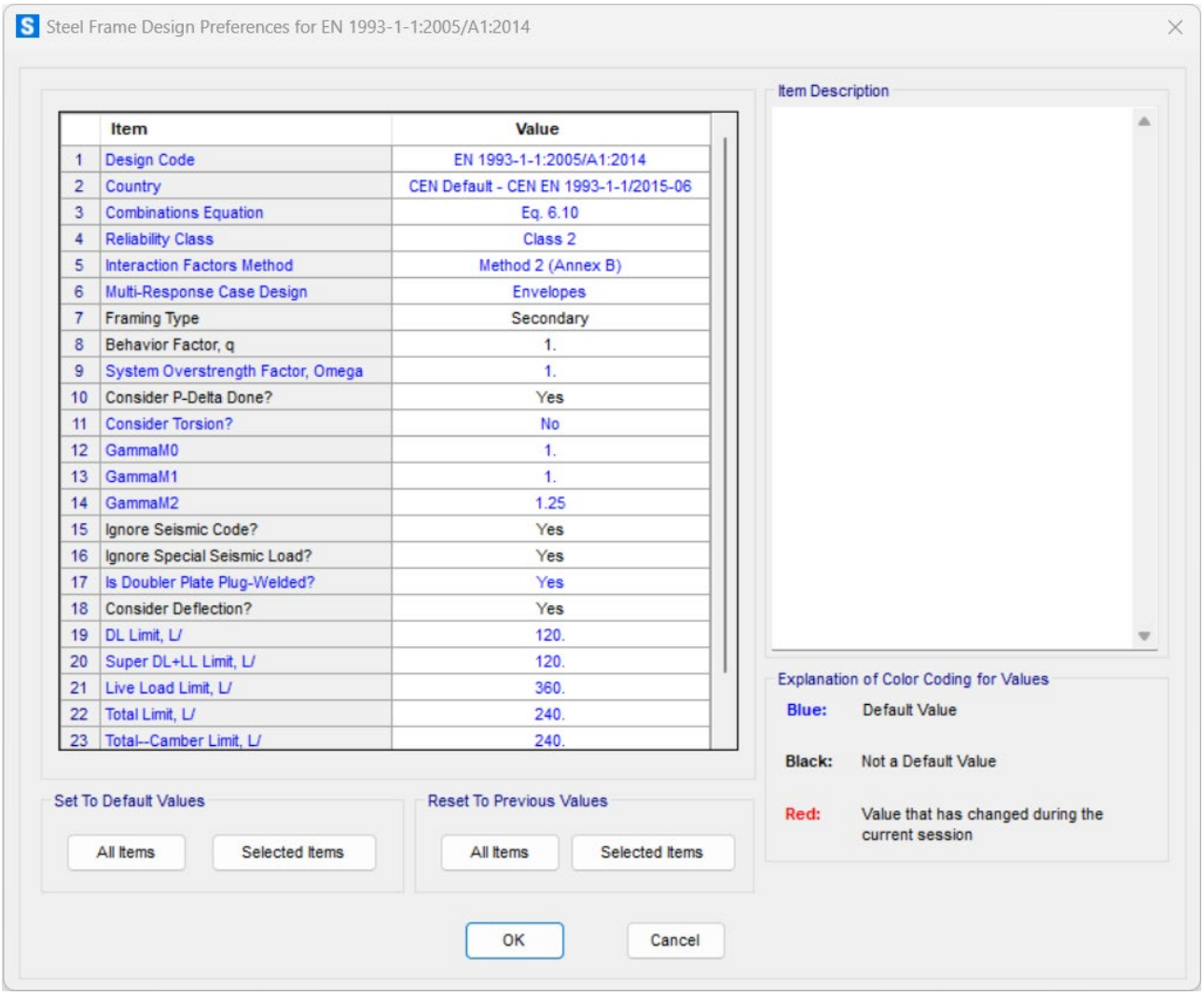
The total weight DEAD + SD was estimated in favor of safety about 35 ton. For the real values refer to the 4.2.1 and 4.2.2 chapters. The red numbers represent the shift in horizontal place for the shackle pin restraints at the top of cables.

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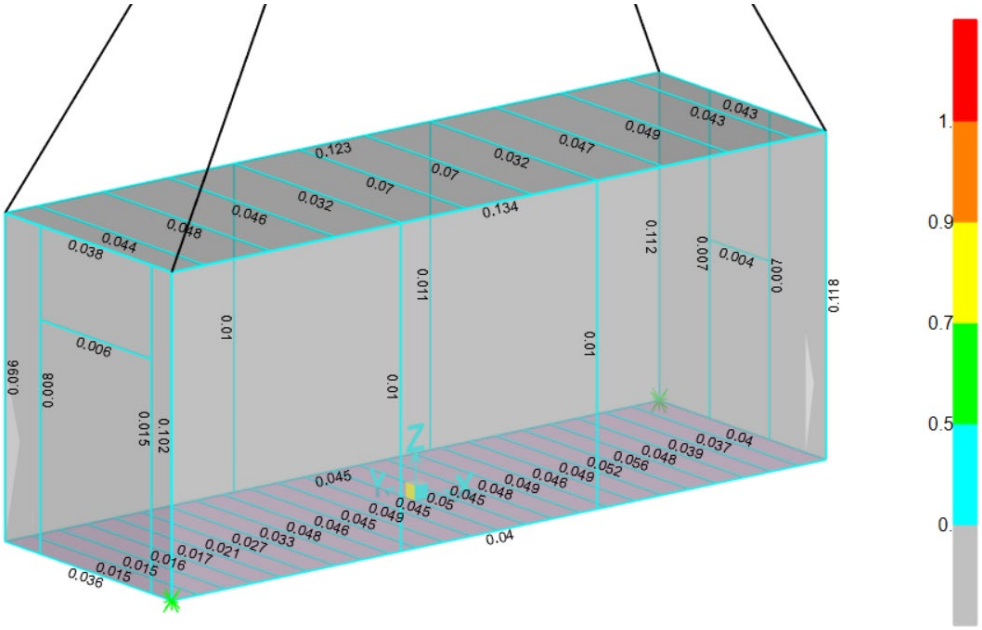
To converge the non-linear analysis results (tension only cables elements) translational XY restrains are added at the bottom corners. These restrains act only against torsional effects on the whole structure acting around the vertical Z axis.

9.2 STRESS CHECK LIFTING

All sections are check and verified in according with EN 1993 combination LLC2. Showed below the detailed printout for each type of section in its combination of maximum stress and the force diagrams with values for roof frames.



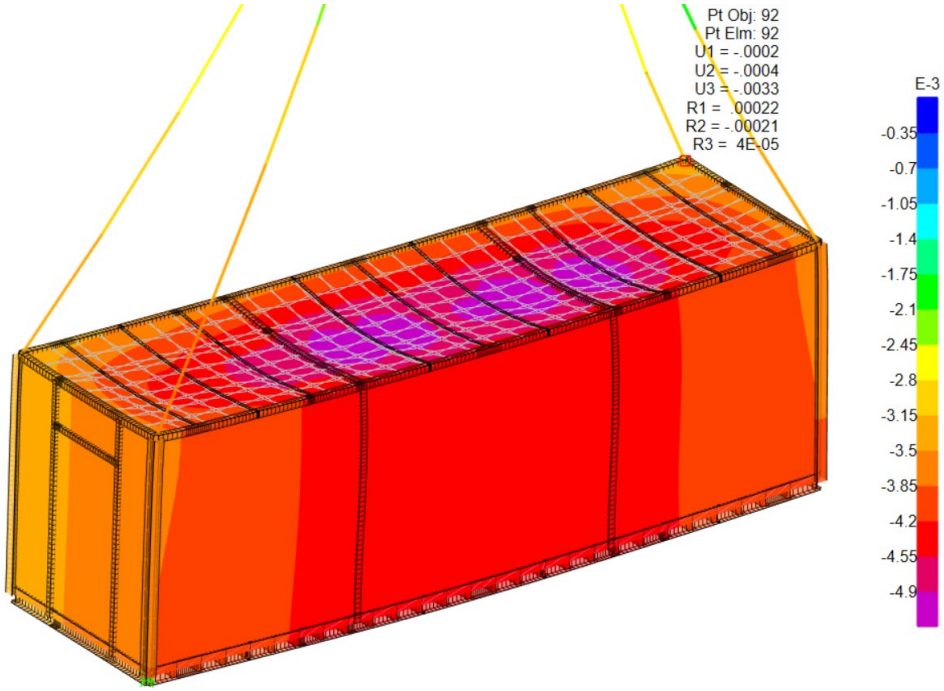
For lifting condition is automatically calculated also the relative deflection and compared with the limit L/240 (for beams). For beams in compression is calculated the lateral torsion buckling limit from code.



CHECK DESIGN FOR ULS LOADS (ORANGE < 1 RATIO)

9.3 DISPLACEMENT CHECK LIFTING

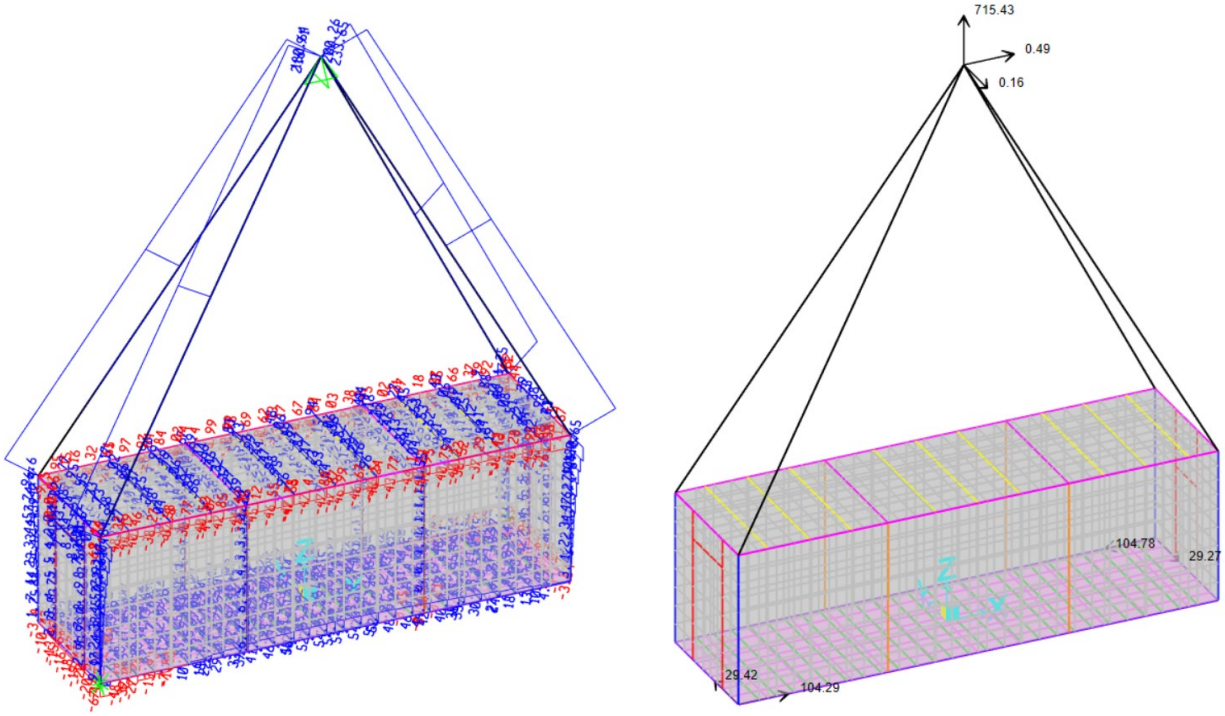
For the graphic visualization of absolute displacement is necessary to remove the elongation of cables taken at its connection end with the shelter.



MAX UZ ABSOLUTE DISPLACEMENT FOR LIFTING ROOF BEAM 4.9-3.3 = 1.6 mm < 13000/360 = 36 mm

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10 LIFTING HOOK DETAIL CHECK



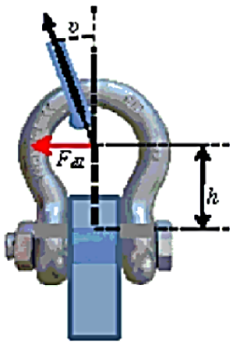
The maximum tension force on cable for lifting stress combination LLC3 (factor 2) is 234 kN.

In the model is applied also the sling load due to the transversal component of tension force. Is added an extra lateral load of 5% 234 kN = 12 kN in the X and Z directions (horizontal in Femap).

This force is applied on the spider node represented the surface contact between shackle and lifting lug. The model is characterized by solid hexahedral elements for a total of 33704 (20218 nodes).

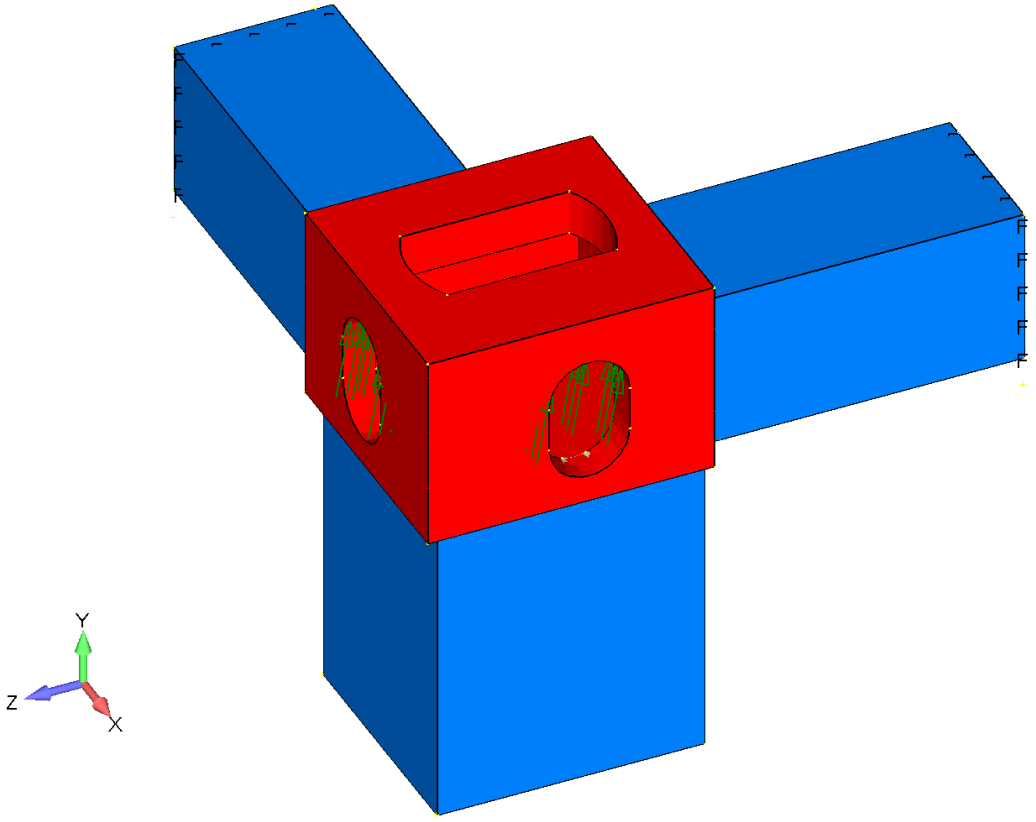
P.2.6.1

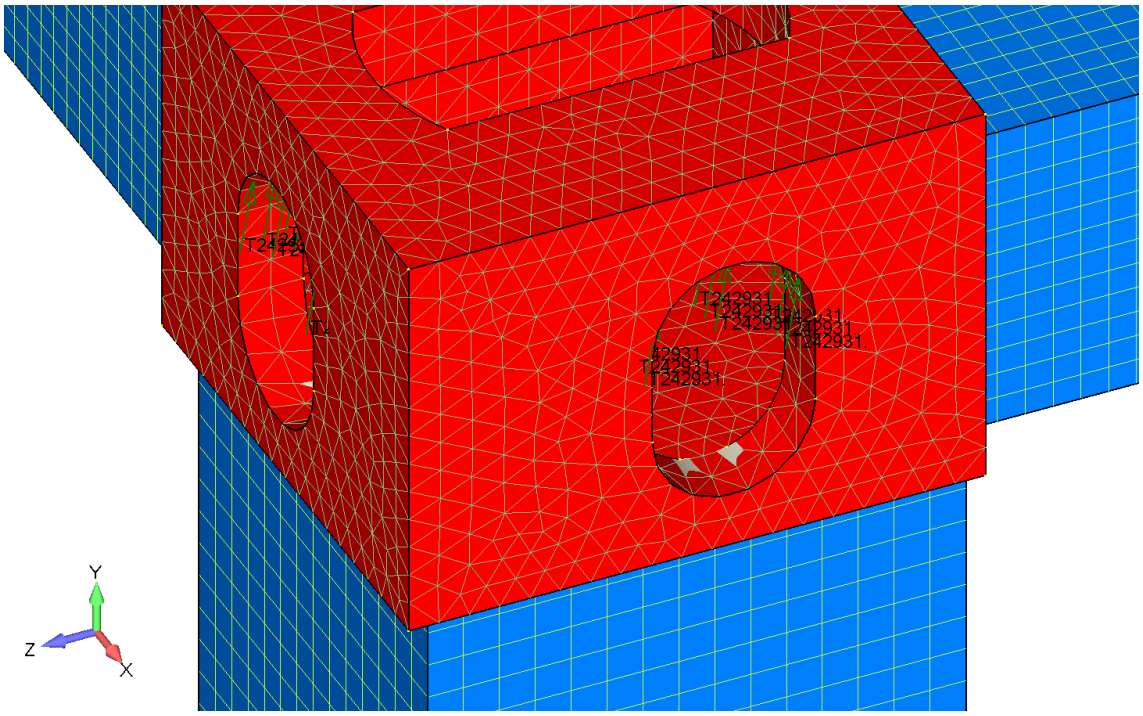
The design loads on the padeye may be calculated as indicated below. The following assumptions apply:

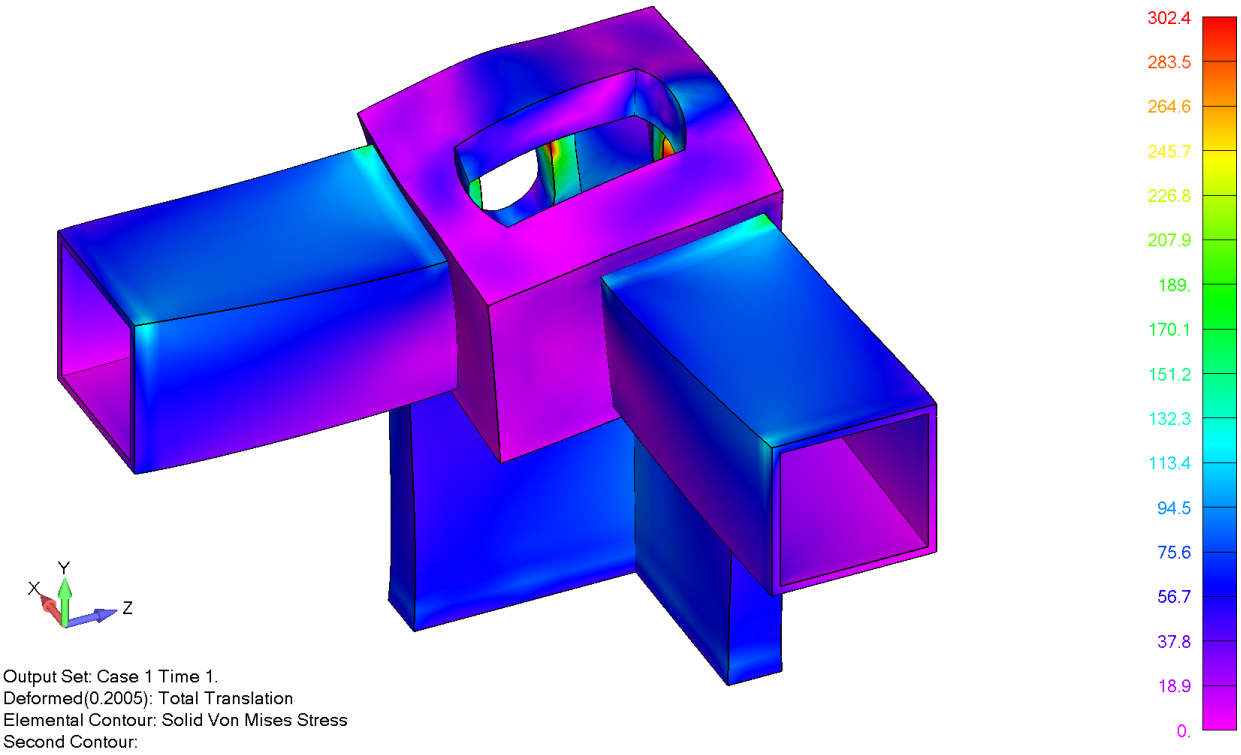


- The sling design load (FSD) is transferred to the padeye through a shackle as indicated on the sketch.
- No friction between sling and shackle.
- The shackle is positioned centric in the padeye.
- Lateral load (F_{dl}) is transferred to the padeye through contact pressure between shackle body and padeye and/or as friction force between pin and padeye. Load resultant is assumed to work at top of pin.
- Moment (M_e) is transferred to the padeye through contact pressure between shackle pin and padeye.

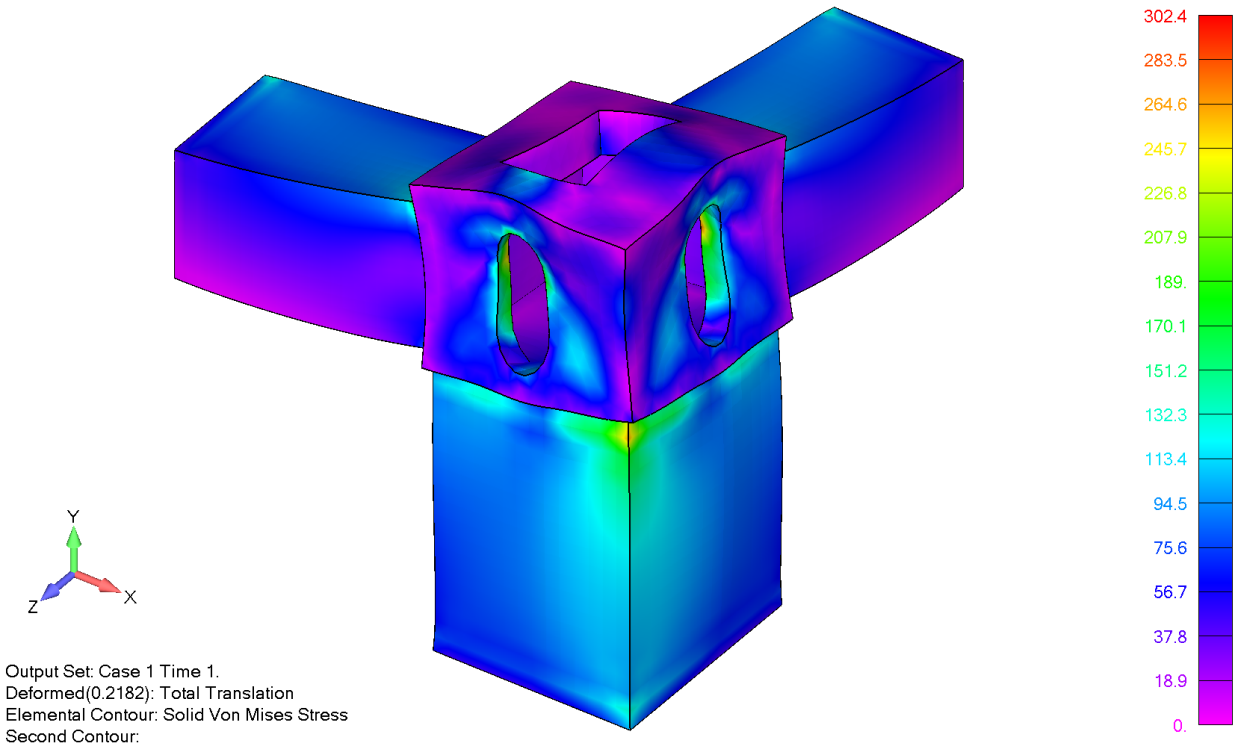
F_d=FSD × cos(v)	F_{dl}=FSD × sin(v)	M_e=F_{dl} × h


Y
Z
X


Y
Z
X

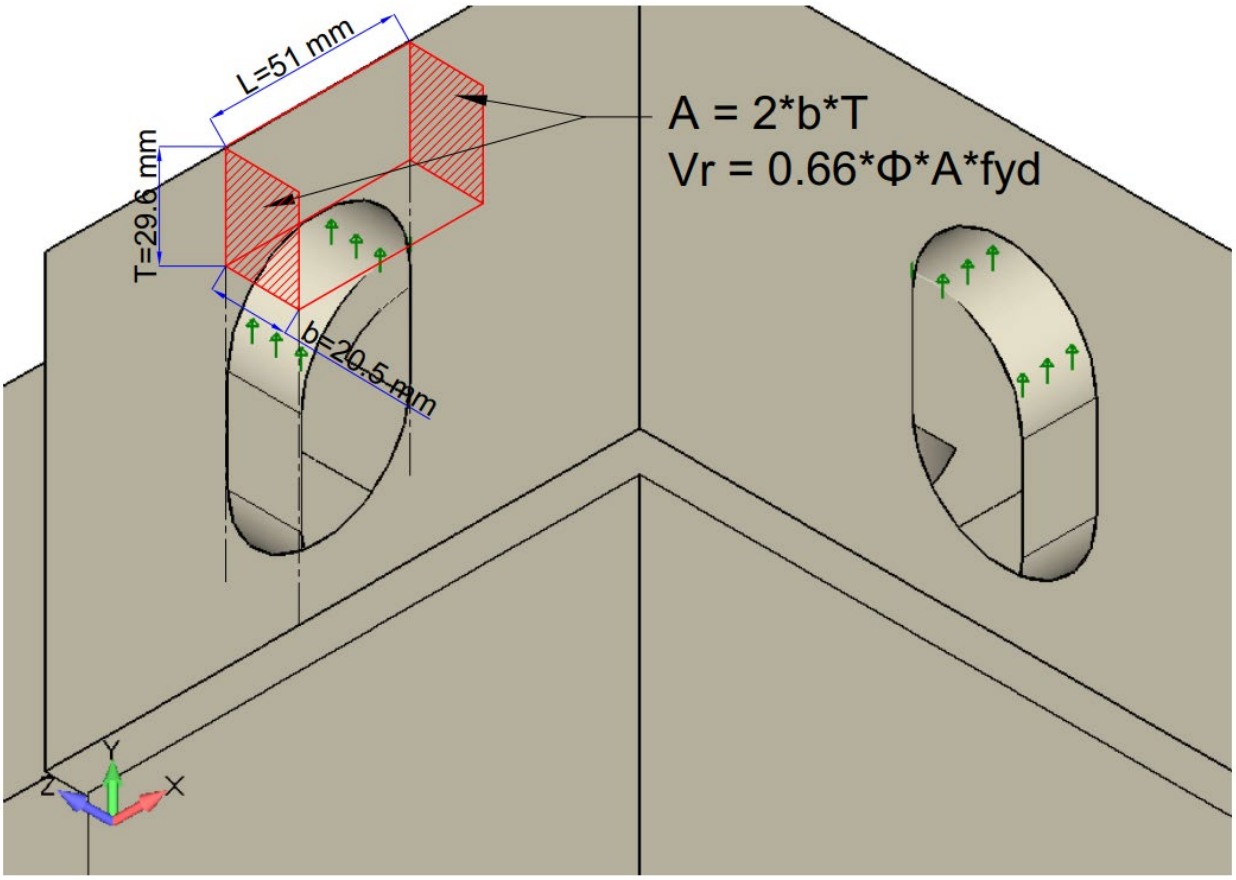


Output Set: Case 1 Time 1.
Deformed(0.2005): Total Translation
Elemental Contour: Solid Von Mises Stress
Second Contour:



Output Set: Case 1 Time 1.
Deformed(0.2182): Total Translation
Elemental Contour: Solid Von Mises Stress
Second Contour:

*MAXIMUM STRESS 302.4 MPA < 355*0.9 = 320 MPA*



For shear check of the lifting point subjected to tension from lifting cables, the shear stress is manually checked and compared with the limit value of the steel.

$A = 2*b*T = 2*20.5*29.6 = 1213.6\ mm^2$

$Vr = 0.66*\Phi*A*fyd = 0.66*0.9*1213.6*355 = 255912\ N = 256\ kN > 234\ kN$ **(Verified)**

11 CONCLUSIONS

All structural components of cabin are verified. The stresses and displacements are compatible with the real behaviour and the structure is capable of supporting of assigned load.

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