Base Load Power Hub (BLPH)

NITROGEN GENERATION PACKAGE A-64000
PACKAGE STRUCTURAL CALCULATION REPORT
INCLUDING FIXING POINTS and LIFTING POINTS

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ROSETTI MARINO

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None

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1 INTRODUCTION

1.1 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.

1.1.1 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.

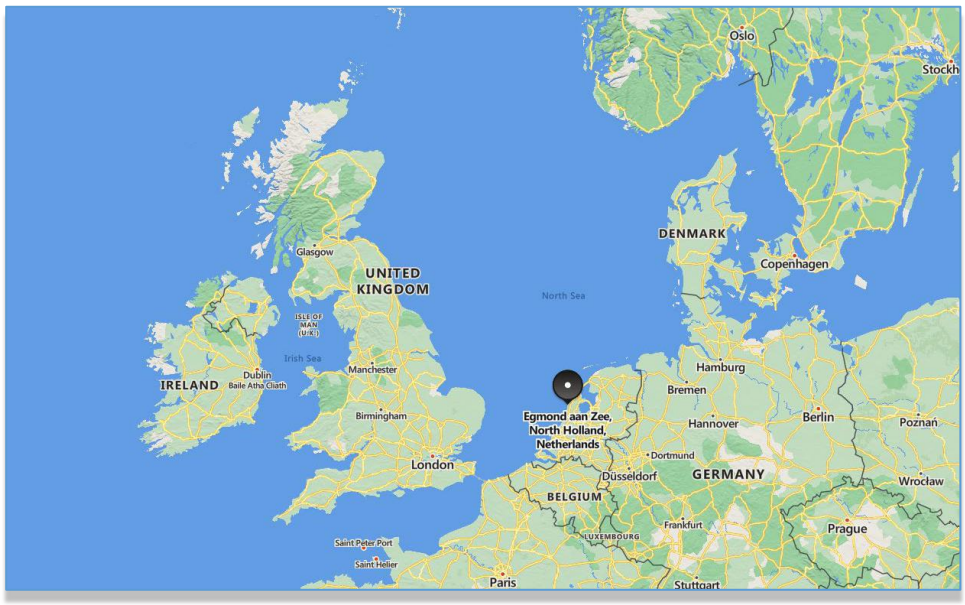


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

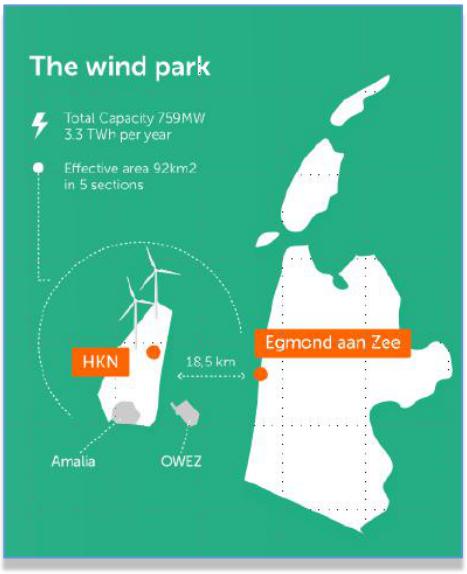


Figure 2 - Wind Park Details

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.

1.1.2 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.

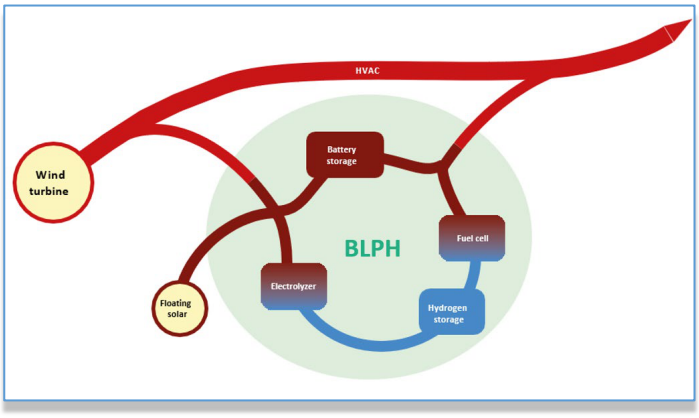


Figure 3 – BLPH Concept

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.

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2 DOCUMENT SCOPE

This document identifies any electrical equipment to be fed with its main characteristics.

2.1 REFERENCES

Doc. No.	Description
1724000437-PR-PID-00018	PACKAGE P&ID
1724000437-MAC-DA-00005	CERTIFIED PACKAGE GENERAL ARRANGEMENT AND DIMENSIONAL OUTLINE DRAWINGS (INCLUDING : NAMEPLATE, BASEFRAME, FOUNDATION LOADS, NOZZLES LOADS, NOZZLES LIST, BATTERY LIMITS, CoG)

Table 1 - Reference Documents

2.2 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

3 STRUCTURAL CALCULATION

This report deals with the structural design of the nitrogen generation package in the following conditions:

- Lifting conditions
- Operating conditions: static + action of wind
- Transportation conditions, including wind action

3.1 CODES AND STANDARDS

The design of the structure is carried out in accordance with the following Codes and Standards:

- UNI EN 1990 “EUROCODE 0 – Basis of Structural Design”
- UNI EN 1991 "EUROCODE 1 – Actions on structures”
- UNI EN 1993 “EUROCODE 3 – Design of steel structures”

3.2 MATERIALS OF CONSTRUCTION

According with Bill of Material contained in technical drawings, the material of construction for the main structure elements is S 355 J2 (EN 10025-2), having the following mechanical properties:

MATERIAL	**Steel S355 J2** (EN 10025-2)	
Elastic modulus	E	210000 [MPa]
Poisson	ν	0.29
Density	Ro	7870 [Kg/m3]
Yield strength	Fty	350 [MPa]
Ultimate strength	Ftu	420 [MPa]

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3.3 LIFTING ANALYSIS

Is considered as the load of the materials forming a permanent part of the structure unit. It is defined as the load of structures and equipment on operating conditions:

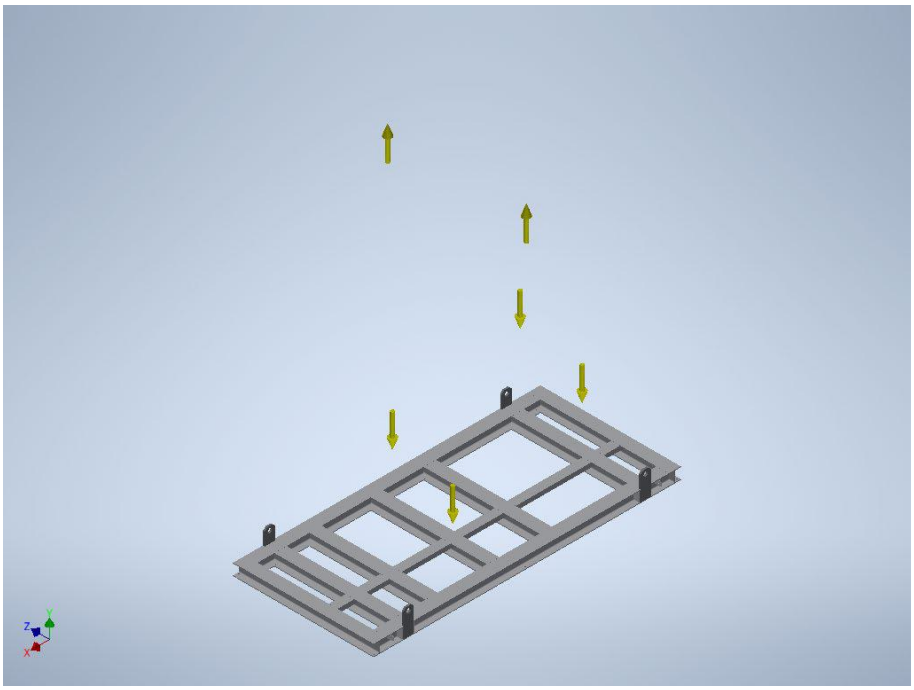
Item	Weight (kg)	Weight (N)
PSA	2500	24525
Filter group	250	2452,5
Control Panel (UCP)	350	3433,5
Baseframe	800	7848
TOTAL (including piping and valves)	5000	49050

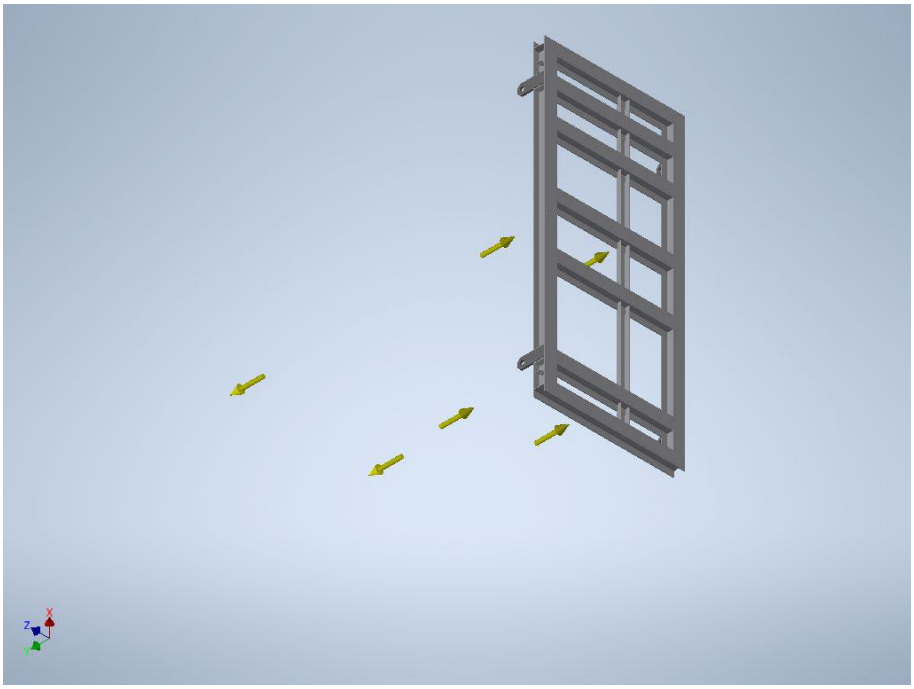
Each load has been applied as concentrated in each center of gravity.

The padeye has been also calculated, as shown in section 3.4.

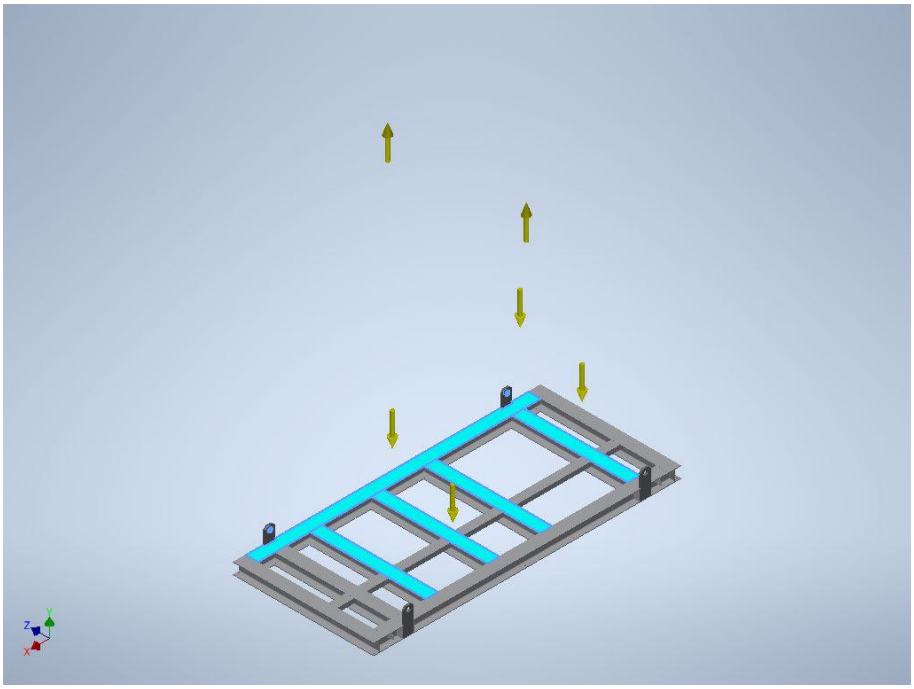
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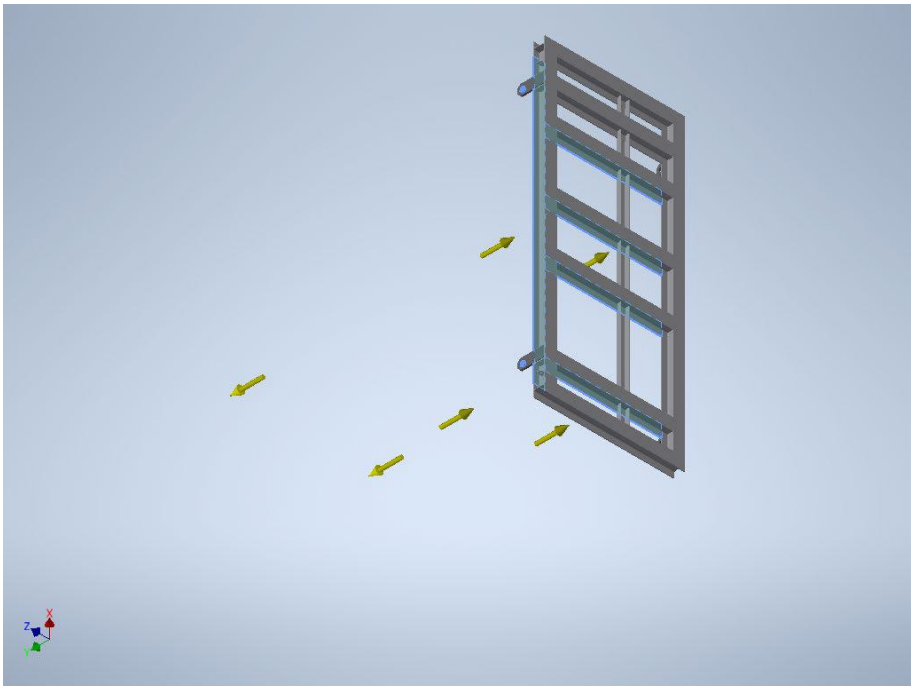
Gravity



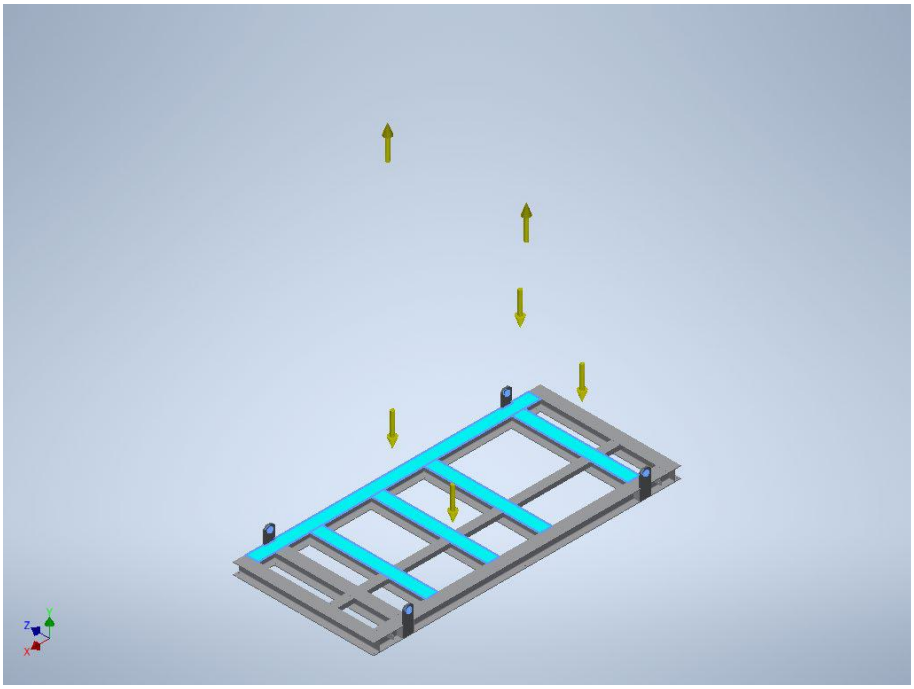


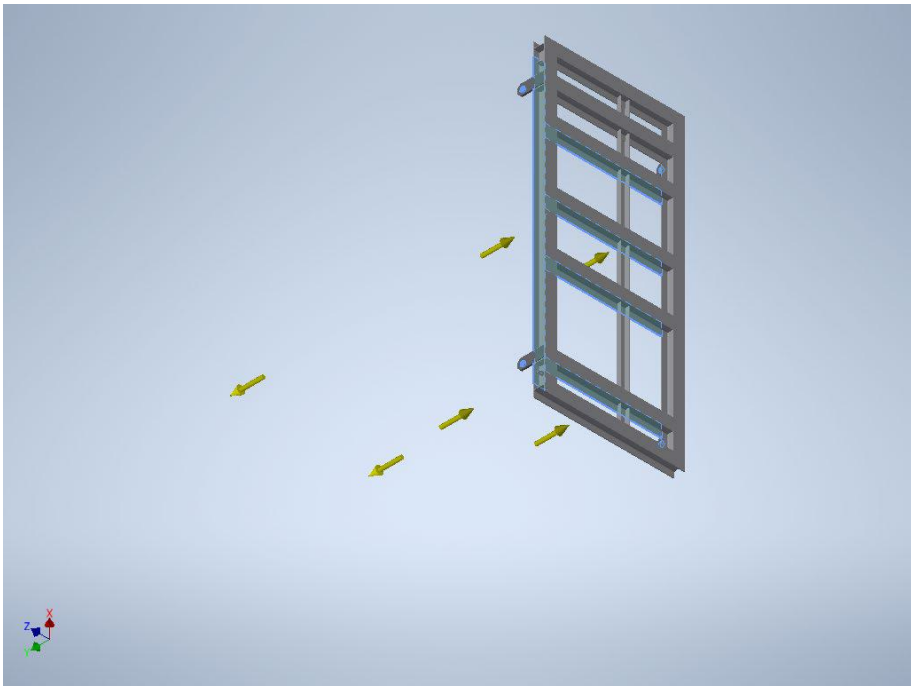
Lifting load_1 (applied according to the lifting sketch)



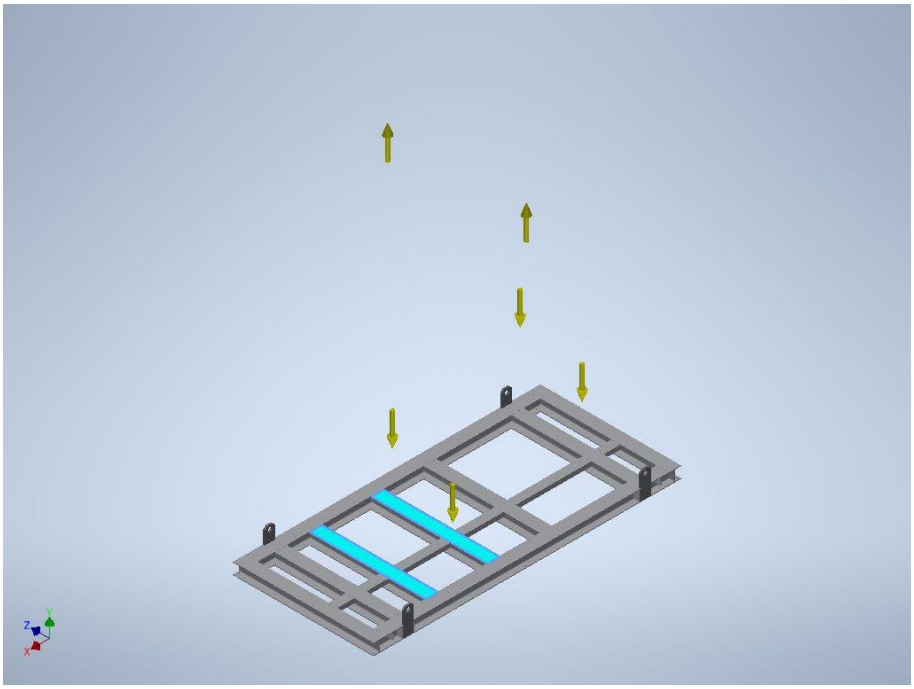


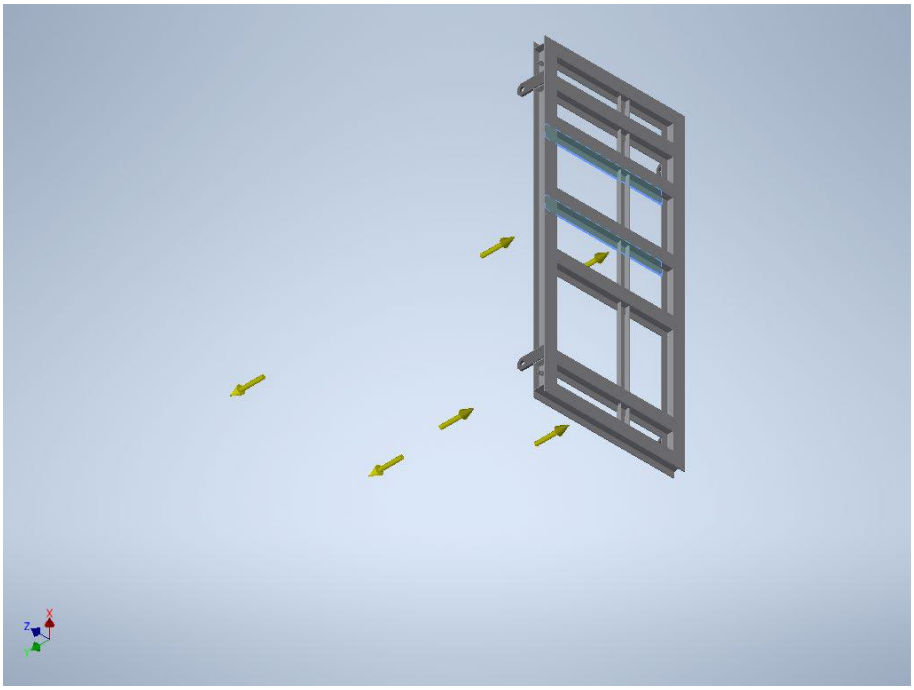
Lifting load_2 (applied according to the lifting sketch)



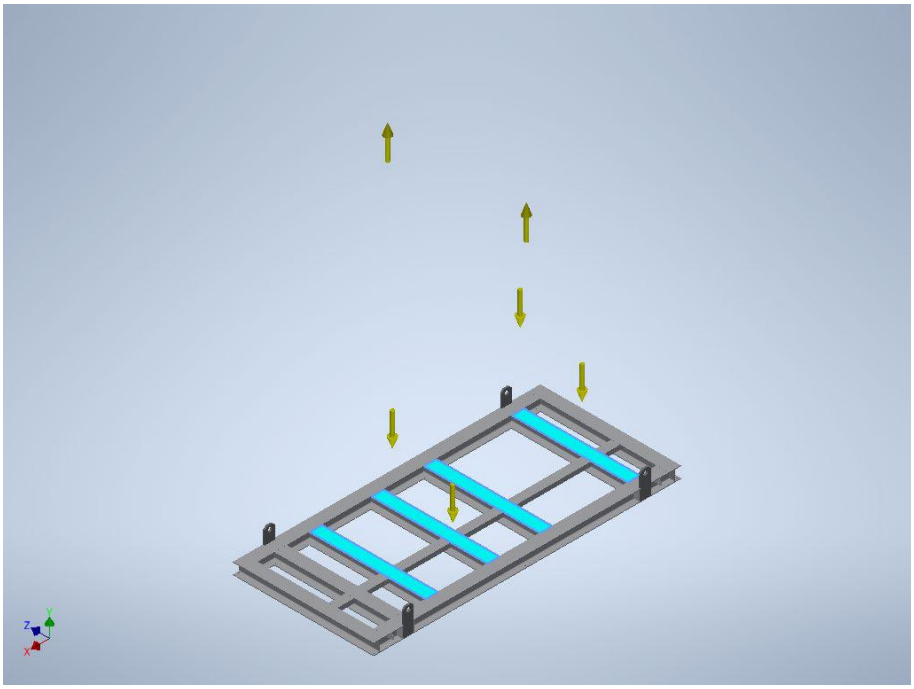


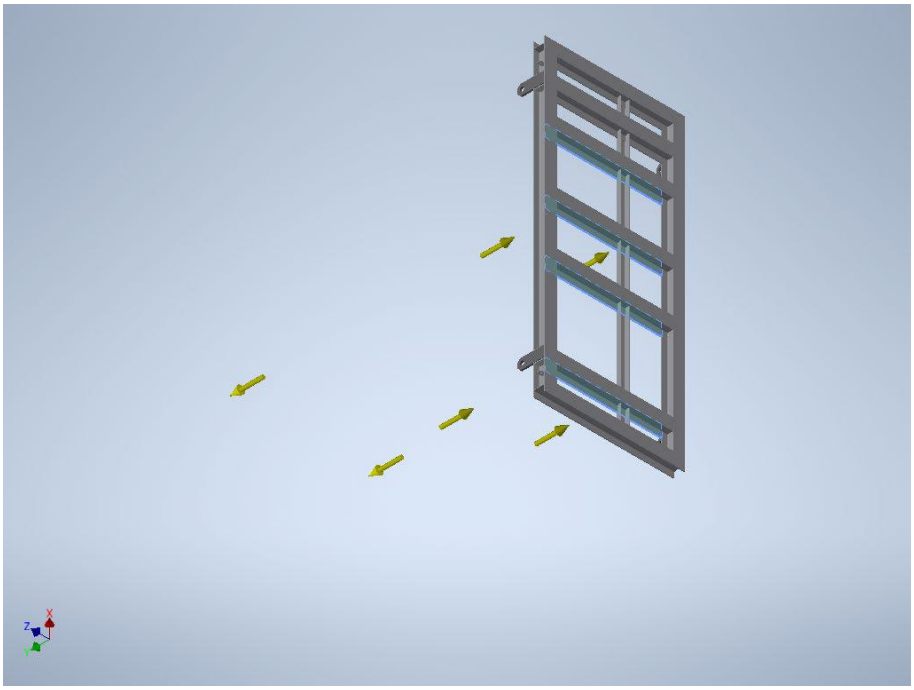
PSA



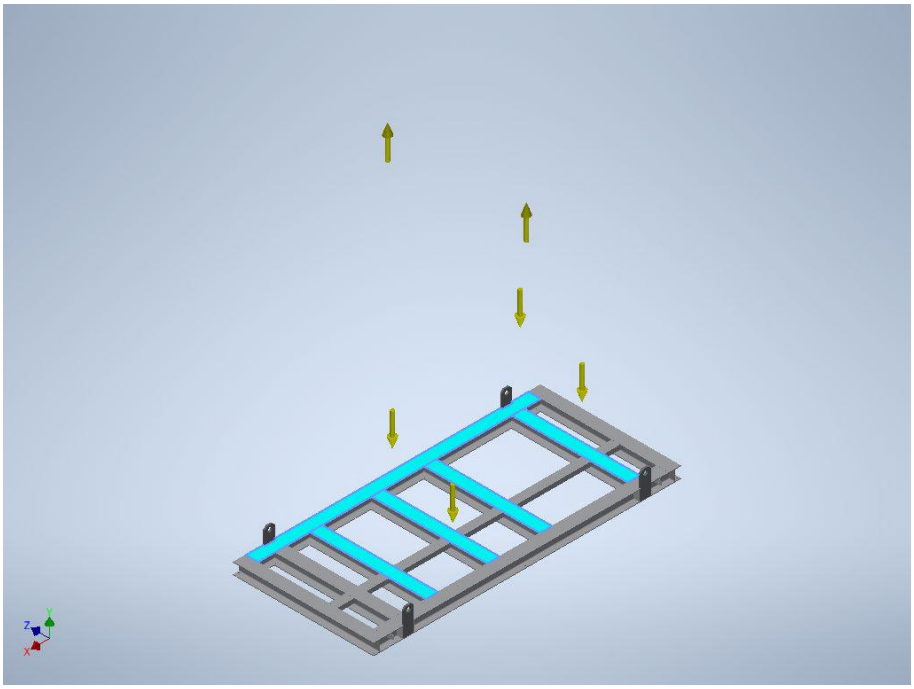


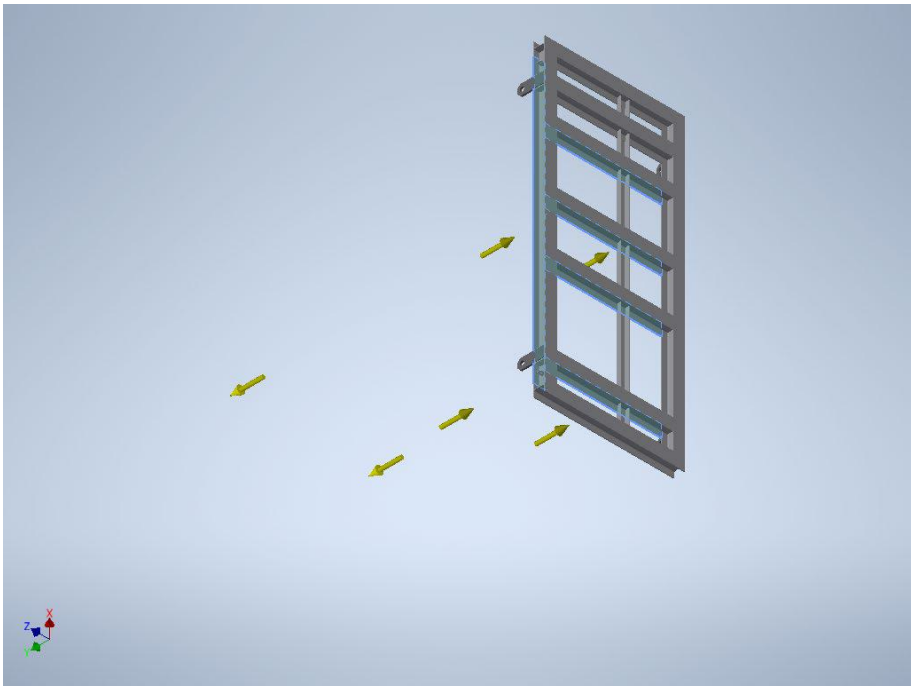
Filter group



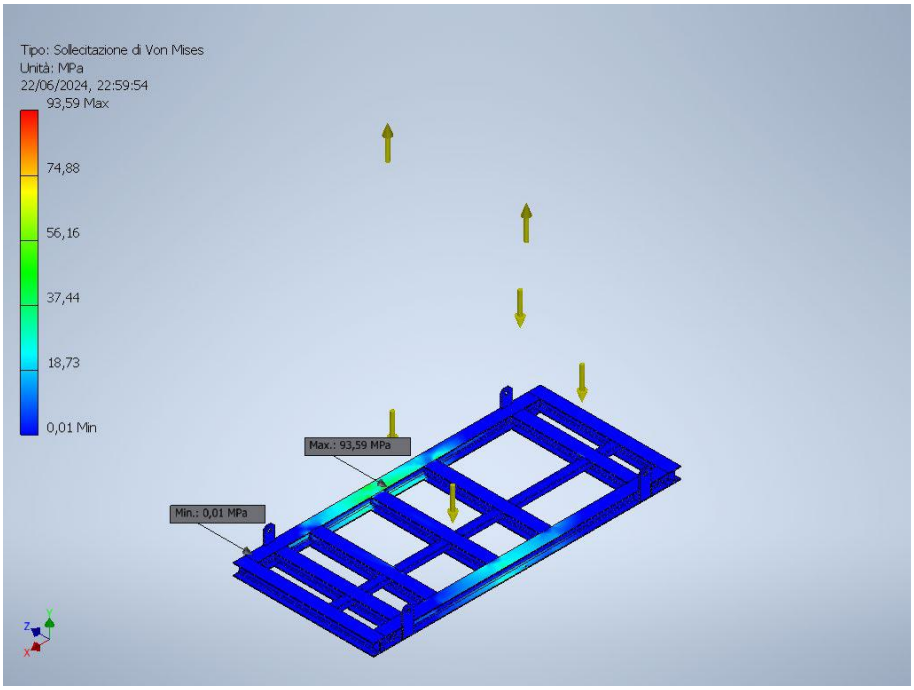


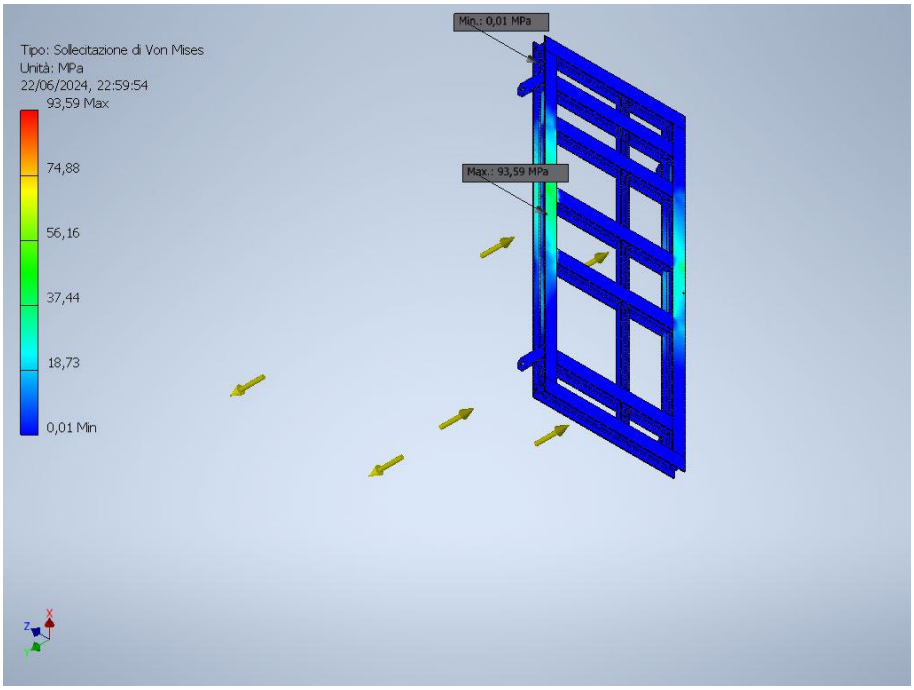
Local Control Panel (LCP)



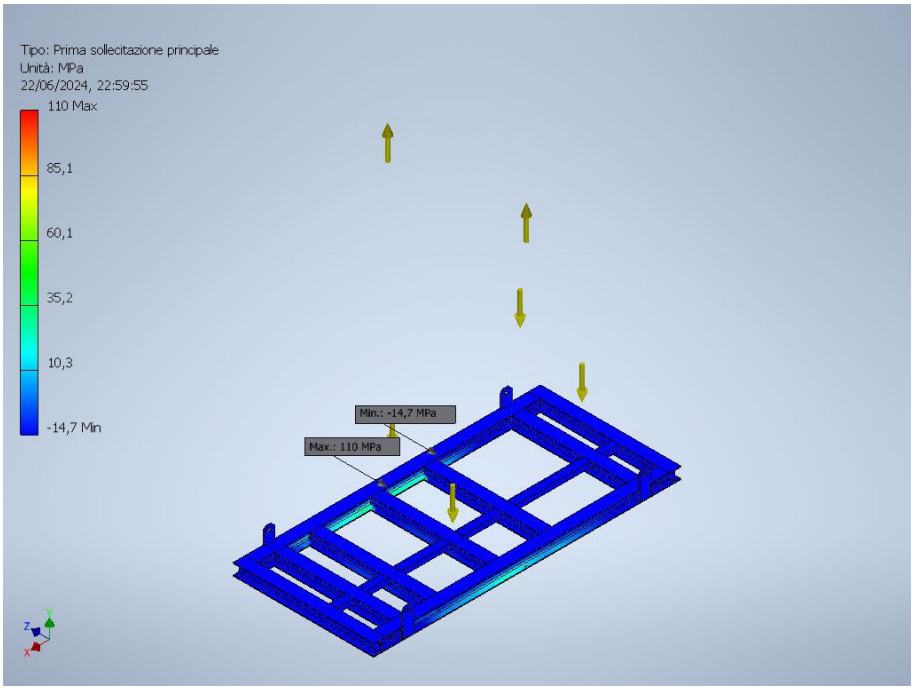


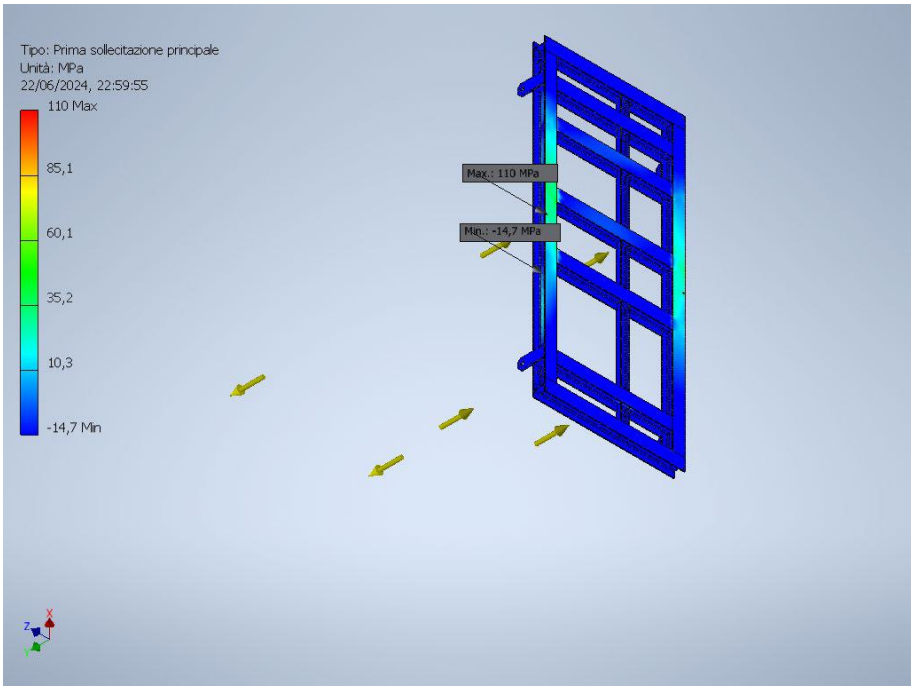
Von Mises stress



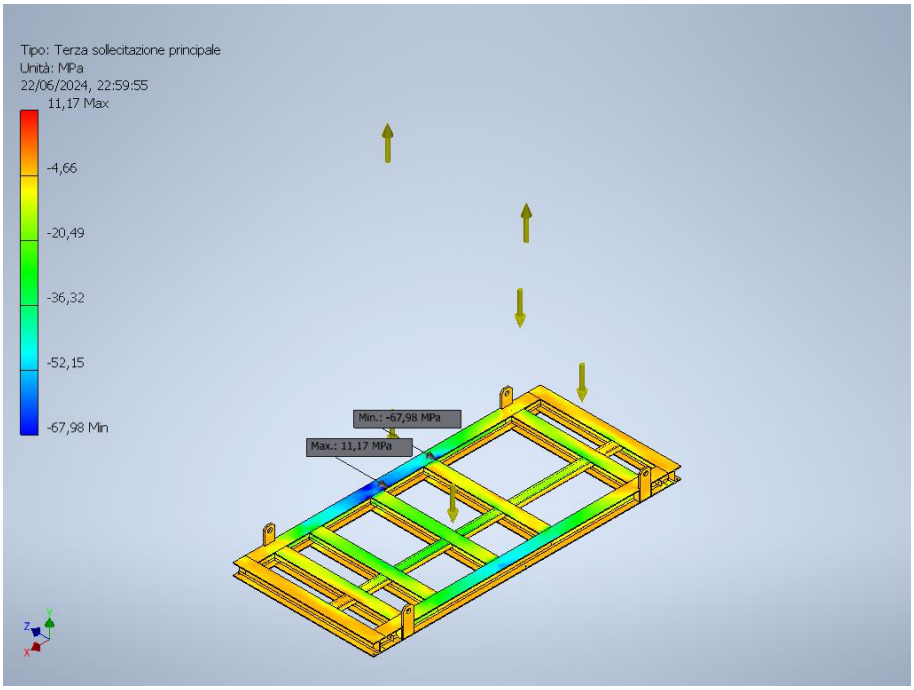


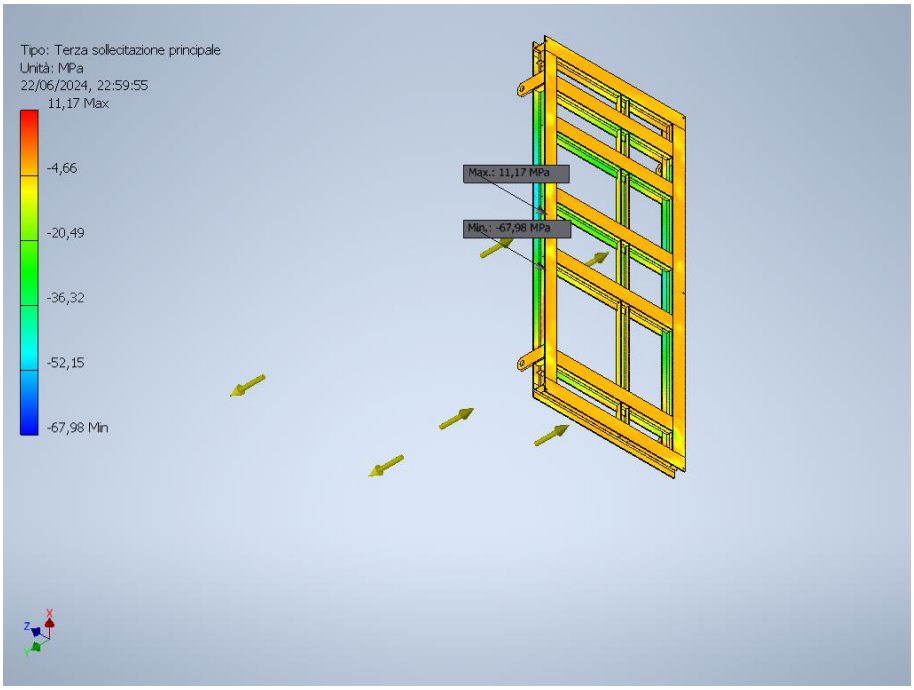
First principal stress



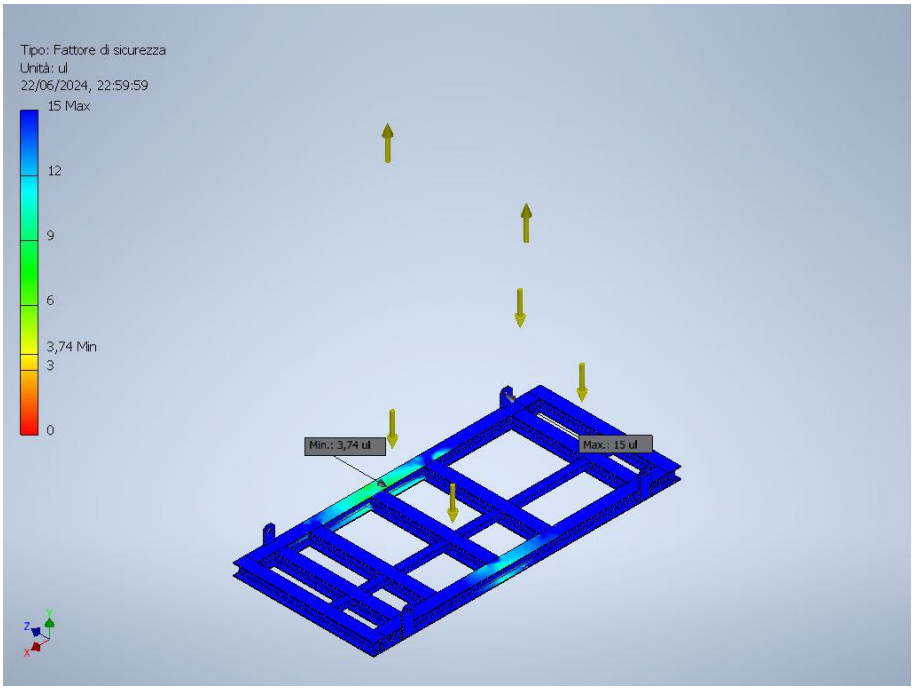


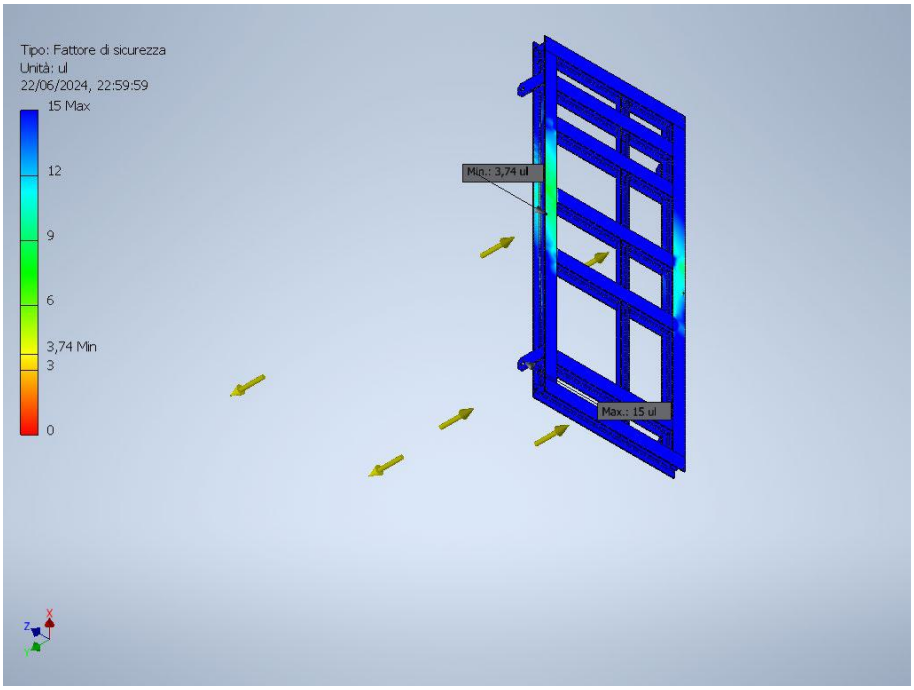
Third principal stress





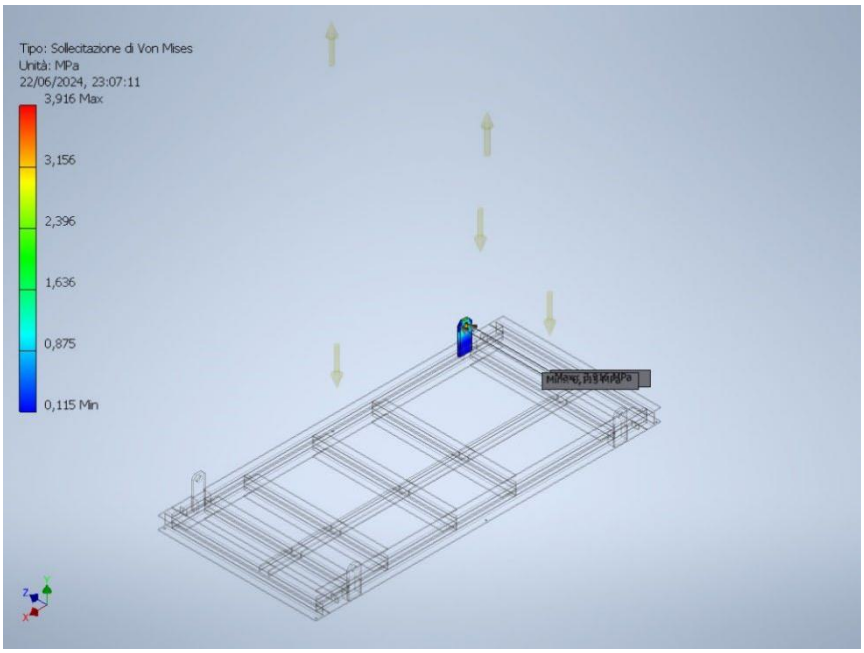
Safety factor

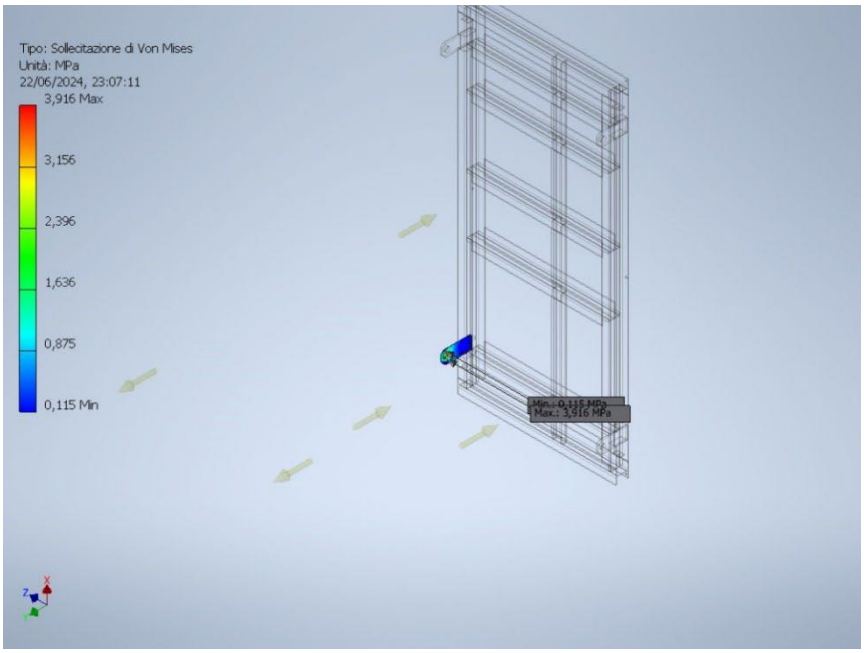




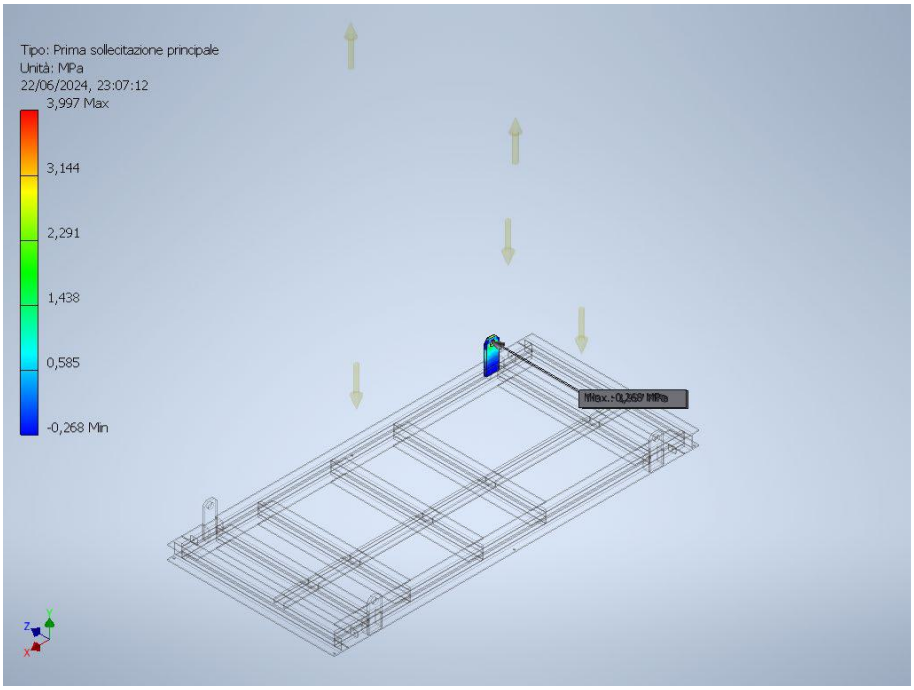
3.4 PADEYE ANALYSIS

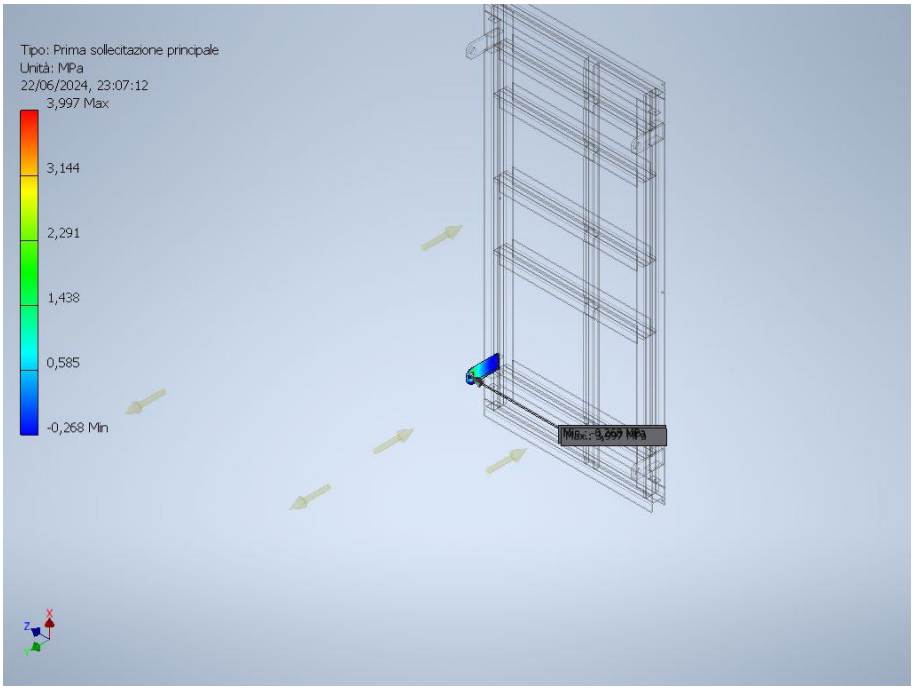
Von Mises stress



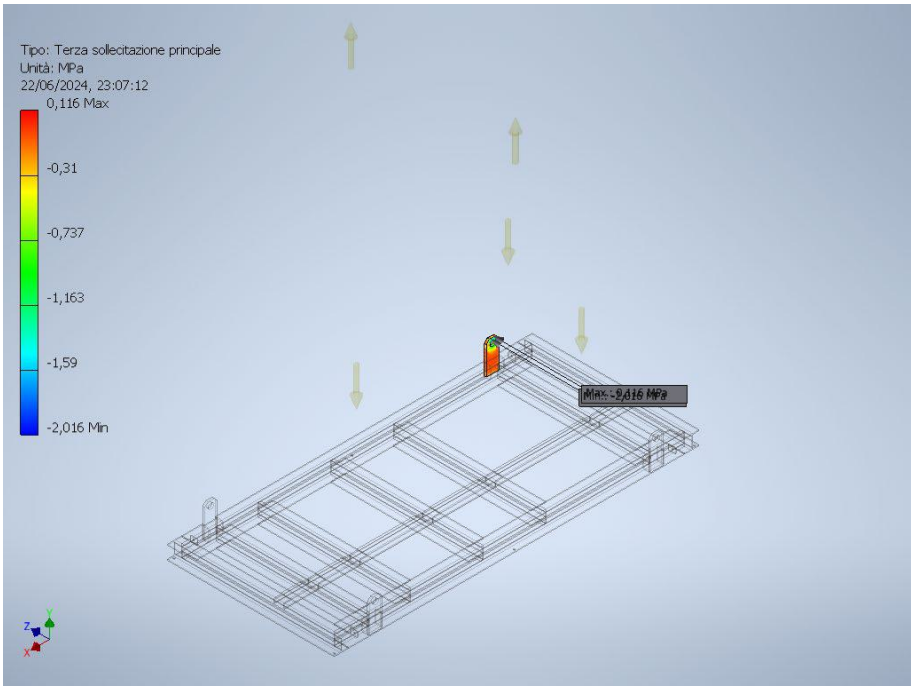


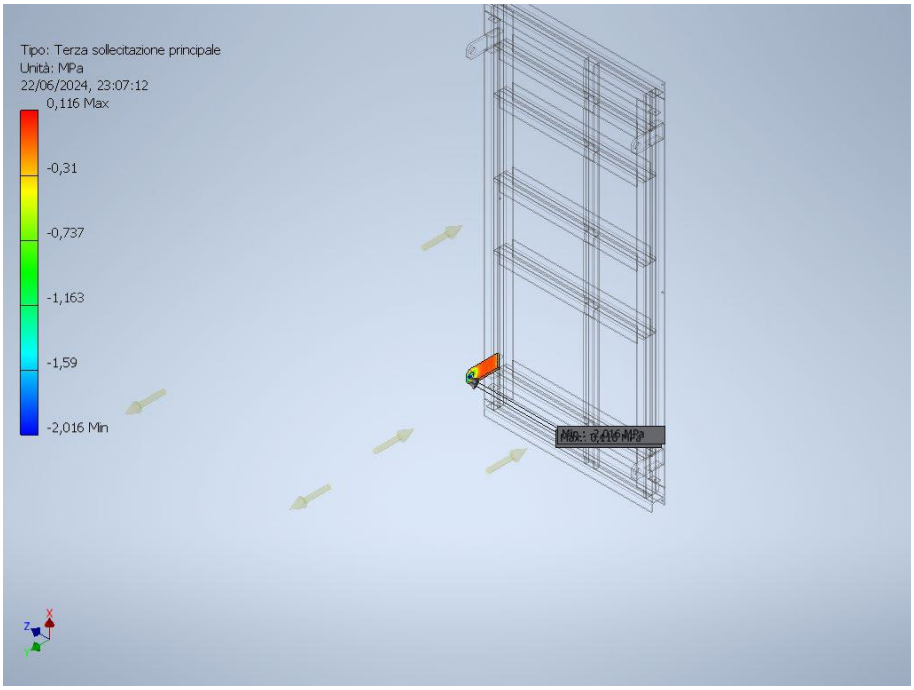
First principal stress



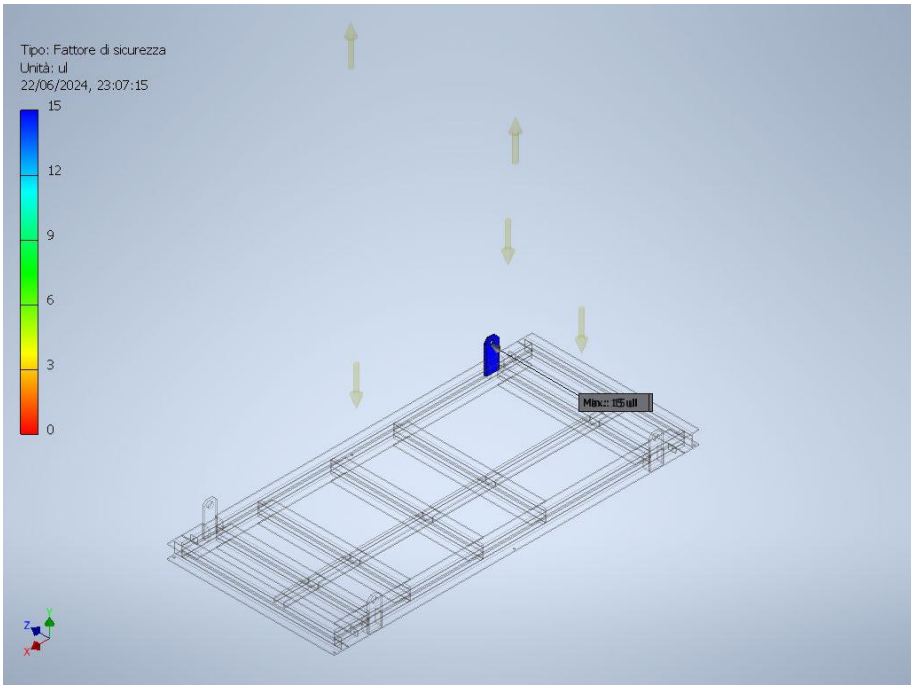


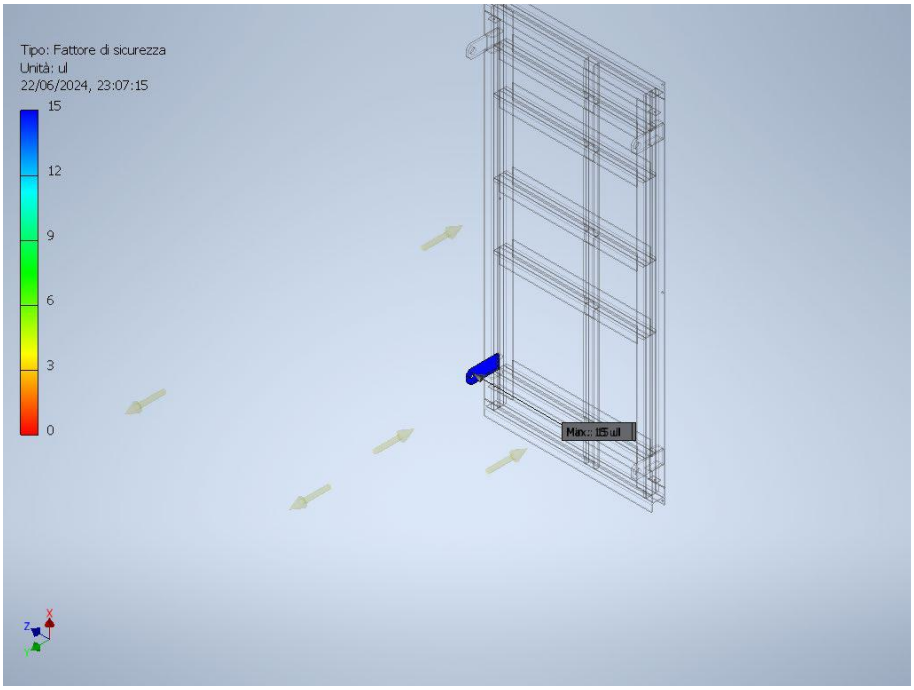
Third principal stress





Safety factor





3.5 STATIC ANALYSIS

Is considered as the load of the materials forming a permanent part of the structure unit. It is defined as the load of structures and equipment on operating conditions:

Item	Weight (kg)	Weight (N)
PSA	2500	24525
Filter group	250	2452,5
Control Panel (UCP)	350	3433,5
Baseframe	800	7848
TOTAL (including piping and valves)	5000	49050

Action of wind is considered for this calculation.

Wind Loads are defined in project specification "STRUCTURAL DESIGN BASIS" document No. 123A90-DDL-ST-SP-90017 Rev.0

Design Wind Speed: 40 m/s – 50ys return period.

Peak velocity pressure:

$q_p(z)=[1+7\cdot l_v(z)]\cdot 1/2\cdot\rho\cdot v_m^2(z)=c_e(z)\cdot q_b$

where:

ρ = 1.25 kg/m^3 (air density)

$c_e(z) = q_p(z)/ q_b$ (exposure factor)

$q_b = 1/2\cdot\rho\cdot v_b^2$ = 1.0 kPa (basic velocity pressure)

According to EN 1991, Figure 4.2 Paragraph 4.5

$c_e(z)$ = 3.8

$q_p(z)$ **= 3.8 kPa (peak velocity pressure)**

Wind Force

According to EN 1991, Section 5.3 Expression (5.3), wind force F_w may be determined as:

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

where

$c_s c_d = 1$ (structural factor defined in Section 6)

$c_f = 1.26$ (force coefficient, given in Section 7, formula 7.11)

$q_p(z) = 3.8$ kPa (peak velocity pressure)

$A_{ref\text{-}X}$ = (Reference area, X-Direction)

$A_{ref\text{-}Z}$ = (Reference area, Z-Direction)

$F_{w\text{-}X} = 7086$ N

$F_{w\text{-}Z} = 14172$ N

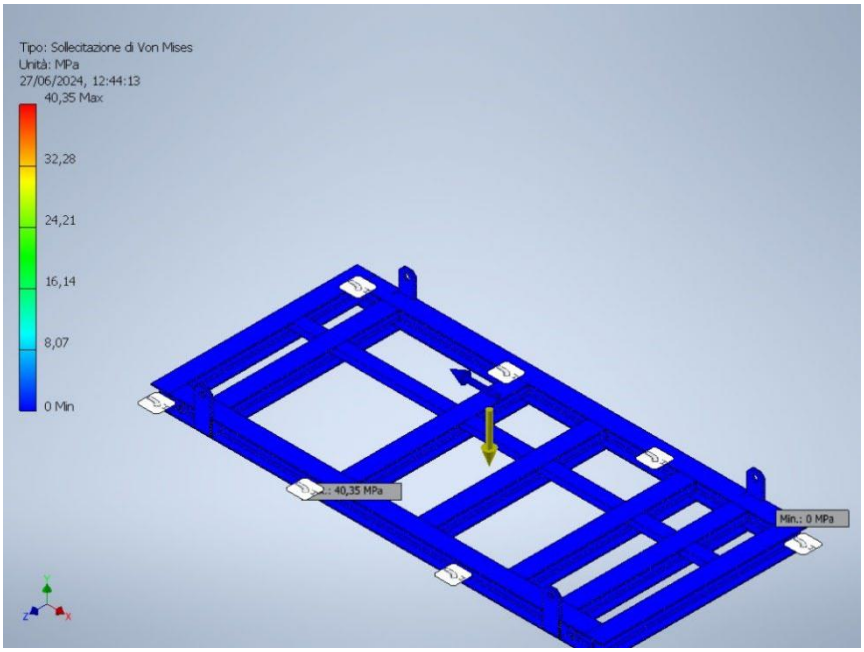
Calculation cases are:

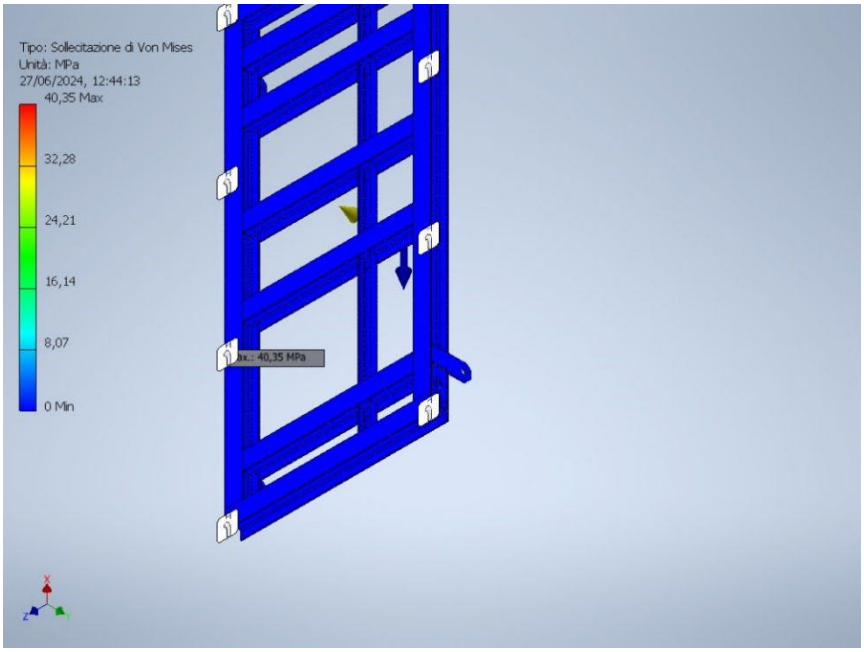
- Permanent load + Wind action along X- direction
- Permanent load + Wind action along X+ direction
- Permanent load + Wind action along Z- direction
- Permanent load + Wind action along Z+ direction

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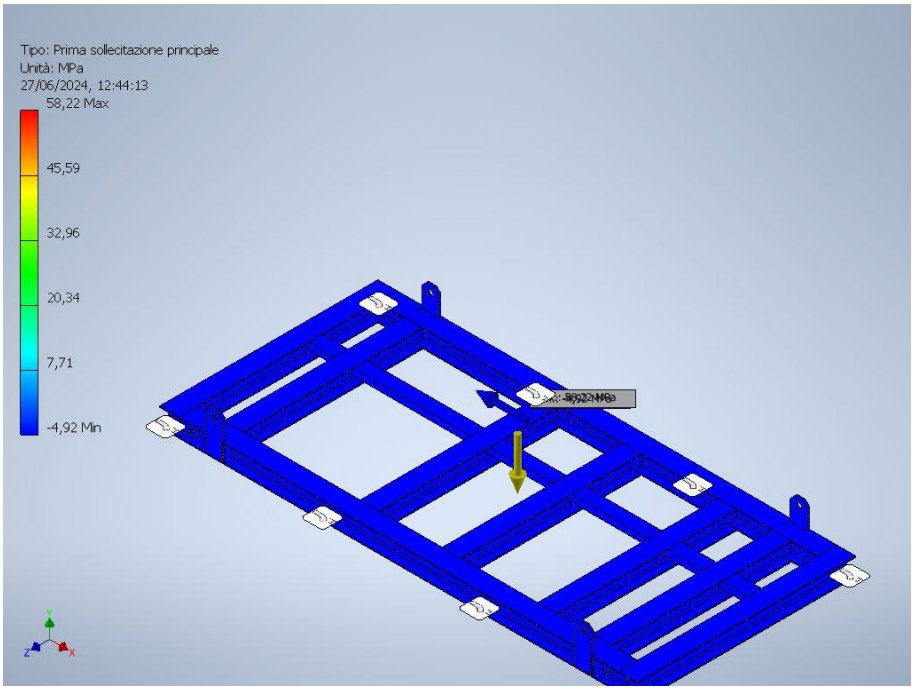
3.5.1 PERMANENT LOAD + WIND (X- DIRECTION)

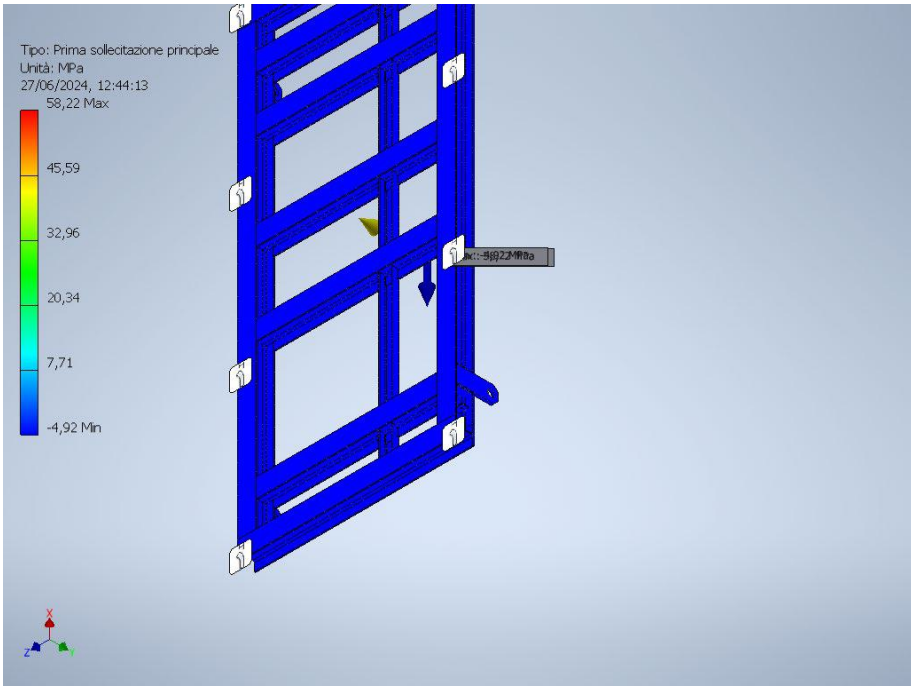
Von Mises stress



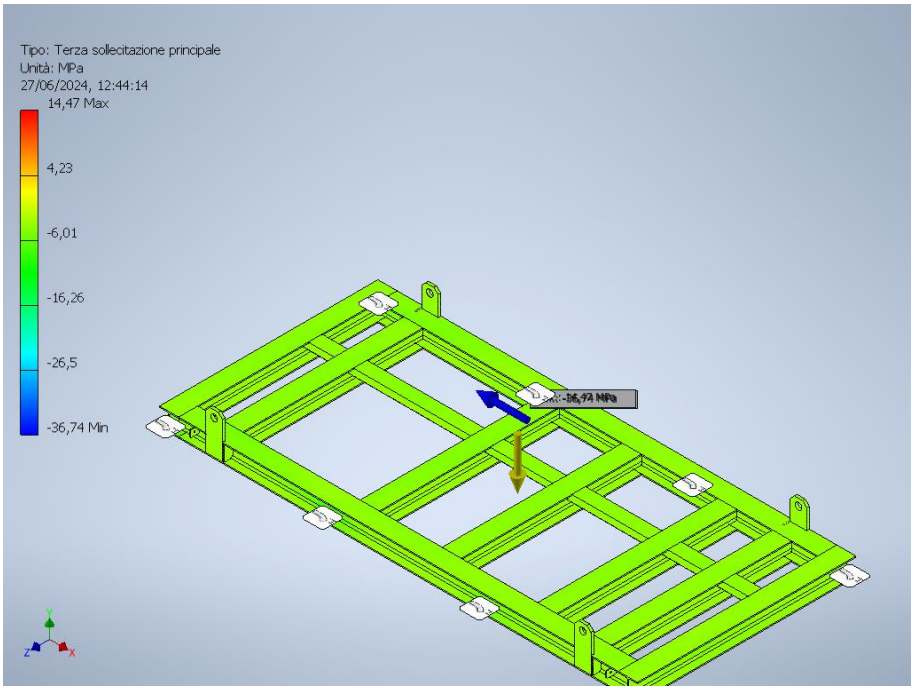


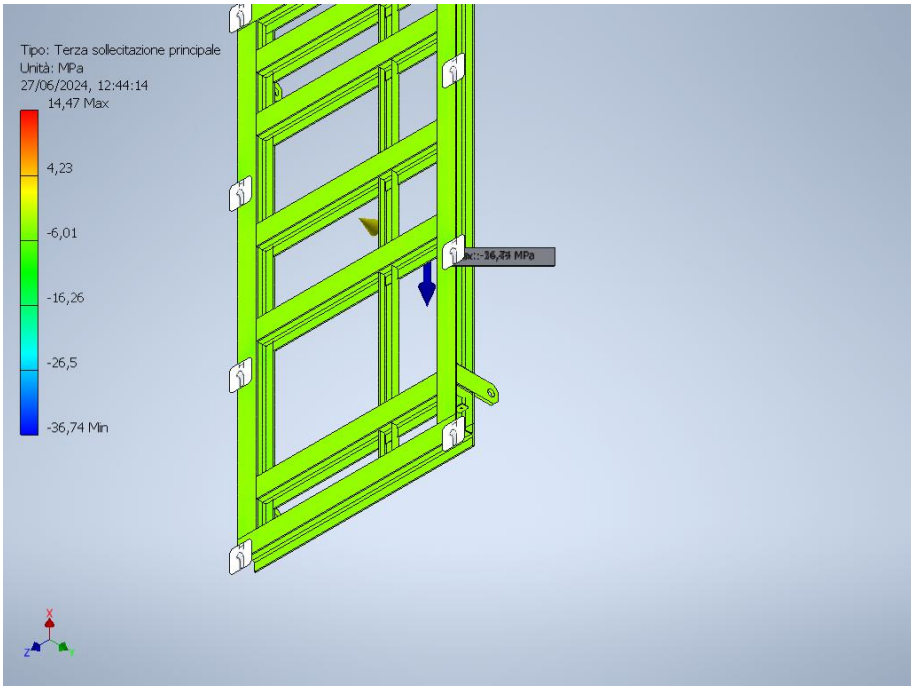
First principal stress



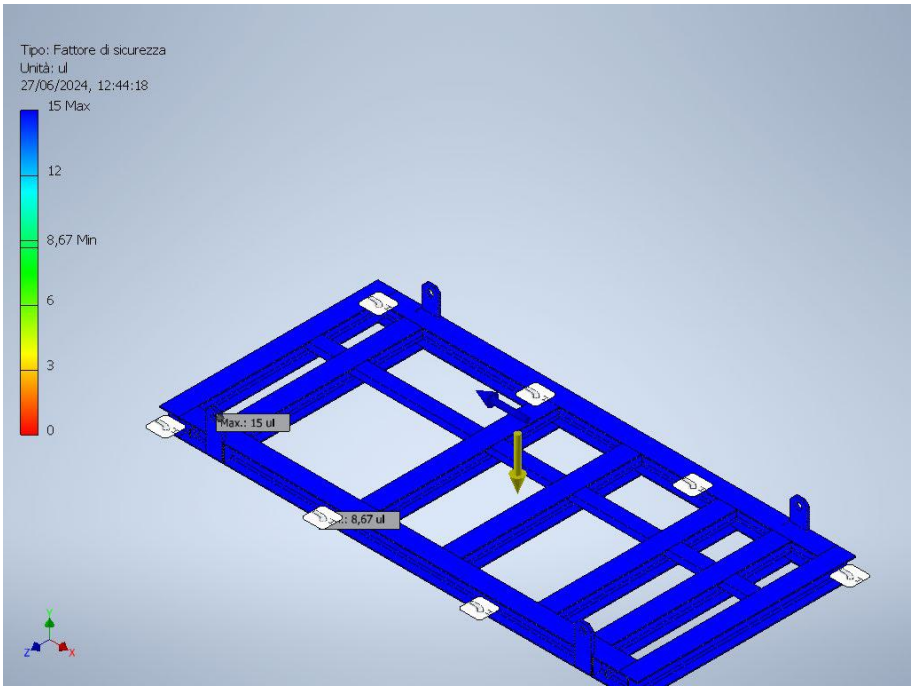


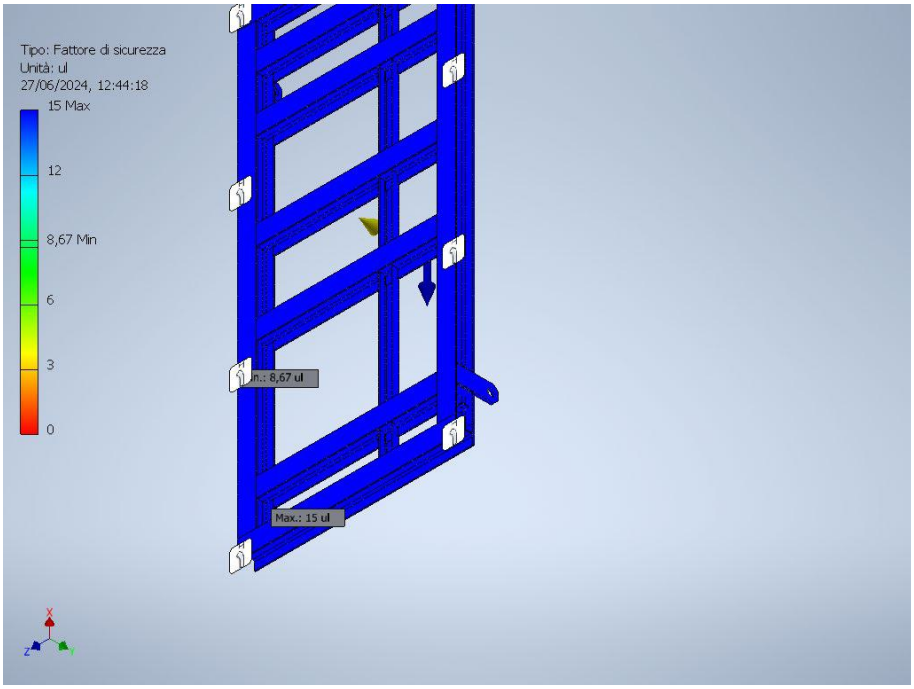
Third principal stress





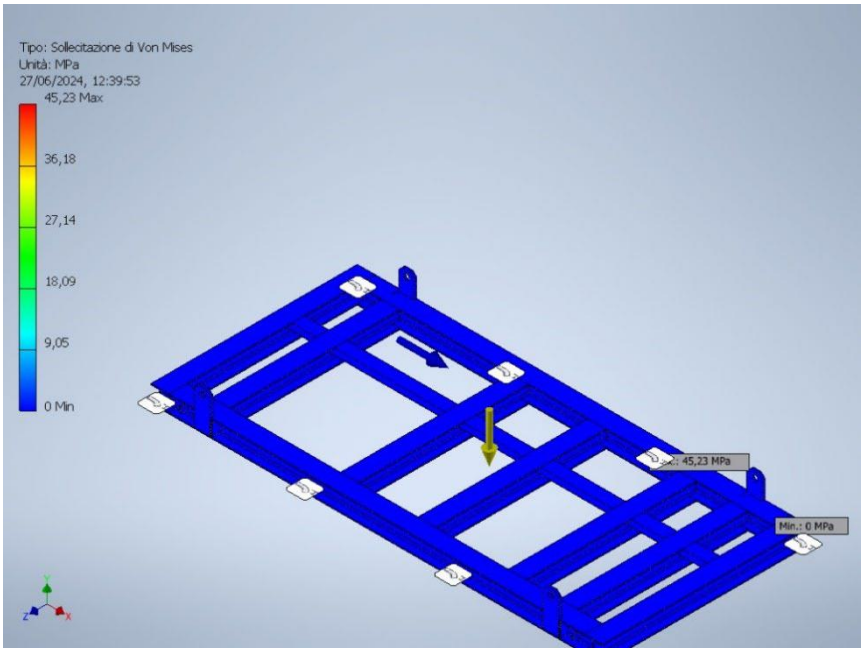
Safety factor

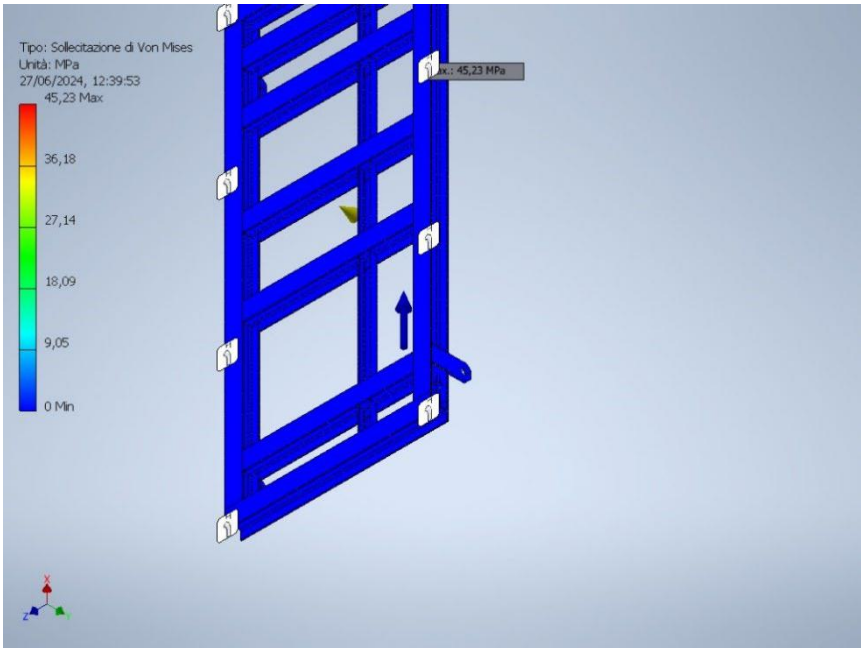




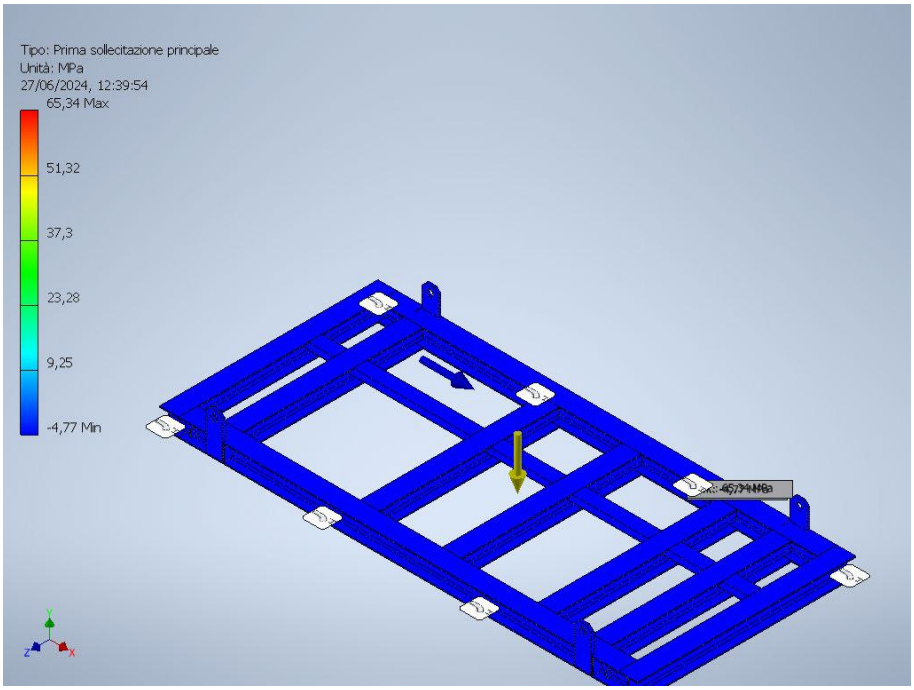
3.5.2 PERMANENT LOAD + WIND (X+ DIRECTION)

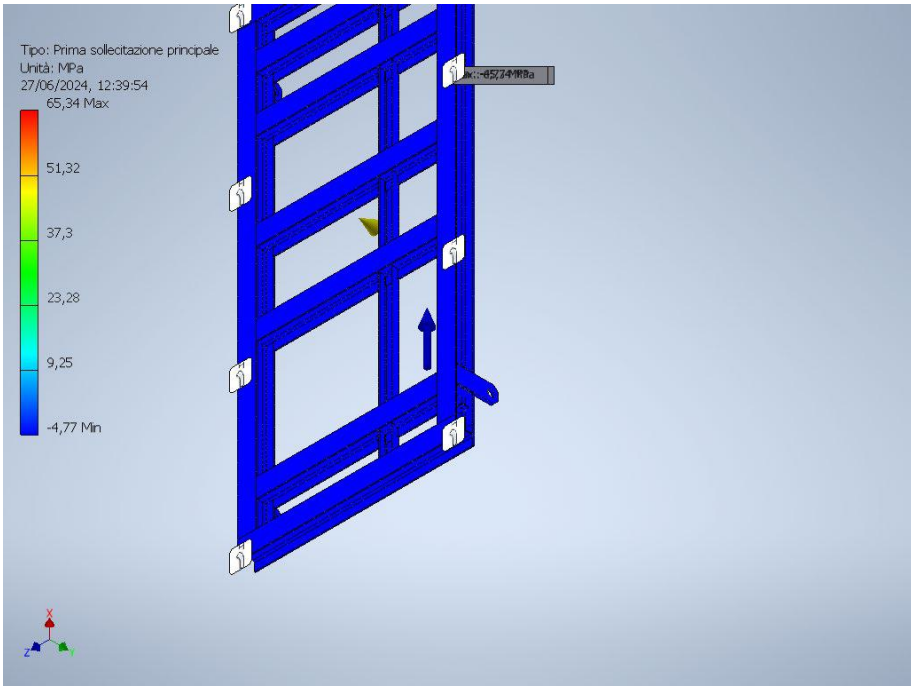
Von Mises stress



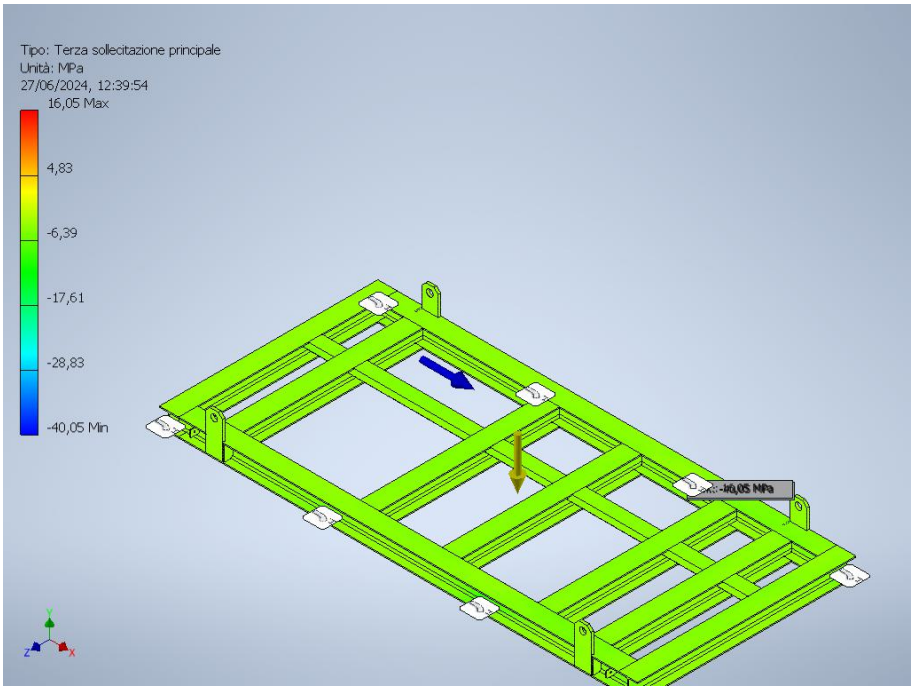


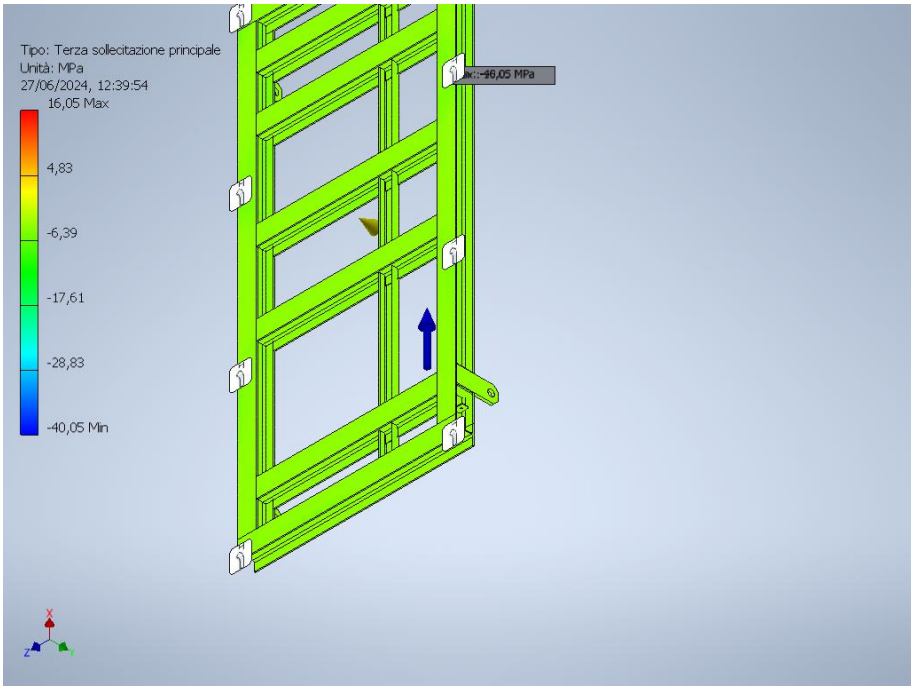
First principal stress



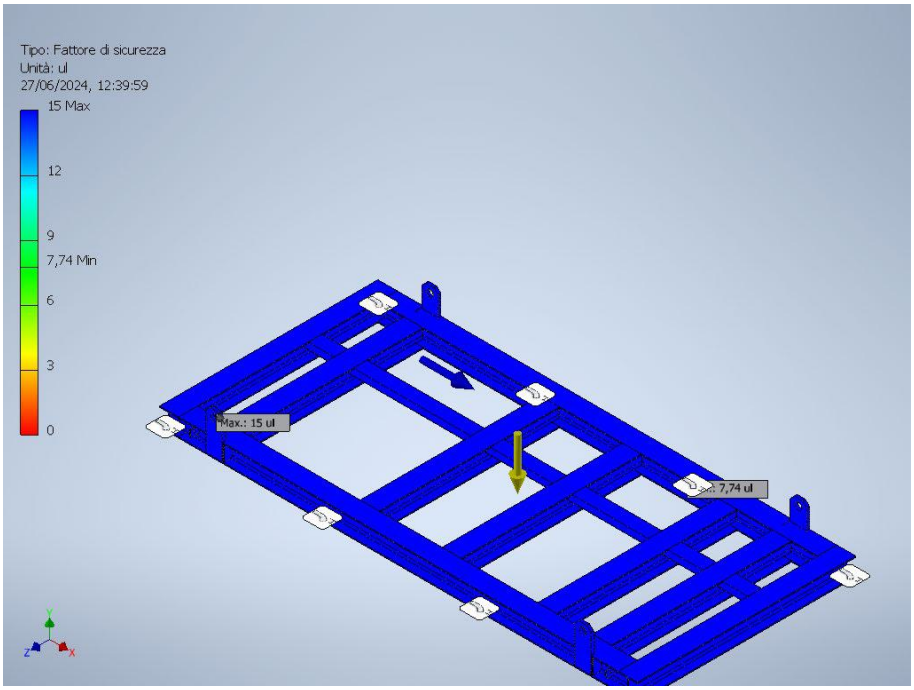


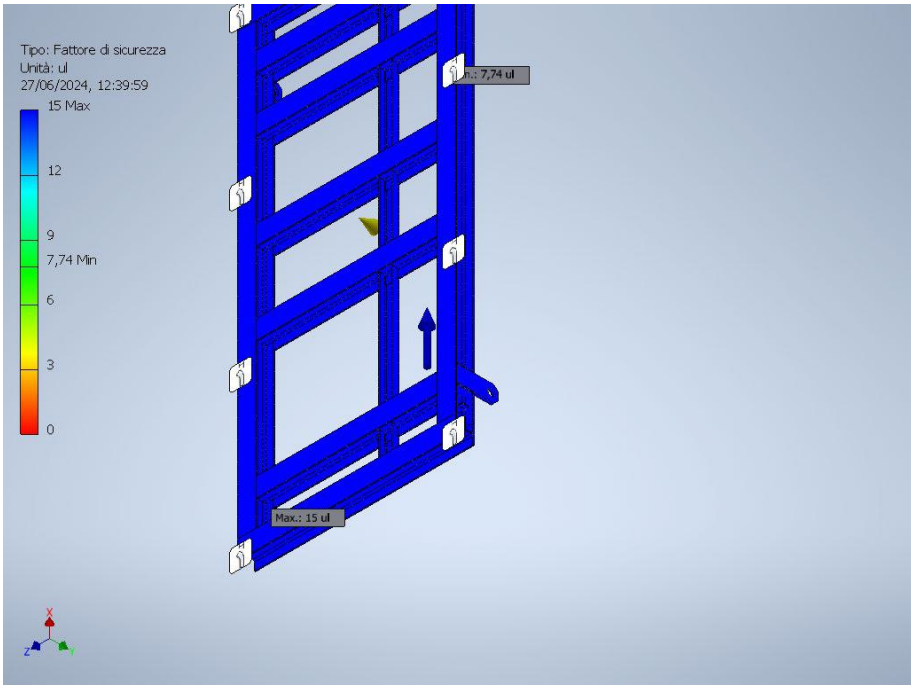
Third principal stress





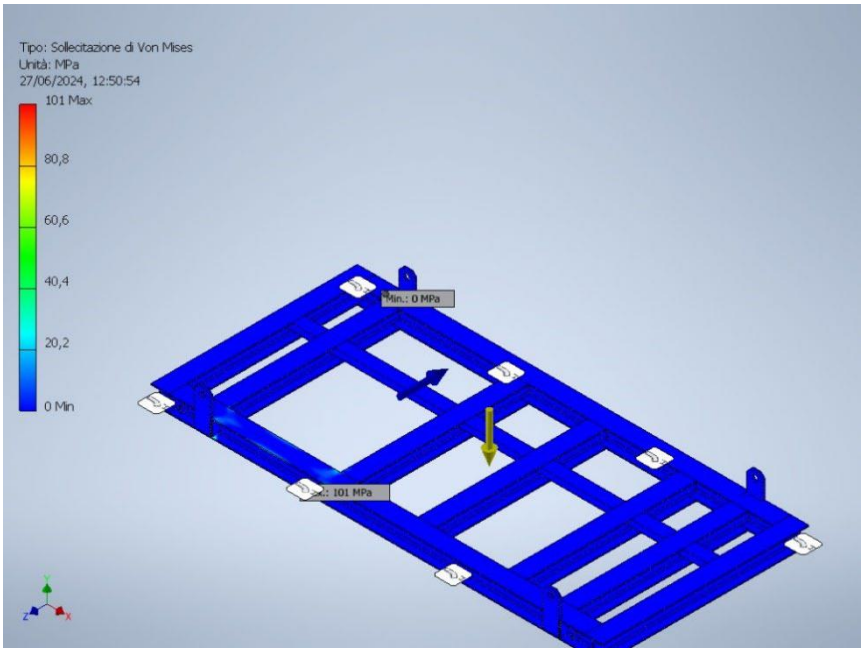
Safety factor

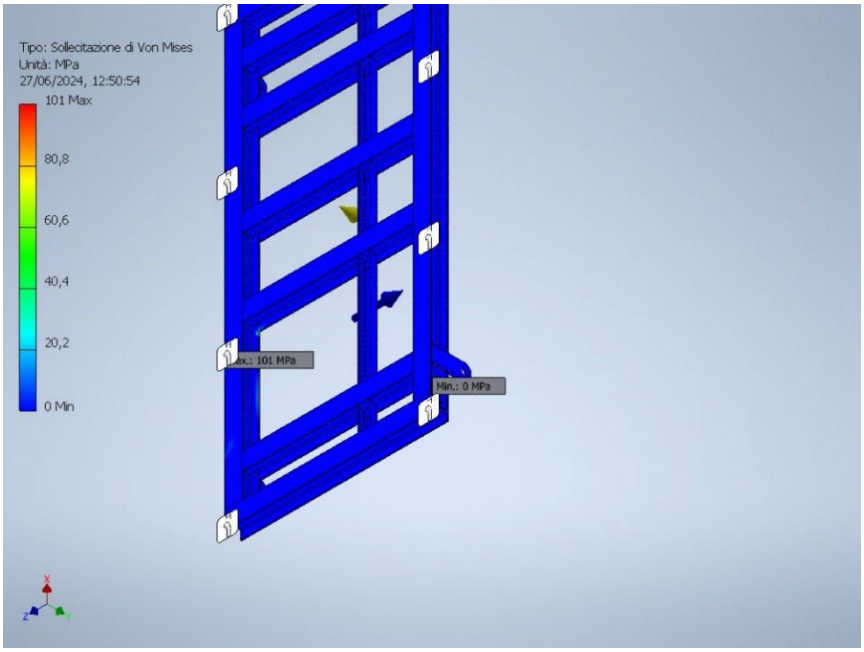




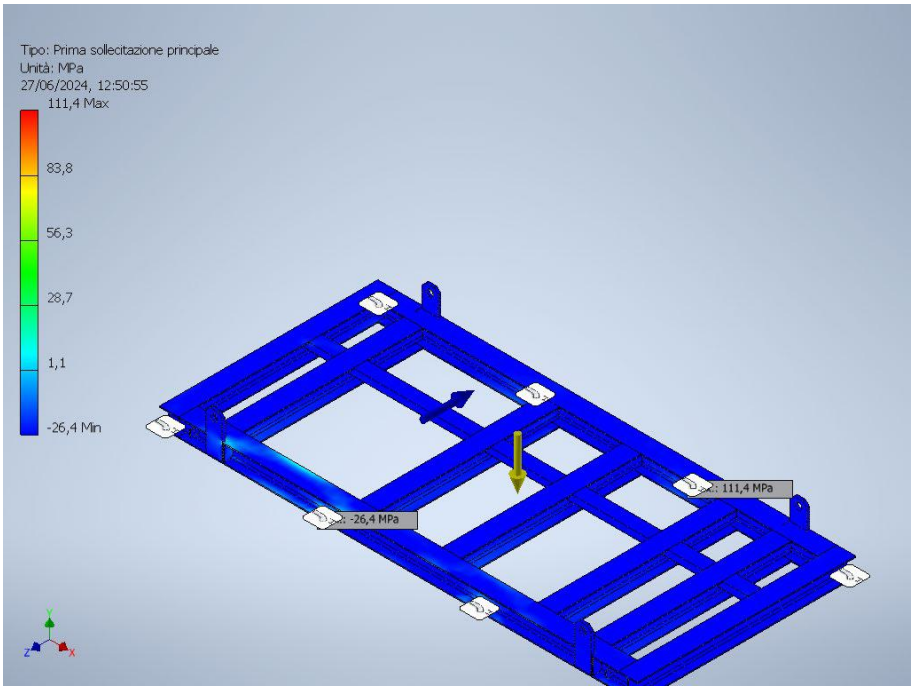
3.5.3 PERMANENT LOAD + WIND (Z- DIRECTION)

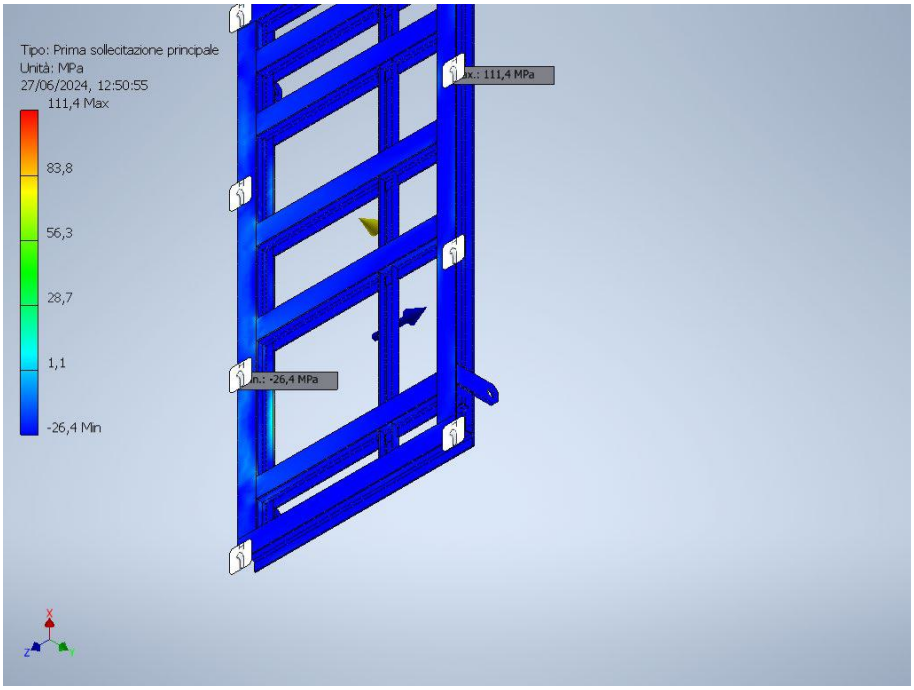
Von Mises stress





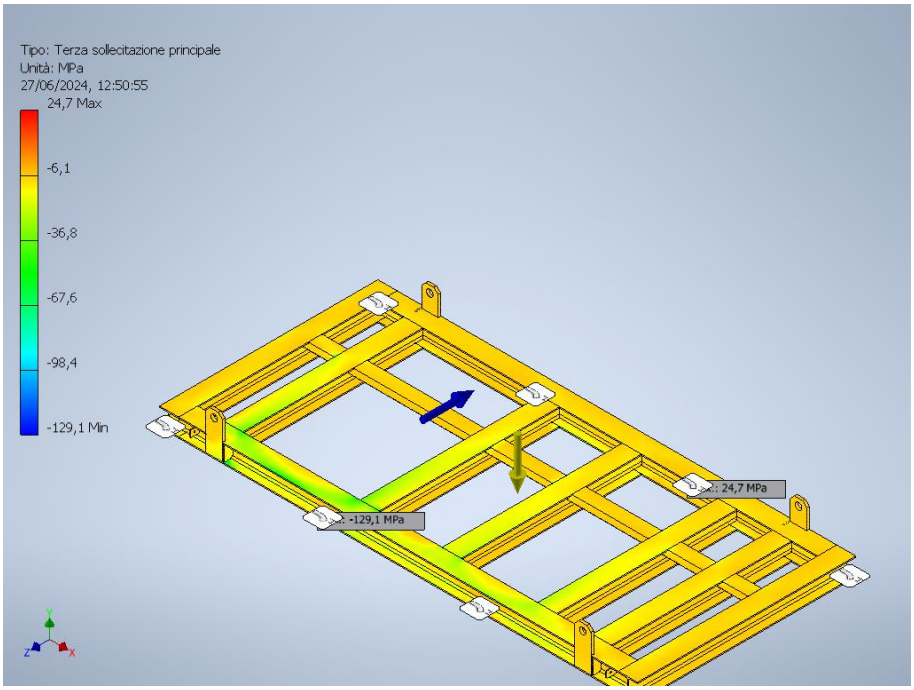
First principal stress

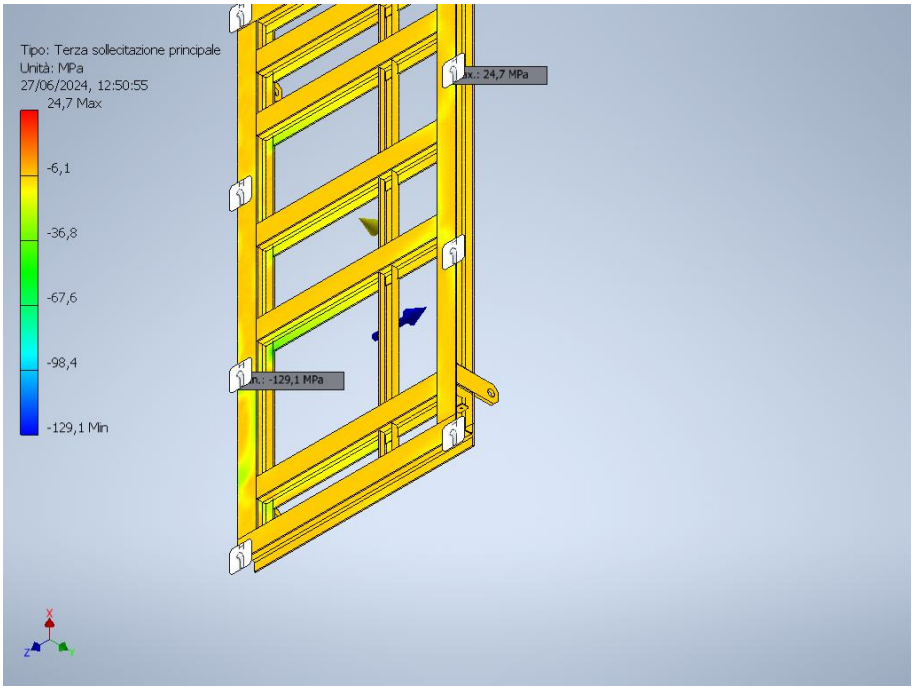




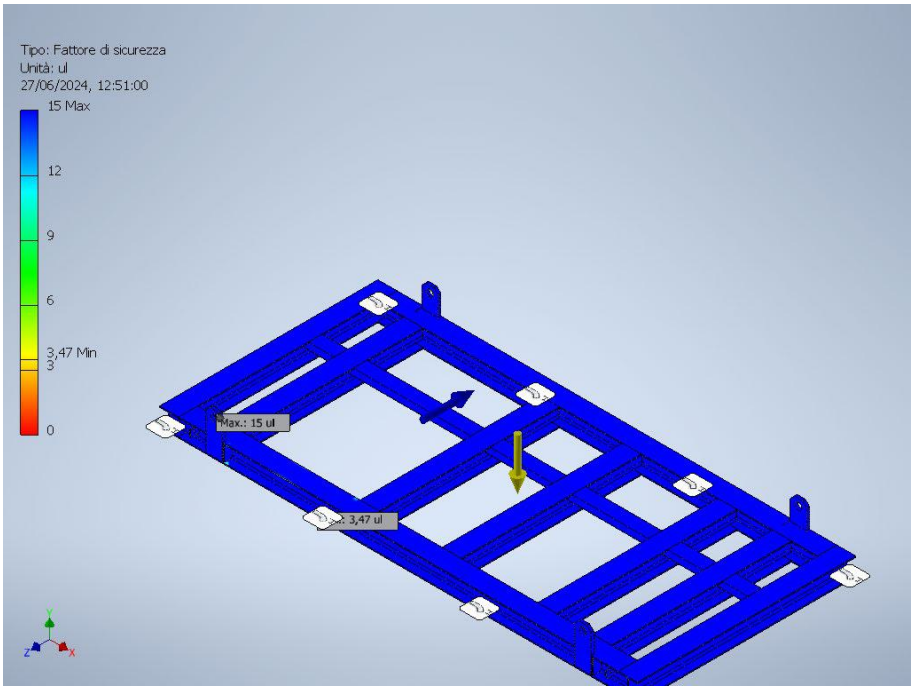
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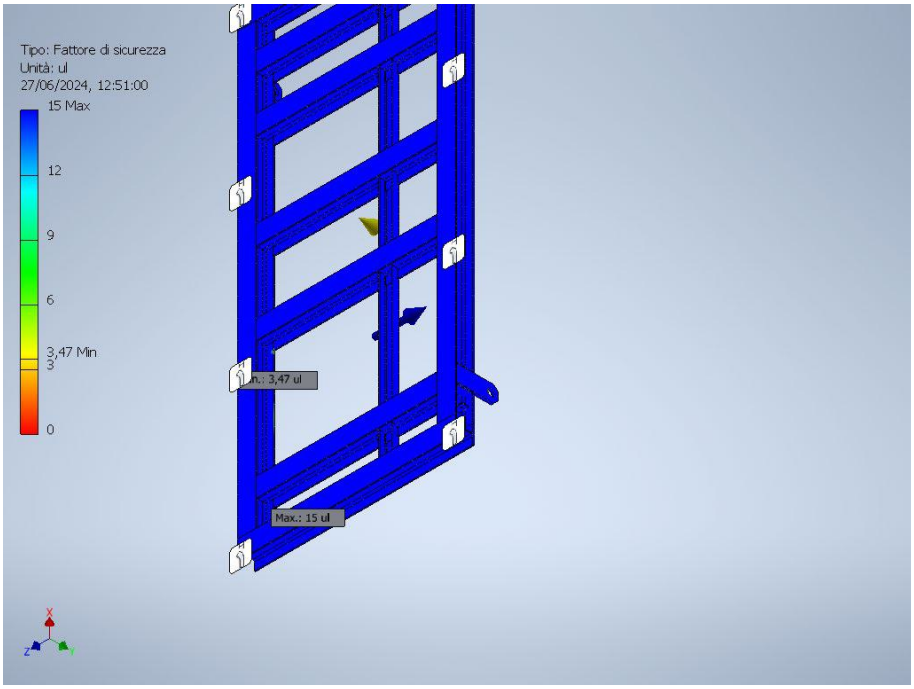
Third principal stress





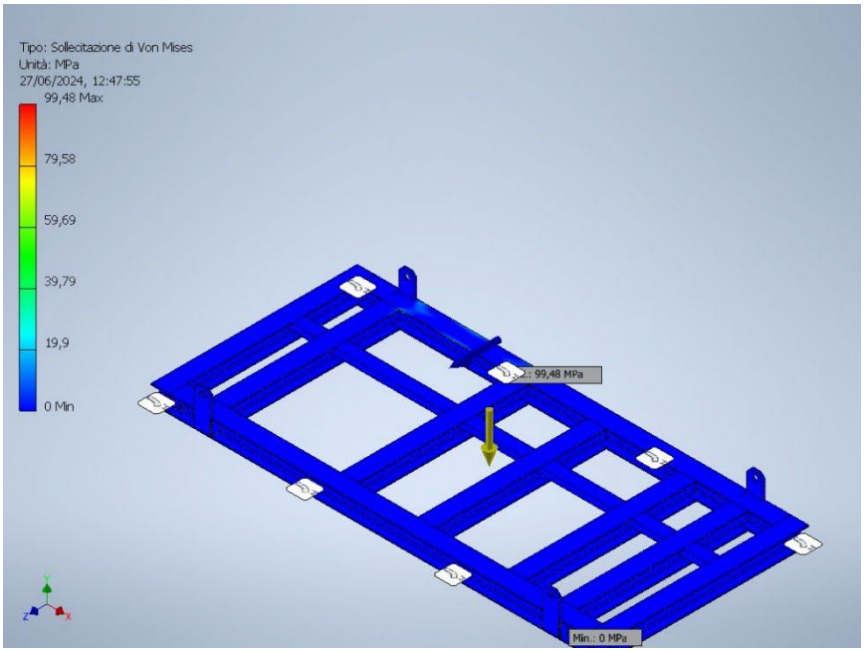
Safety factor

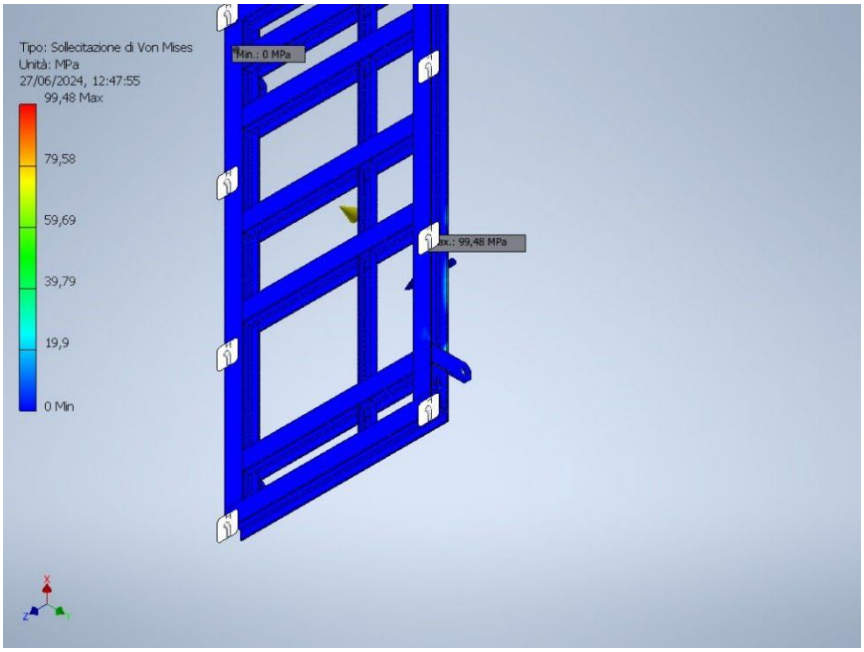




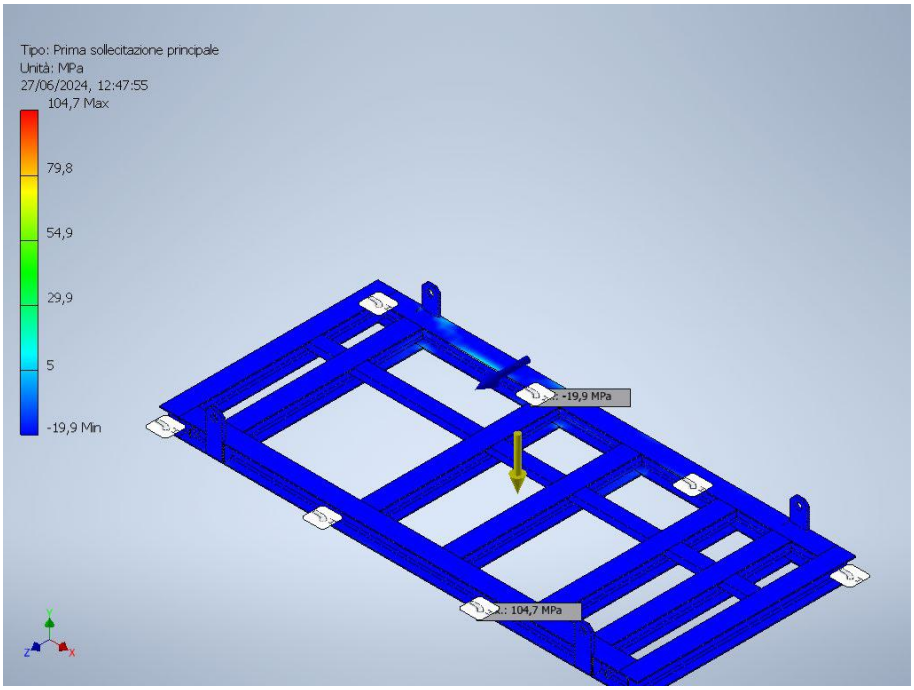
3.5.4 PERMANENT LOAD + WIND (Z+ DIRECTION)

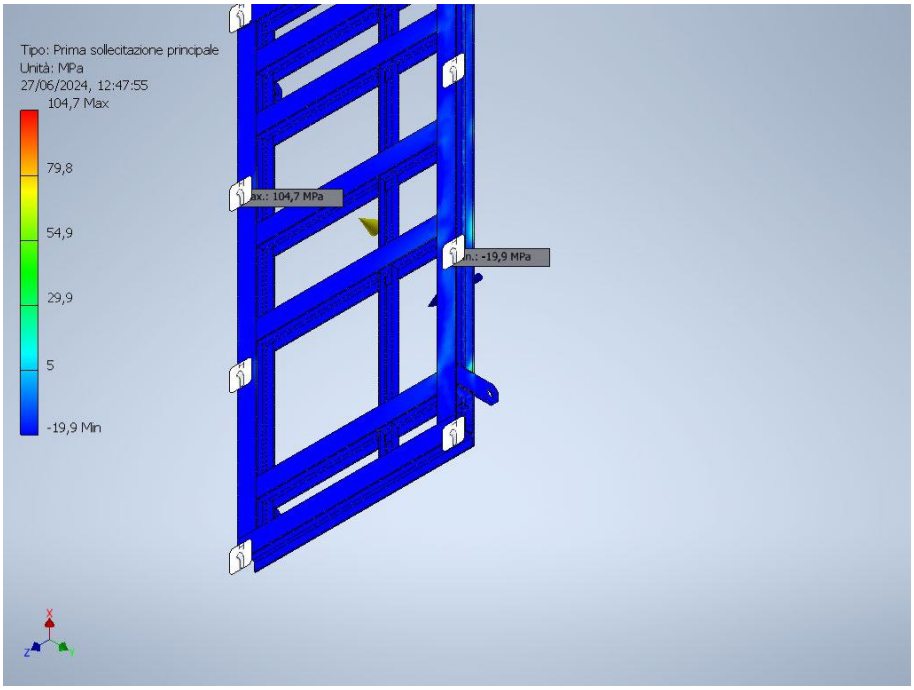
Von Mises stress



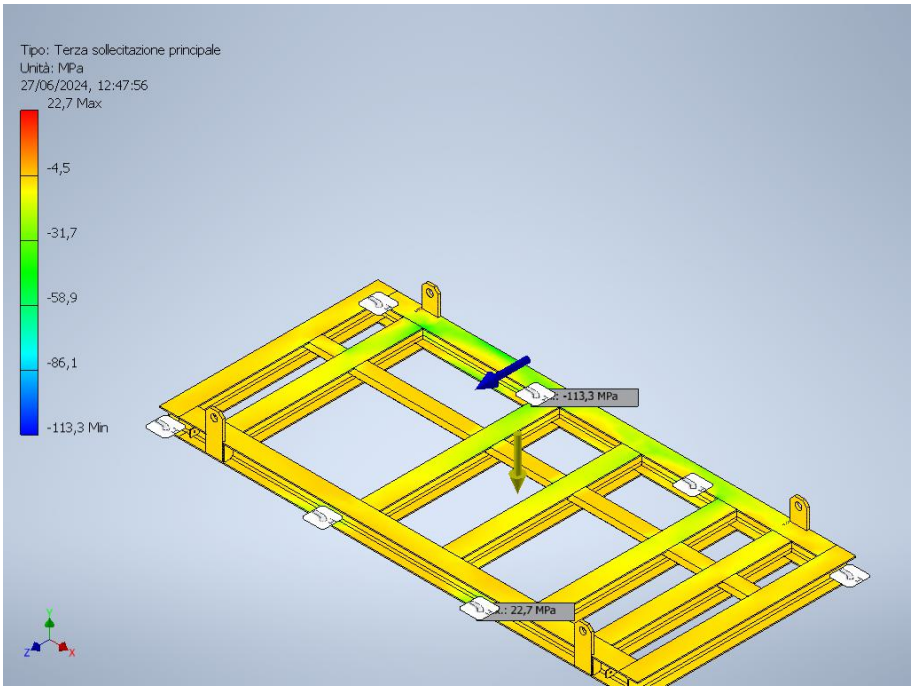


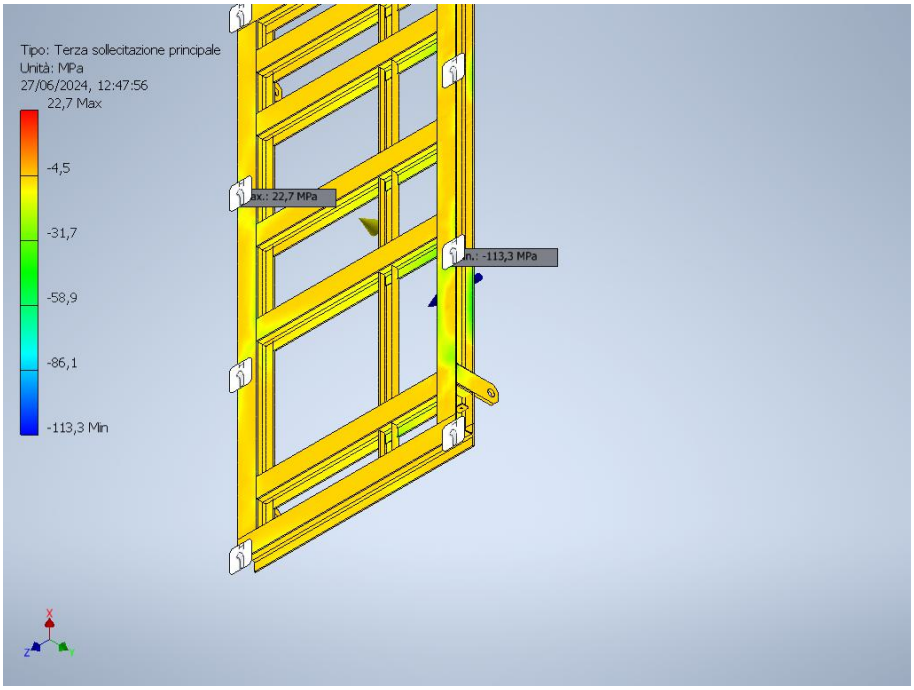
First principal stress



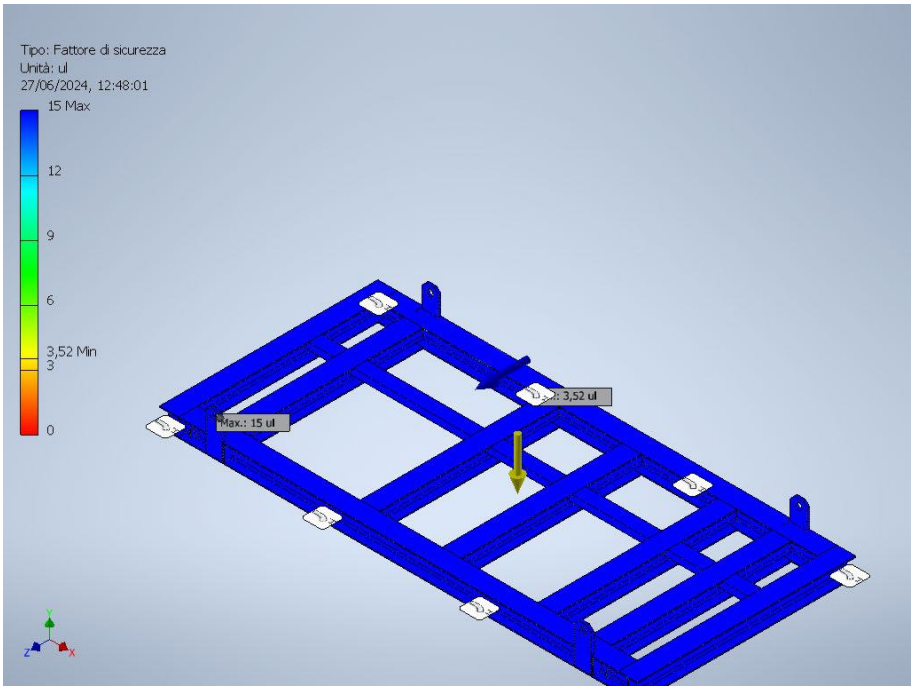


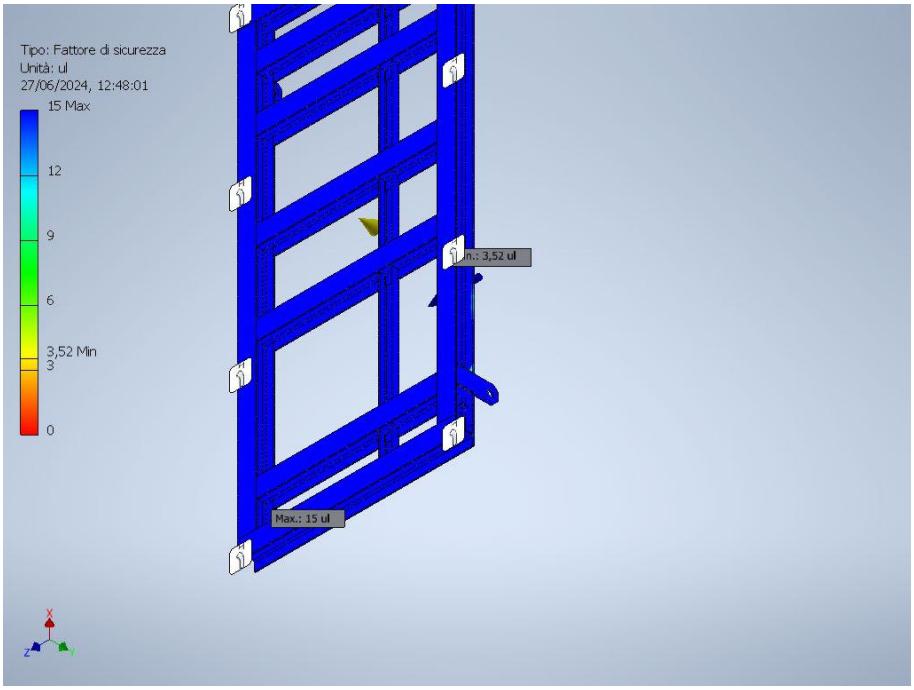
Third principal stress





Safety factor





3.6 TRANSPORTATION ANALYSIS

Transportation load has been considered as an horizontal acceleration equal to 0.7g.

The transportation load has been combined with the action of wind as calculated in the previous section. Calculation cases are:

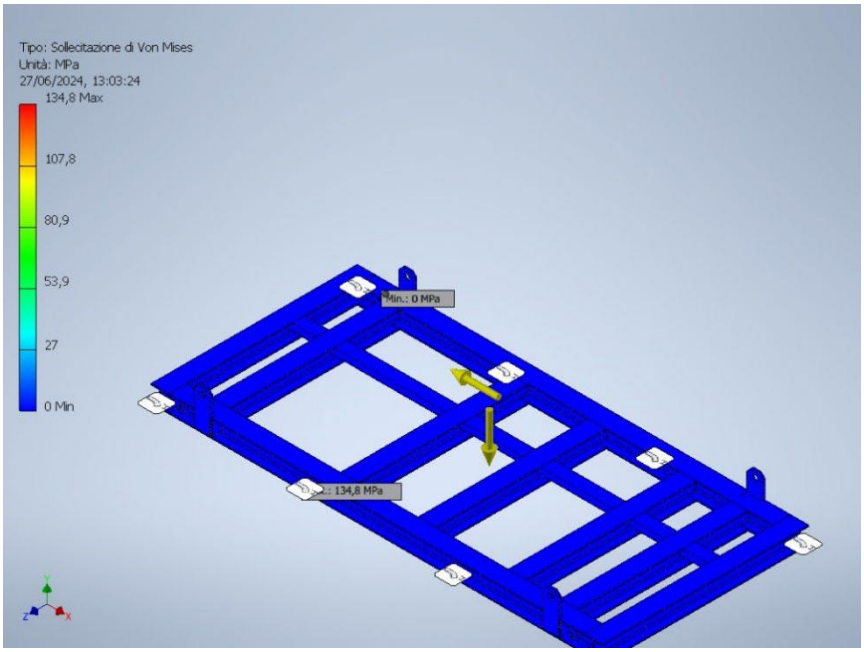
- Transportation load + Wind action along X- direction
- Transportation load + Wind action along X+ direction
- Transportation load + Wind action along Z- direction
- Transportation load + Wind action along Z+ direction

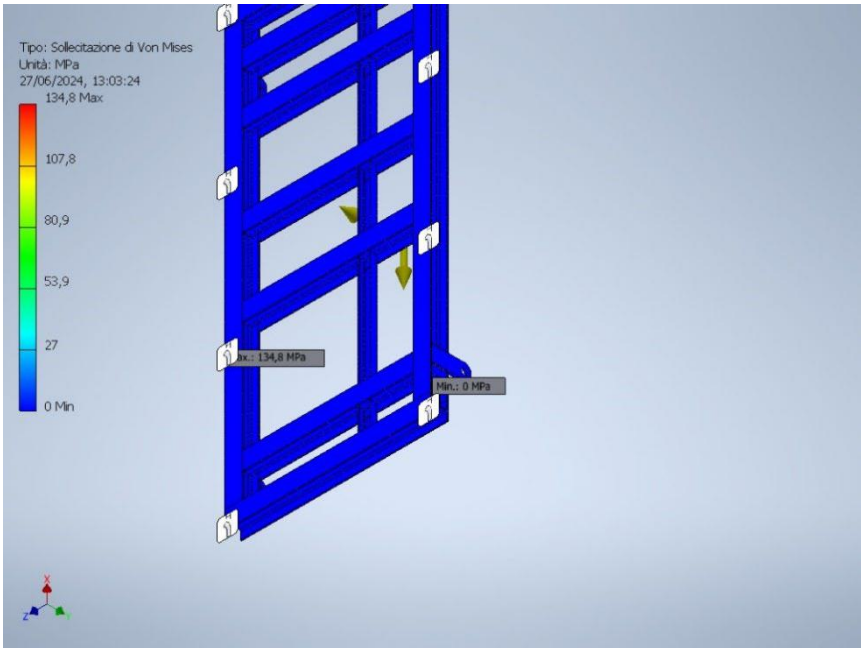
To be more conservative, transportation load and wind actions have been considered acting in the same direction for each calculation case.

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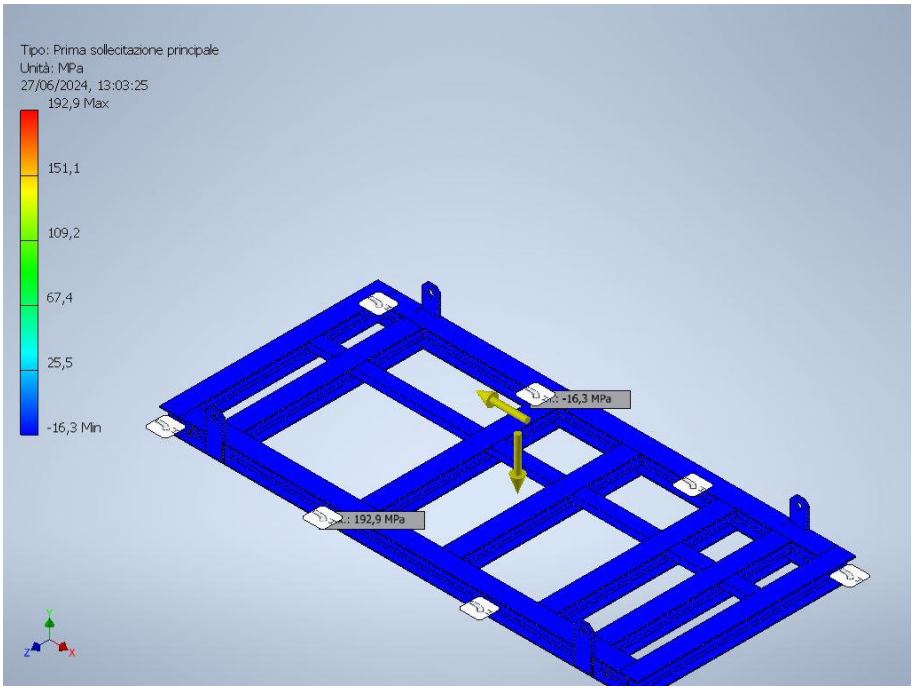
3.6.1 TRANSPORTATION LOAD + WIND (X- DIRECTION)

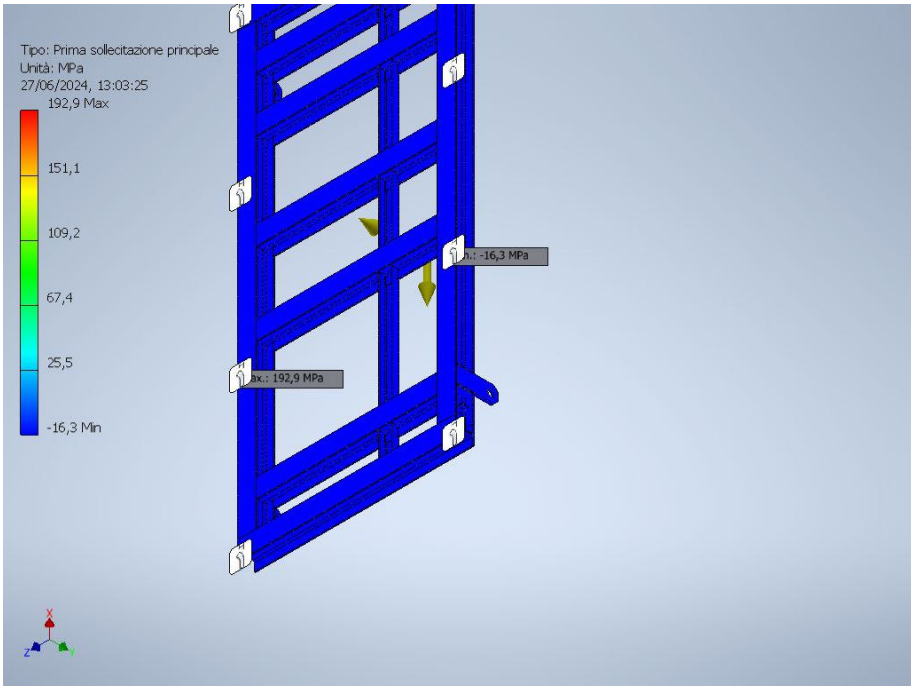
Von Mises stress



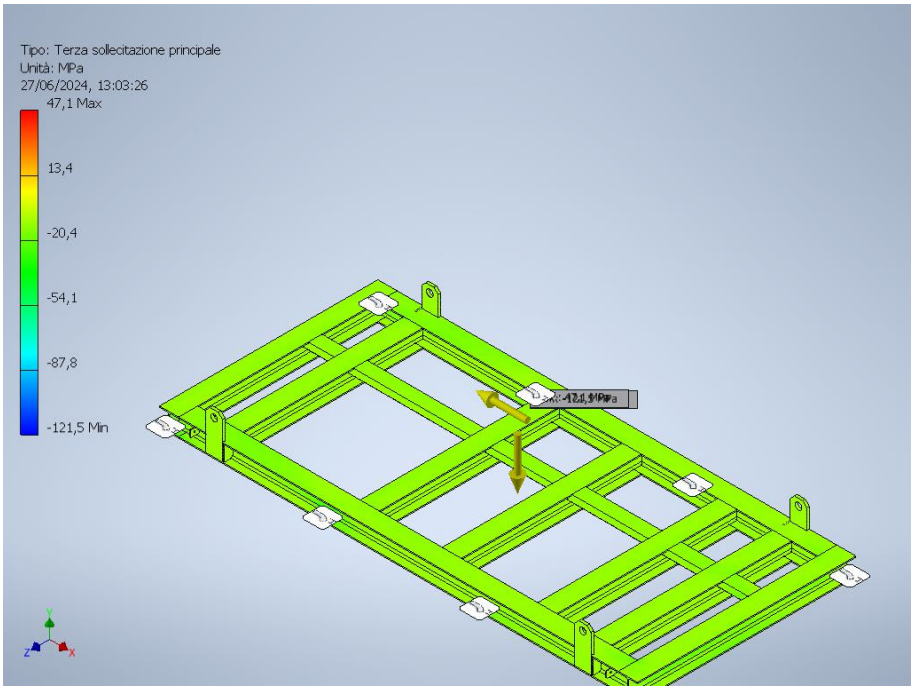


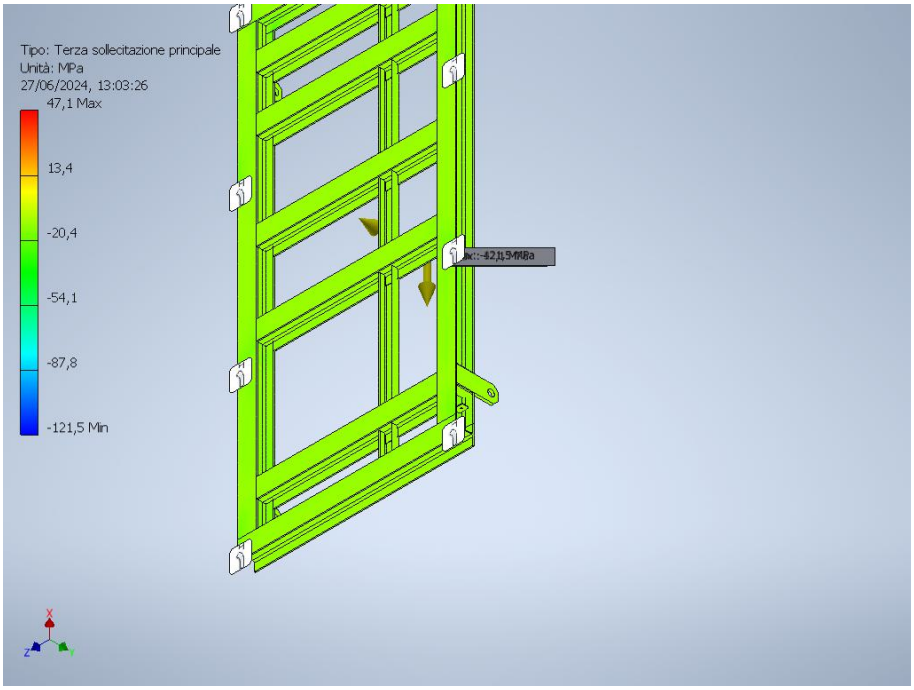
First principal stress



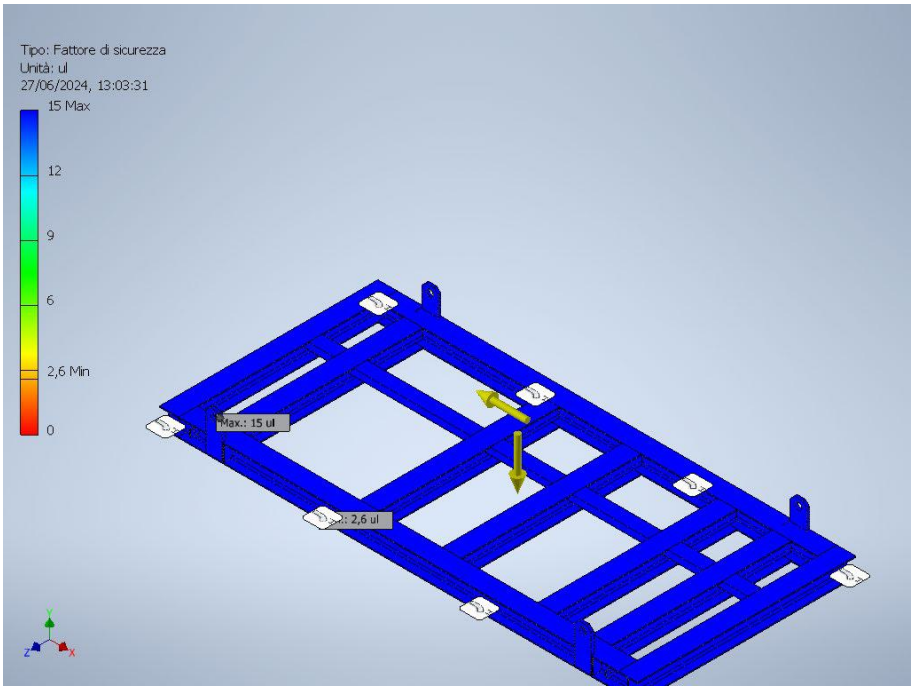


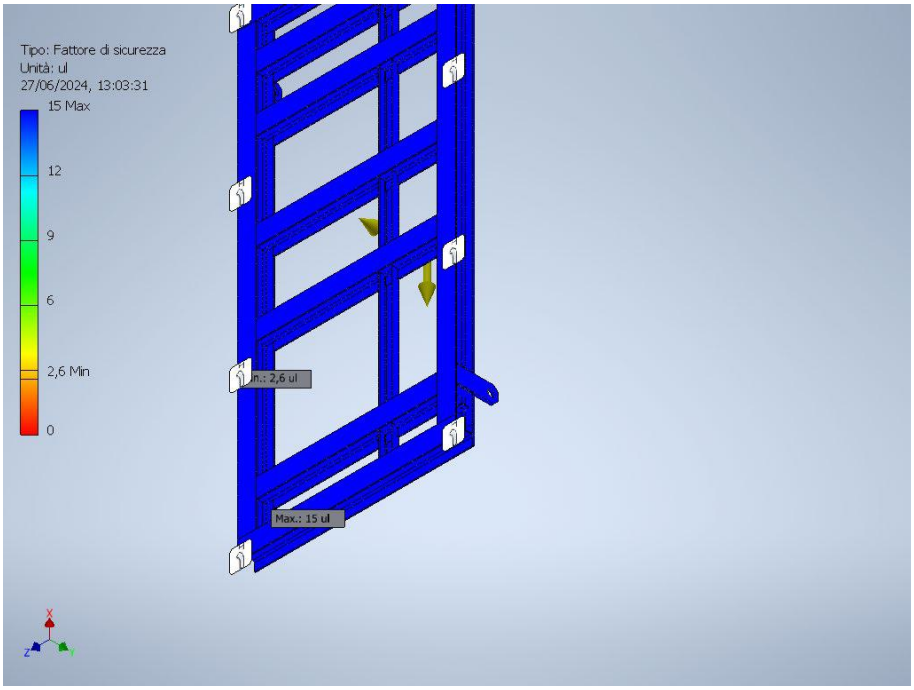
Third principal stress





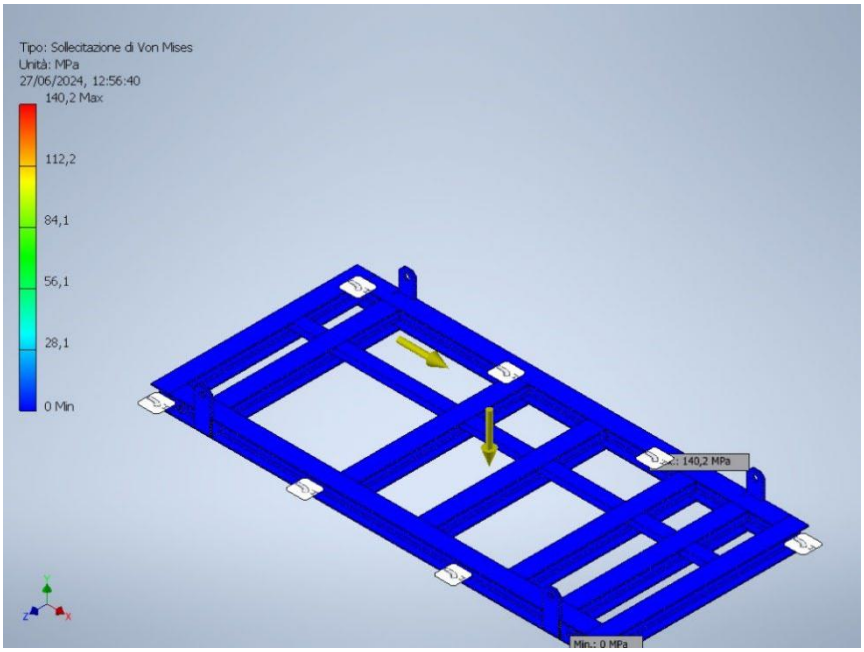
Safety factor

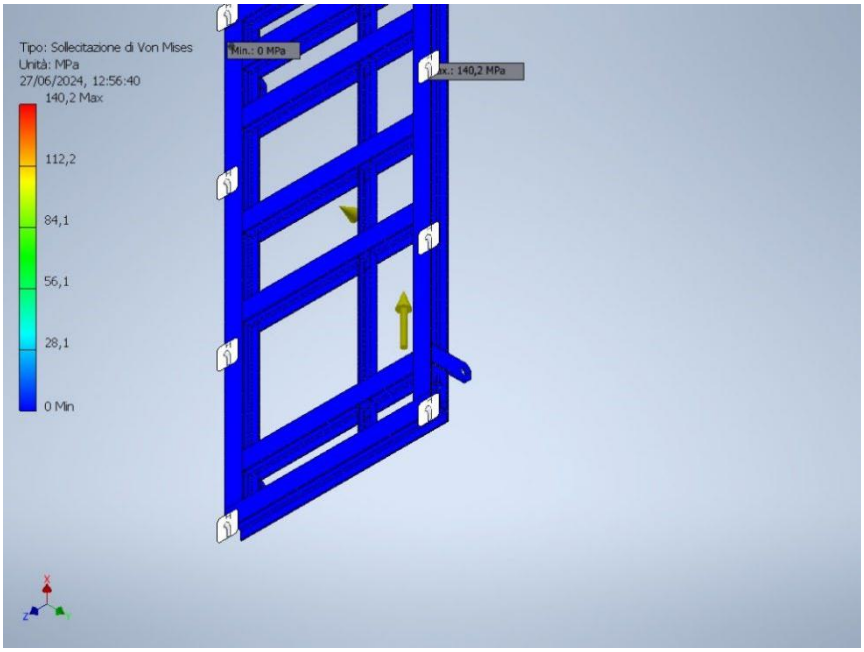




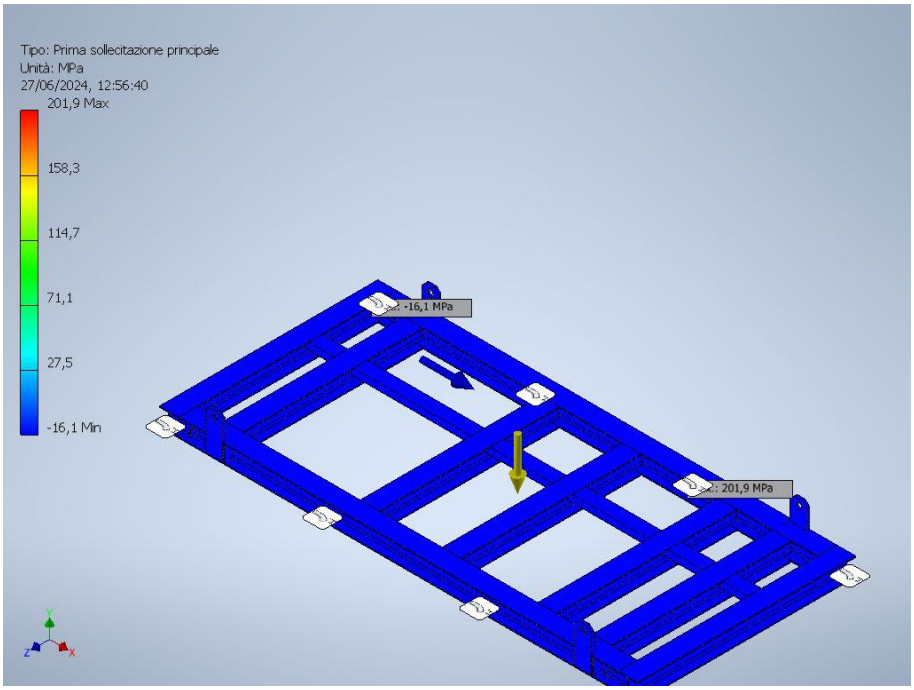
3.6.2 TRANSPORTATION LOAD + WIND (X+ DIRECTION)

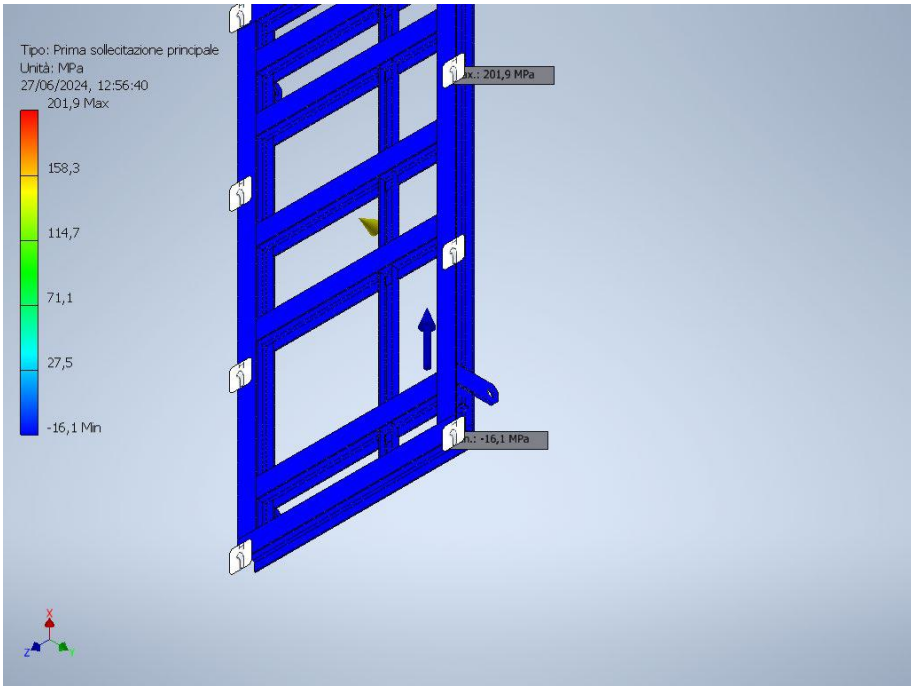
Von Mises stress



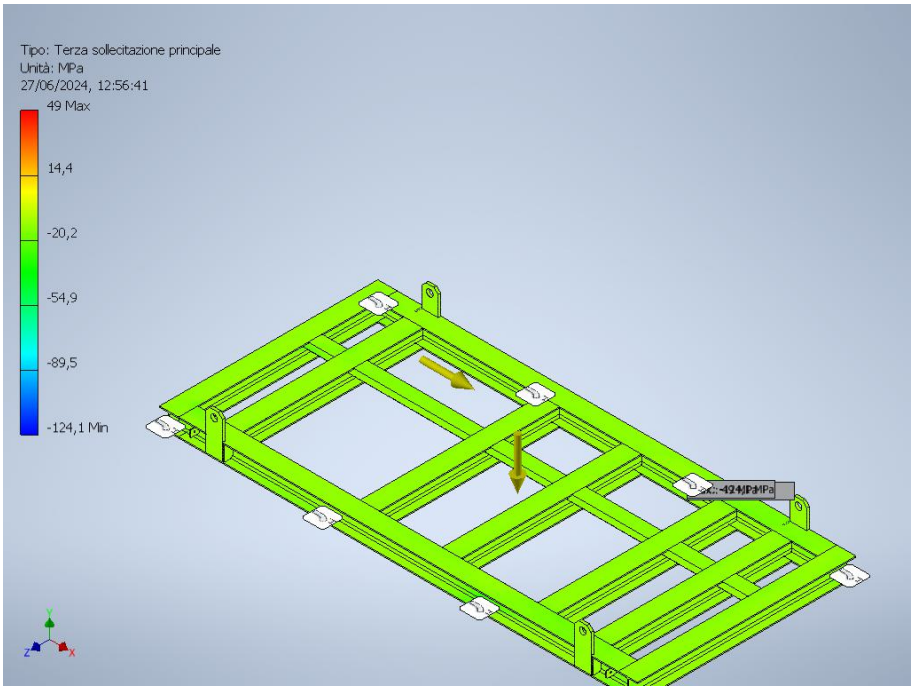


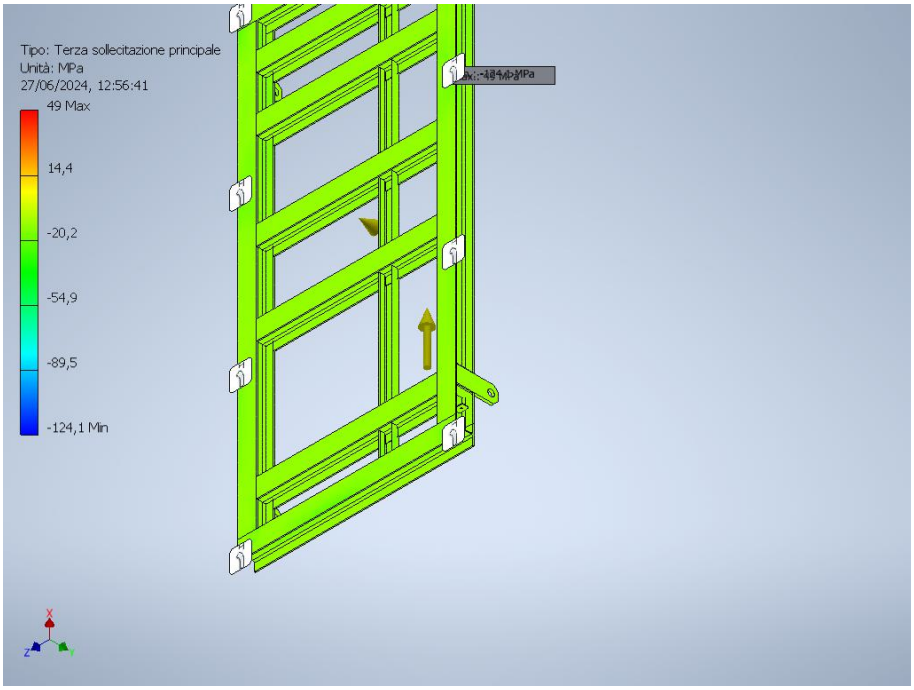
First principal stress



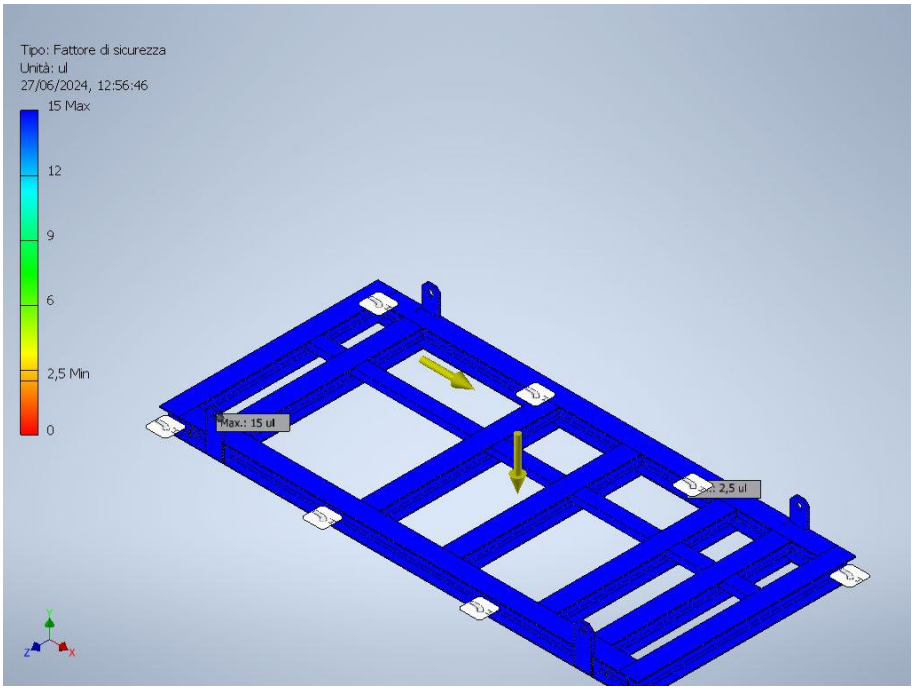


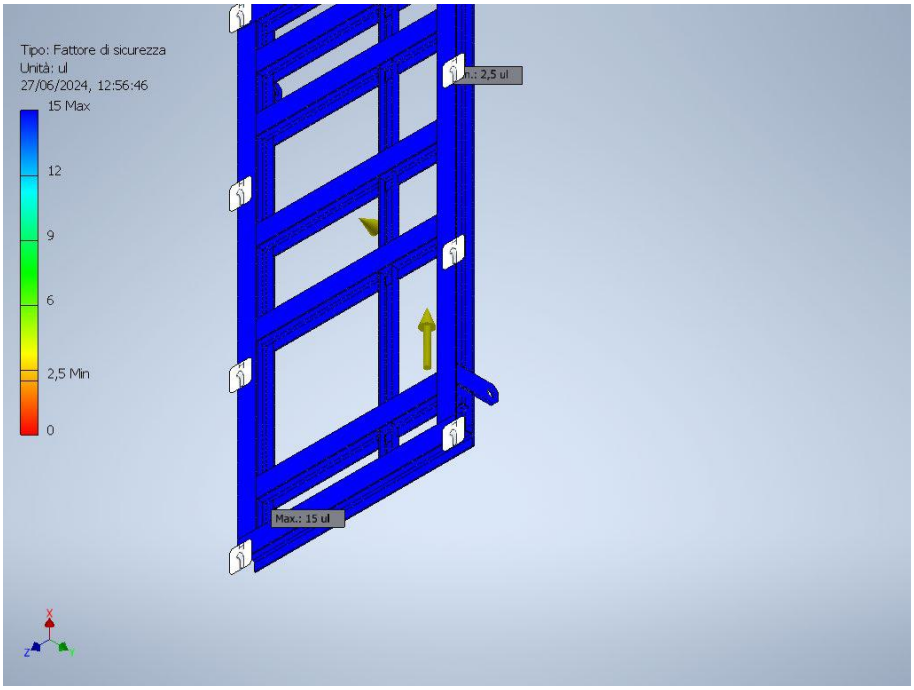
Third principal stress





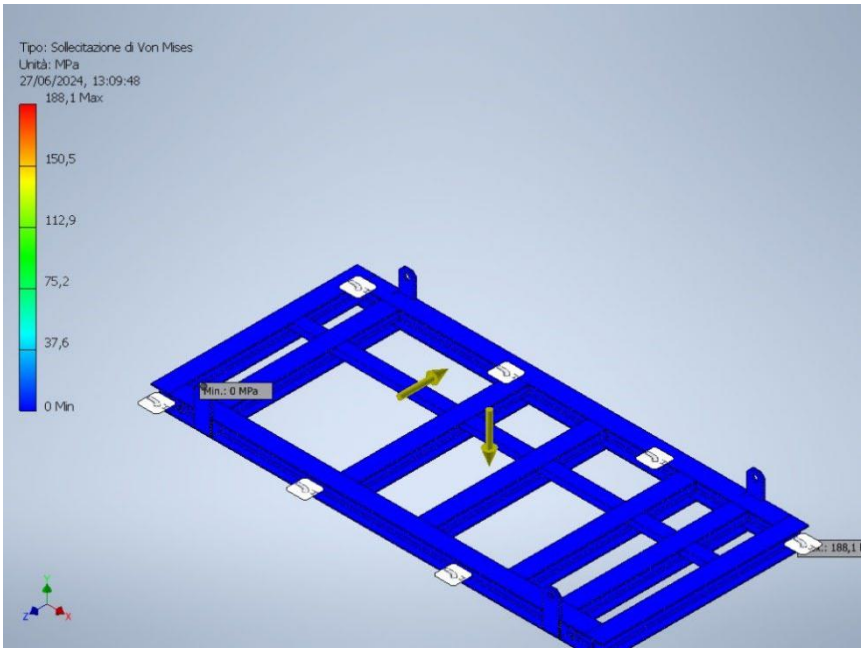
Safety factor

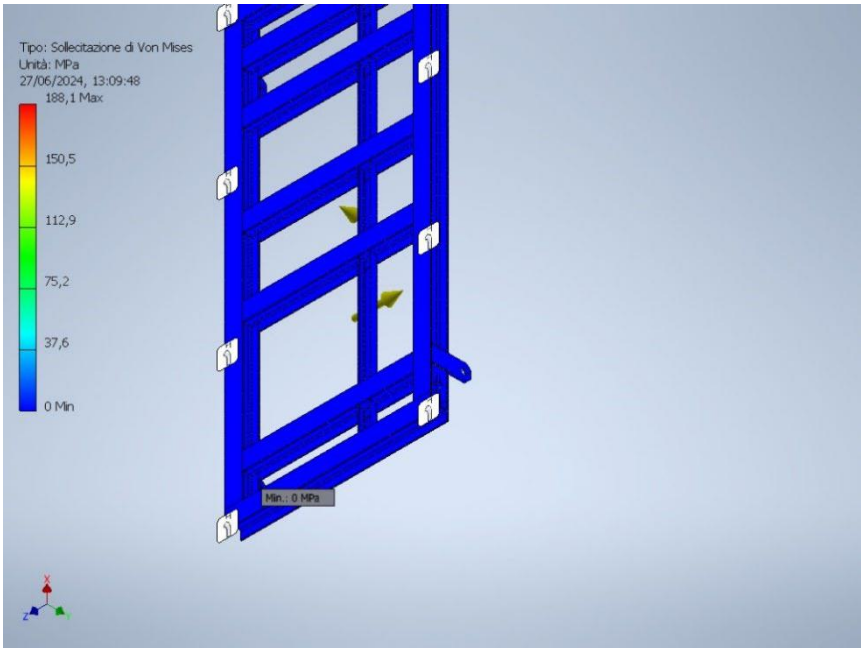




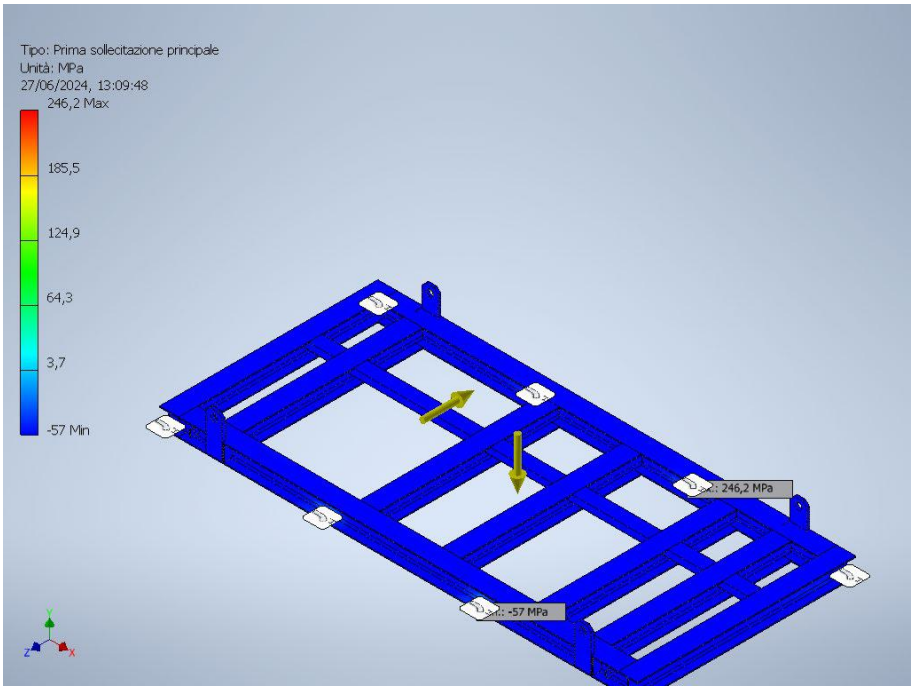
3.6.3 TRANSPORTATION LOAD + WIND (Z- DIRECTION)

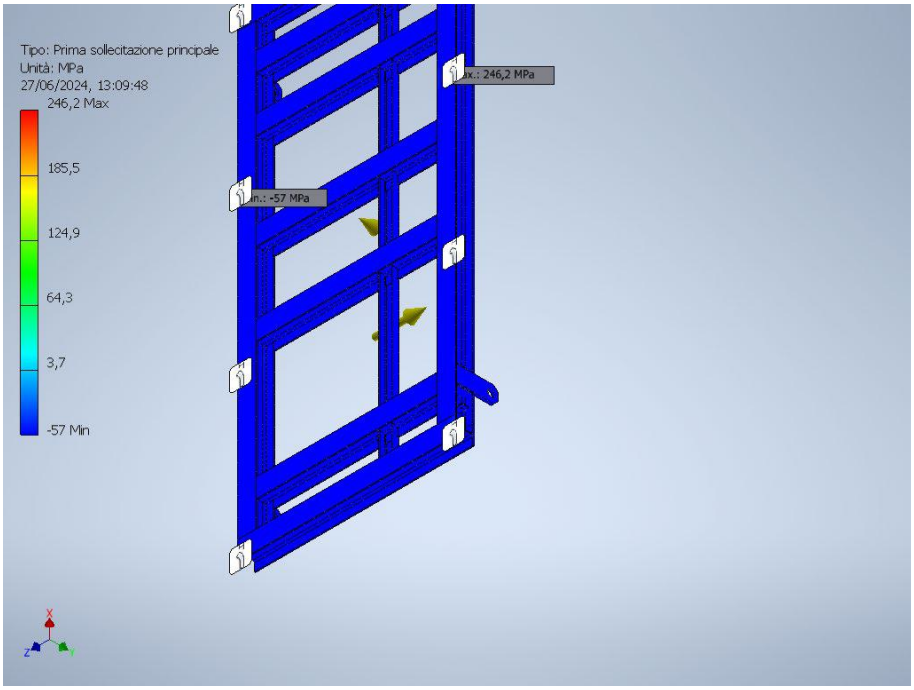
Von Mises stress



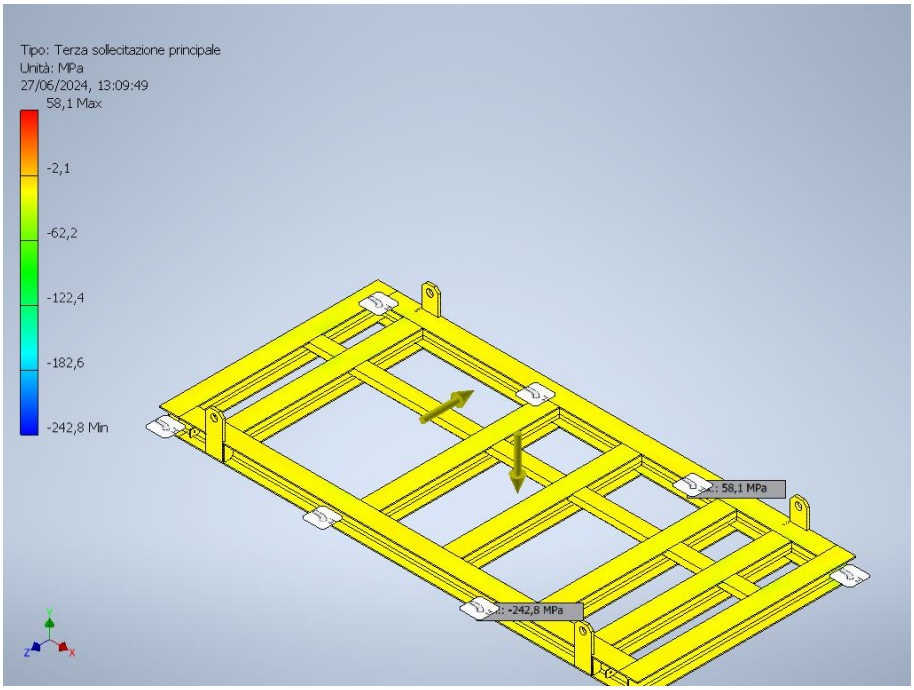


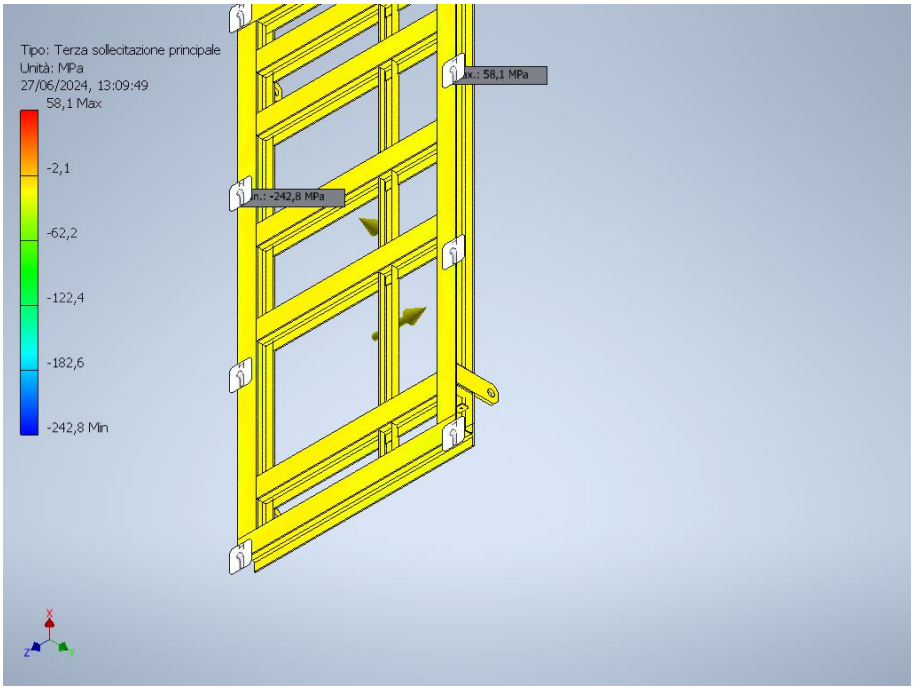
First principal stress



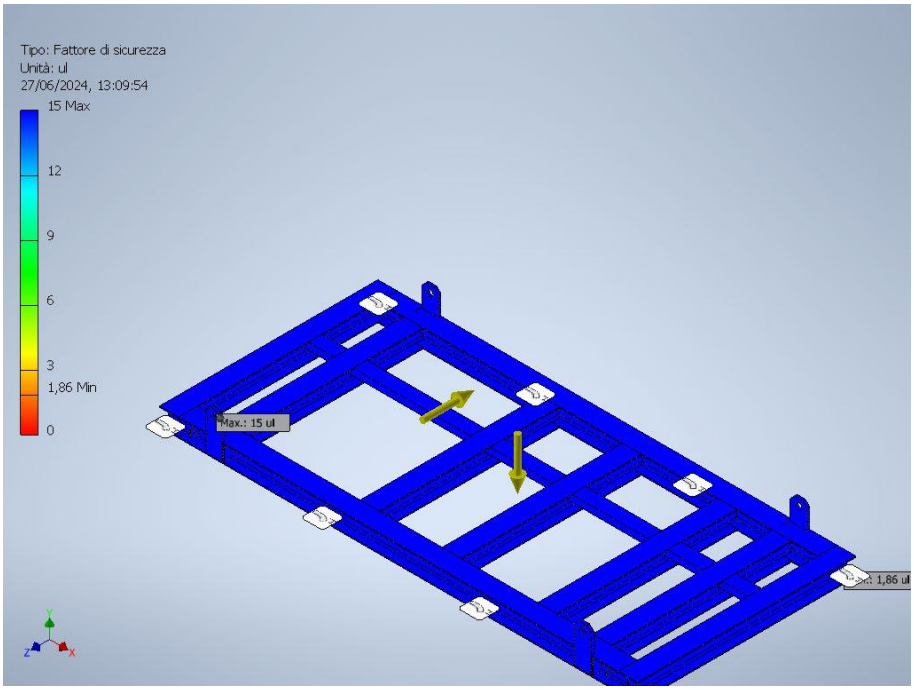


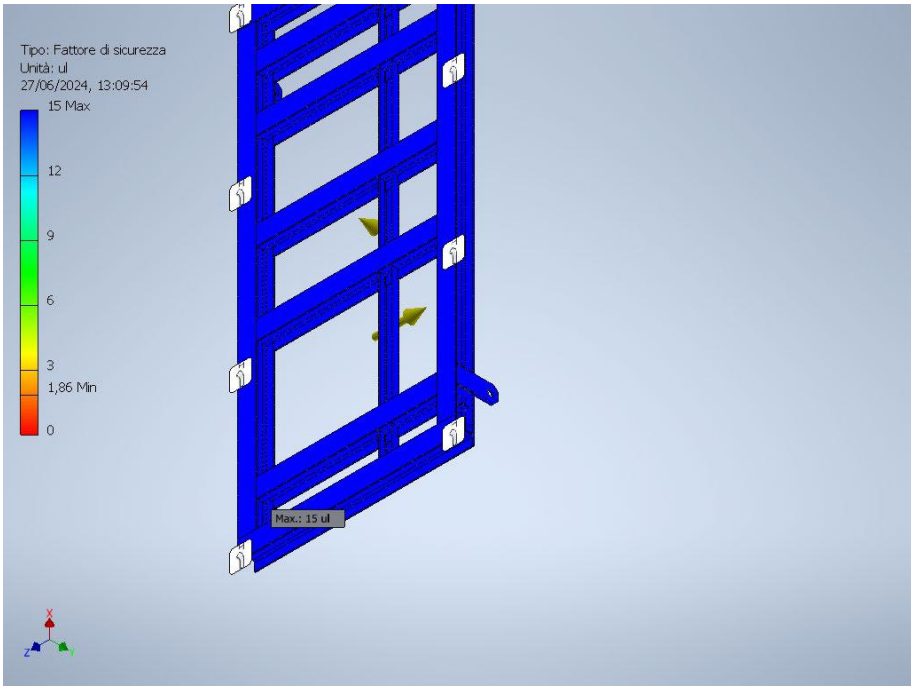
Third principal stress





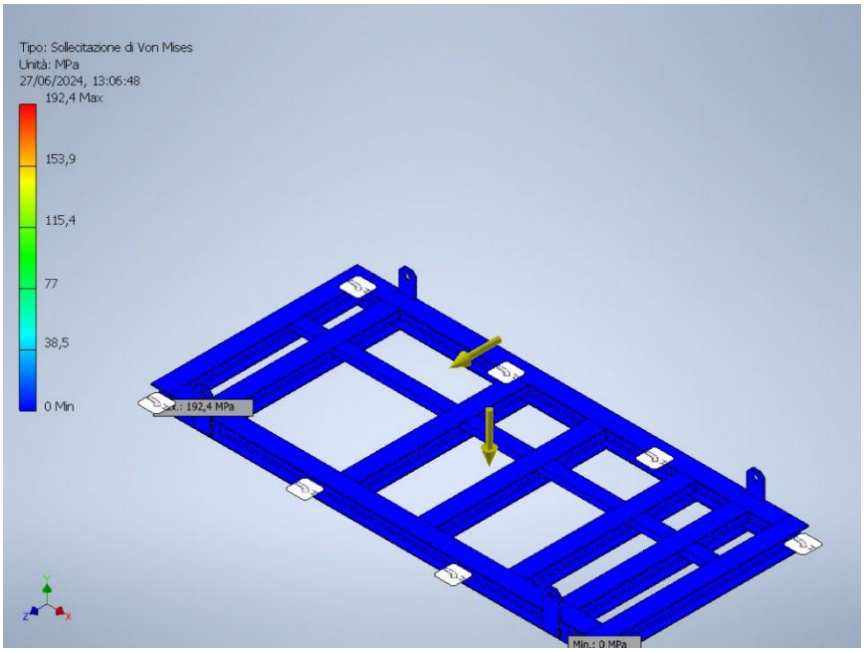
Safety factor

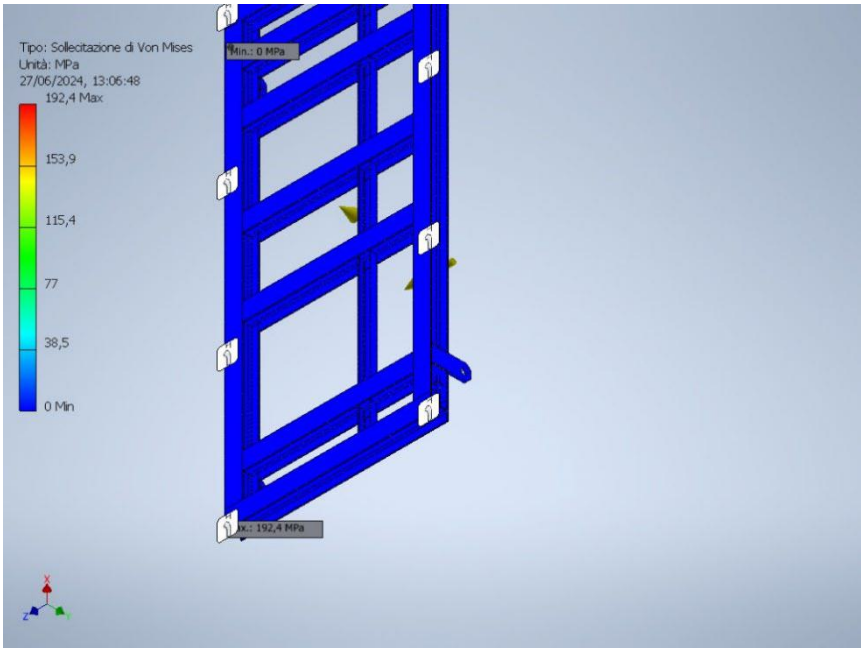




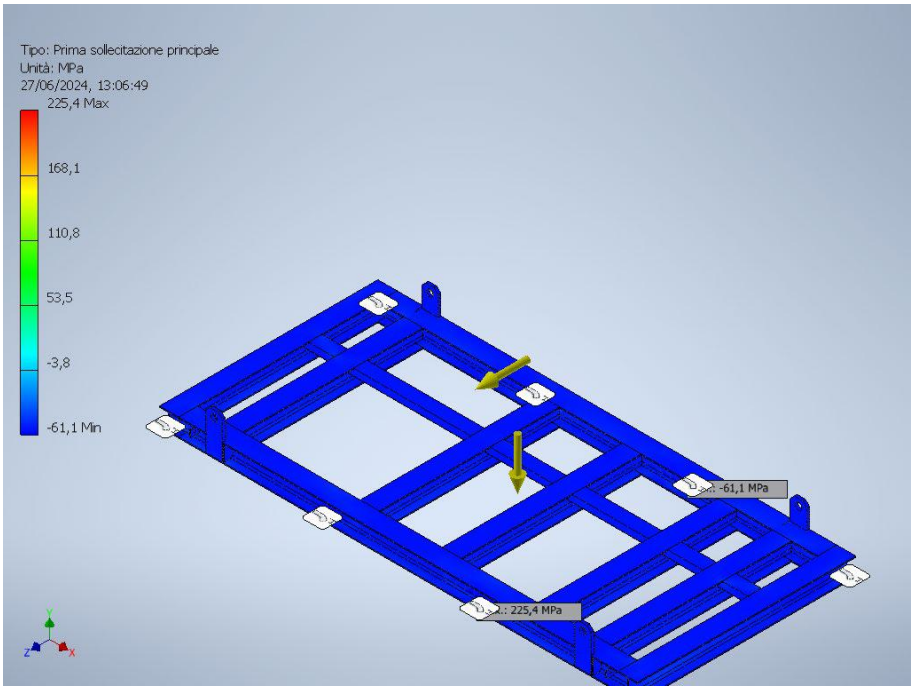
3.6.4 TRANSPORTATION LOAD + WIND (Z+ DIRECTION)

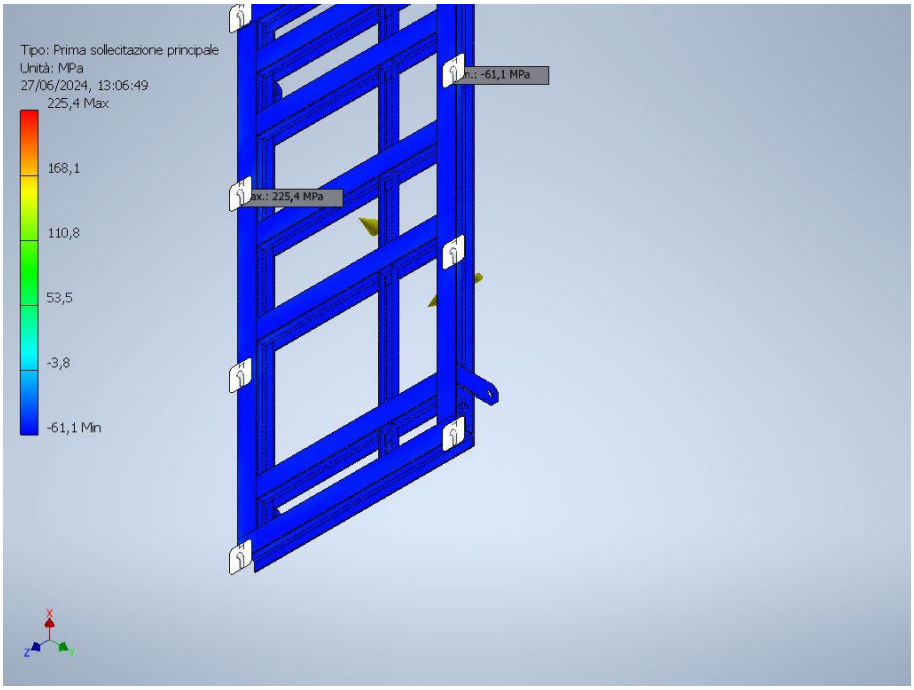
Von Mises stress



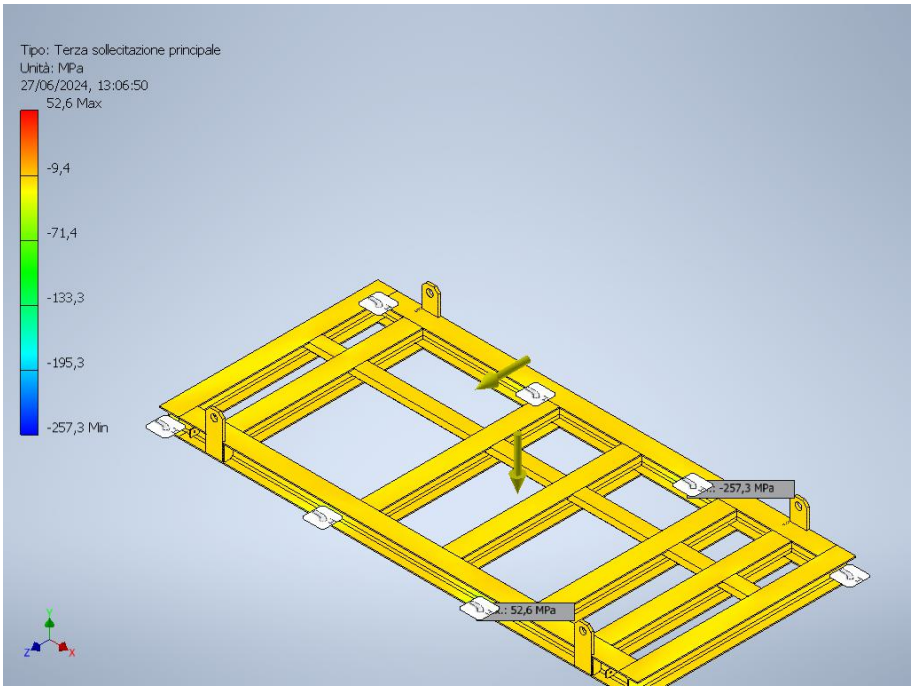


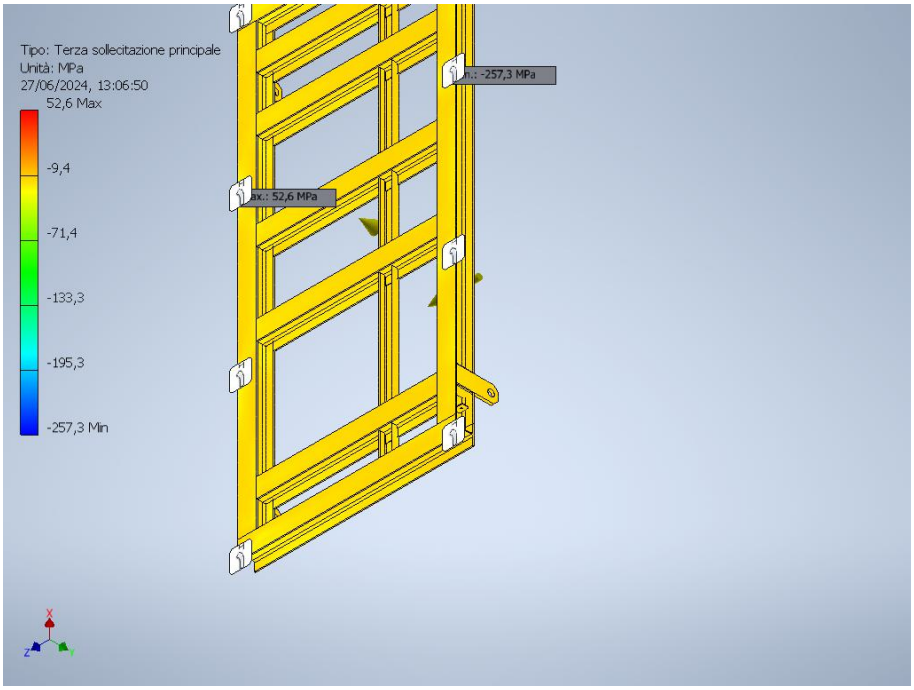
First principal stress



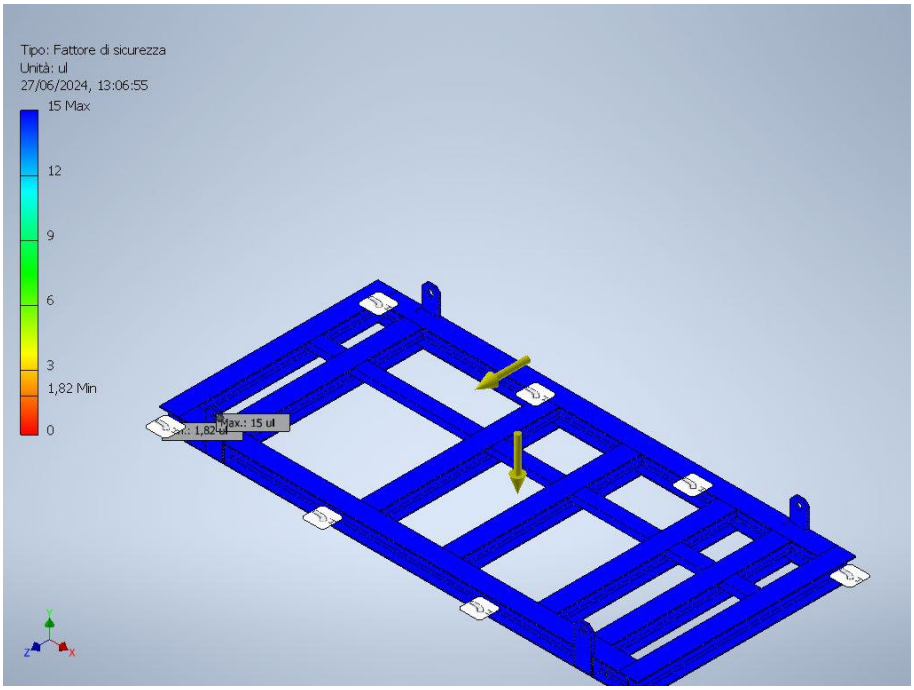


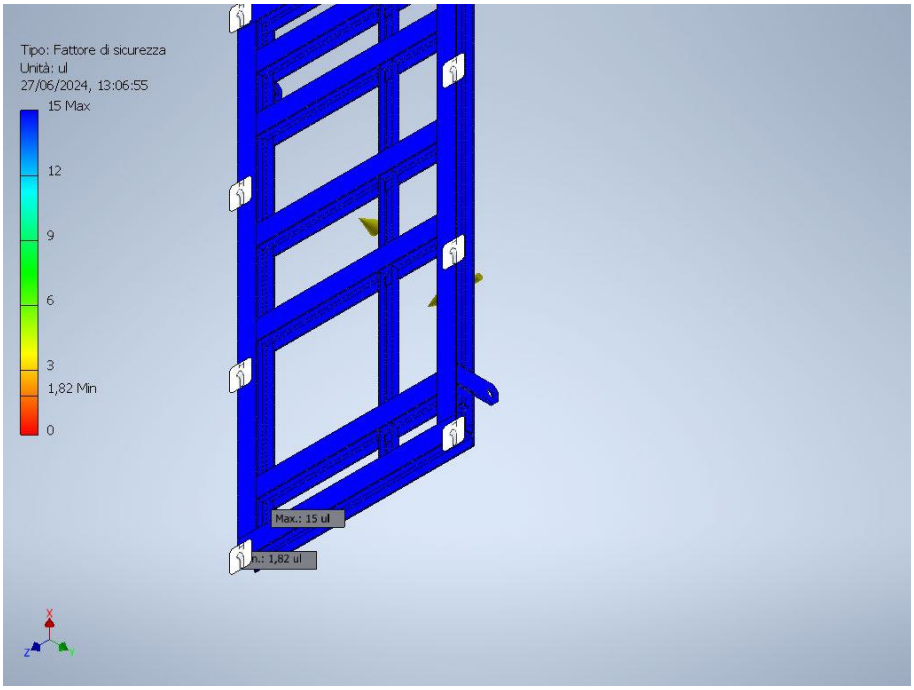
Third principal stress





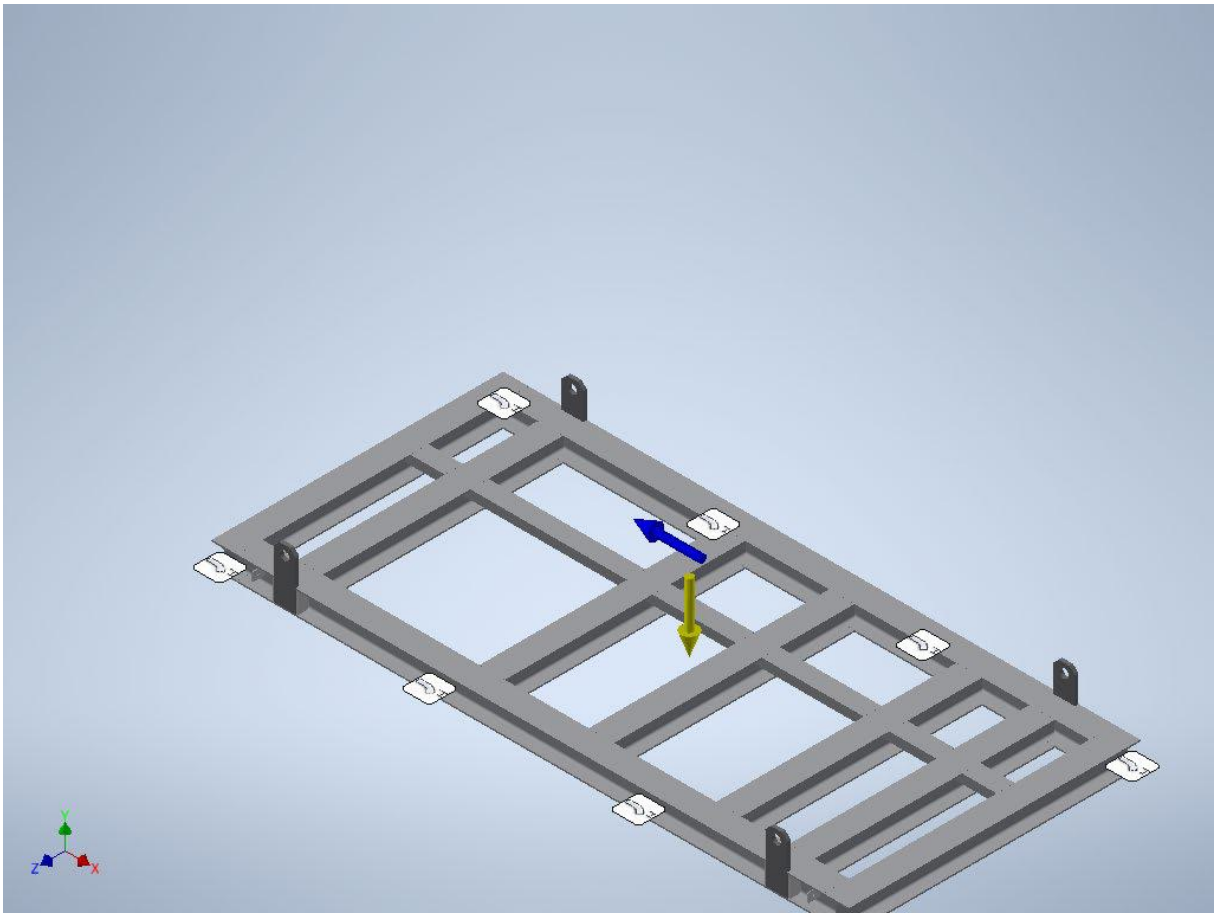
Safety factor





3.7 ANCHOR BOLTS CHECK

The skid is constrained to the main structure in no.8 points, by mean of M12 x 80 mm screws, in ASTM A 320 Gr. L7 steel.



The following tables show the valueas of the support reactions for each constraint in the Static + Wind load combination case and in the Transportation + Wind load combination case.

STATIC + WIND X+ DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	953,481	-759,395	5,743	1,884
		-241,636		-3,258
		-523,506		-4,338
Vincolo di fissaggio:2	914,648	-785,647	7,480	-2,289
		-243,072		5,513
		400,321		-4,507
Vincolo di fissaggio:3	1315,950	-634,428	30,559	30,550
		1112,450		-0,183
		-302,764		0,719
Vincolo di fissaggio:4	1941,440	-1455,680	16,279	6,560
		964,290		4,150
		-848,721		-14,309
Vincolo di fissaggio:5	2000,460	-1487,350	22,785	-7,601
		968,326		-2,660
		923,040		-21,314
Vincolo di fissaggio:6	1349,900	-560,094	31,181	-31,131
		1172,690		-1,752
		365,121		0,256
Vincolo di fissaggio:7	812,095	-674,650	12,612	-11,951
		443,855		-3,690
		85,665		1,621
Vincolo di fissaggio:8	850,948	-728,808	11,922	11,406
		427,915		3,179
		-99,200		1,391

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-0,56	X	0,03
Y	1,17	Y	0,01
Z	0,92	Z	0,00

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-1,49	X	-0,03
Y	-0,24	Y	0,00
Z	-0,85	Z	-0,02

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STATIC + WIND X- DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	1833,910	1339,200	20,666	-7,593
		914,468		1,033
		856,459		19,192
Vincolo di fissaggio:2	1748,520	1298,780	21,068	7,716
		887,678		-2,853
		-763,228		19,395
Vincolo di fissaggio:3	1129,110	986,275	14,316	13,983
		508,699		-2,949
		-208,264		-0,846
Vincolo di fissaggio:4	733,707	617,398	6,407	-1,752
		-195,604		-6,001
		344,796		1,401
Vincolo di fissaggio:5	789,998	609,002	4,783	1,718
		-191,936		2,919
		-465,160		3,378
Vincolo di fissaggio:6	1024,910	856,356	14,404	-14,255
		530,022		1,783
		190,180		-1,042
Vincolo di fissaggio:7	1328,460	699,782	28,171	28,142
		1061,690		-1,197
		-384,601		0,438
Vincolo di fissaggio:8	1354,040	679,085	28,842	-28,814
		1089,780		-0,910
		429,700		0,875

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	1,34	X	0,03
Y	1,09	Y	0,00
Z	0,86	Z	0,02

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	0,61	X	-0,03
Y	-0,20	Y	-0,01
Z	-0,76	Z	0,00

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STATIC + WIND Z+ DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	1509,590	1421,790	11,719	-9,468
		448,142		3,240
		-237,824		6,099
Vincolo di fissaggio:2	3966,000	982,321	49,260	13,372
		1531,500		33,272
		-3524,020		33,774
Vincolo di fissaggio:3	6421,680	-2562,120	63,413	61,475
		2581,490		-15,482
		-5292,390		-1,539
Vincolo di fissaggio:4	3908,560	-2348,860	28,089	9,843
		1534,980		-13,028
		-2720,930		-22,856
Vincolo di fissaggio:5	994,434	763,208	19,939	-8,997
		526,105		15,457
		360,037		-8,816
Vincolo di fissaggio:6	5529,690	4755,480	10,279	4,912
		-2423,490		-8,677
		1445,550		2,501
Vincolo di fissaggio:7	8209,050	3982,340	75,821	56,043
		2539,350		51,069
		-6714,250		0,140
Vincolo di fissaggio:8	7943,080	-6992,860	79,546	-11,839
		-2670,560		77,823
		2657,160		11,440

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	4,76	X	0,06
Y	2,58	Y	0,08
Z	2,66	Z	0,03

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-6,99	X	-0,01
Y	-2,67	Y	-0,02
Z	-6,71	Z	-0,02

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STATIC + WIND Z- DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	4077,310	1360,140	50,471	-13,529
		1575,440		-35,228
		3506,060		33,515
Vincolo di fissaggio:2	1887,840	1800,310	12,939	9,024
		560,341		-5,335
		93,904		7,585
Vincolo di fissaggio:3	5118,560	4212,700	13,427	-6,954
		-2530,380		10,806
		-1431,770		3,892
Vincolo di fissaggio:4	852,432	482,983	21,478	12,430
		602,082		-17,080
		-361,753		-3,880
Vincolo di fissaggio:5	3998,310	-2660,430	37,952	-12,395
		1544,710		12,269
		2553,910		-33,707
Vincolo di fissaggio:6	6483,640	-2598,040	61,138	-60,559
		2624,160		8,363
		5329,310		-0,765
Vincolo di fissaggio:7	7578,470	-6553,940	76,304	7,961
		-2835,900		-74,804
		-2537,090		12,777
Vincolo di fissaggio:8	8325,220	3955,850	78,646	-56,214
		2526,290		-54,923
		6875,920		2,934

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	4,21	X	0,01
Y	2,62	Y	0,01
Z	6,88	Z	0,03

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-6,55	X	-0,06
Y	-2,84	Y	-0,07
Z	-2,54	Z	-0,03

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TRANSPORTATION + WIND X+ DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	10029,700	-6259,460	87,061	37,181
		-3992,750		-7,884
		-6743,360		-78,327
Vincolo di fissaggio:2	9520,700	-6345,660	92,743	-40,419
		-3938,430		25,118
		5904,660		-79,603
Vincolo di fissaggio:3	5540,090	-4154,310	96,734	96,564
		3600,200		4,261
		-687,622		3,853
Vincolo di fissaggio:4	7097,460	-6151,200	51,452	16,137
		2774,890		25,476
		-2199,240		-41,688
Vincolo di fissaggio:5	7342,170	-6230,310	68,065	-20,157
		2810,120		-18,892
		2682,140		-62,207
Vincolo di fissaggio:6	5574,640	-4043,590	96,202	-95,585
		3685,940		-10,642
		1067,630		2,272
Vincolo di fissaggio:7	4301,410	-4269,050	14,849	-3,273
		-159,761		13,415
		501,803		5,459
Vincolo di fissaggio:8	3963,900	-3926,770	14,135	3,127
		-139,577		-12,736
		-522,978		5,274

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-3,93	X	0,10
Y	3,69	Y	0,03
Z	5,90	Z	0,01

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-6,35	X	-0,10
Y	-3,99	Y	-0,02
Z	-6,74	Z	-0,08

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TRANSPORTATION + WIND X- DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:1	7159,540	6061,350	63,095	-20,402
		2732,670		15,515
		2655,480		57,655
Vincolo di fissaggio:2	6787,920	5866,630	65,975	20,797
		2644,710		-22,300
		-2159,620		58,505
Vincolo di fissaggio:3	5105,370	5104,240	12,518	0,352
		-2,969		-11,316
		-107,369		-5,341
Vincolo di fissaggio:4	9371,620	5939,610	70,540	-35,606
		-3965,710		-36,341
		6068,070		48,860
Vincolo di fissaggio:5	10021,300	6129,010	89,524	36,722
		-3965,770		11,847
		-6865,380		80,783
Vincolo di fissaggio:6	4379,330	4378,900	11,035	0,301
		-36,391		9,578
		48,864		-5,471
Vincolo di fissaggio:7	5504,070	3997,100	93,461	92,941
		3605,610		-9,834
		-1147,840		-0,416
Vincolo di fissaggio:8	5538,280	3903,060	93,936	-93,813
		3627,500		4,618
		1509,940		1,332

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	6,13	X	0,09
Y	3,63	Y	0,02
Z	6,07	Z	0,08

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	3,90	X	-0,09
Y	-3,97	Y	-0,04
Z	-6,87	Z	-0,01

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TRANSPORTATION + WIND Z+ DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:2	13116,600	3002,630	164,710	62,586
		6903,890		68,701
		-10740,800		135,987
Vincolo di fissaggio:3	7228,090	-220,289	123,014	121,945
		4872,390		-16,149
		-5334,470		-1,059
Vincolo di fissaggio:4	12920,300	-4946,220	109,620	46,559
		7307,120		-35,131
		-9438,010		-92,815
Vincolo di fissaggio:5	6040,970	3839,570	83,131	22,995
		-3819,850		-9,131
		-2675,780		79,363
Vincolo di fissaggio:6	7507,200	910,543	126,630	126,567
		-5669,190		-2,676
		-4836,240		2,972
Vincolo di fissaggio:7	7520,630	-542,286	120,190	117,868
		-5485,530		22,882
		-5116,120		-5,408
Vincolo di fissaggio:8	6481,150	1214,070	99,421	94,926
		3974,910		29,314
		-4973,080		3,797
Vincolo di fissaggio:1	7114,850	-3262,470	75,648	15,825
		-3390,970		31,366
		-5336,540		-66,995

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	3,84	X	0,13
Y	7,31	Y	0,07
Z	-2,68	Z	0,14

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-4,95	X	0,02
Y	-5,67	Y	-0,04
Z	-10,74	Z	-0,09

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TRANSPORTATION + WIND Z- DIRECTION				
Nome vincolo	Forza di reazione		Momento di reazione	
	Intensità	Componente (X,Y,Z)	Intensità	Componente (X,Y,Z)
Vincolo di fissaggio:2	6774,150	-2895,760	75,912	-14,625
		-3327,480		-27,622
		5141,160		-69,179
Vincolo di fissaggio:3	7400,780	778,801	128,935	-128,235
		-5621,690		12,924
		4749,900		3,598
Vincolo di fissaggio:4	6339,540	3538,850	55,257	-4,367
		-3853,360		11,841
		3580,210		53,796
Vincolo di fissaggio:5	12453,800	-5597,080	163,139	-62,672
		7231,360		38,793
		8454,460		-145,539
Vincolo di fissaggio:6	7454,840	66,443	123,403	-123,194
		5052,430		7,170
		5481,160		-0,475
Vincolo di fissaggio:7	6467,760	1266,080	100,282	-93,229
		3879,860		-36,367
		5017,540		6,511
Vincolo di fissaggio:8	7611,770	-477,523	122,625	-121,745
		-5642,760		-14,548
		5086,280		-1,884
Vincolo di fissaggio:1	13392,500	3316,800	166,277	-61,617
		6974,550		-78,498
		10941,400		133,002

MAX			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	3,54	X	0,00
Y	7,23	Y	0,04
Z	10,94	Z	0,13

min			
Forza di reazione [kN]		Momento di reazione [kNm]	
	Componente (X,Y,Z)		Componente (X,Y,Z)
X	-5,60	X	-0,13
Y	-5,64	Y	-0,08
Z	3,58	Z	-0,15

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The bolt strength has been verified with respect to the combined tension and shear effects, according to Eurocode EC3.

	Bolt Class	Bolt diameter	Fx [kN]	Fy [kN]	Fz [kN]
Static + wind Max	8.8	M12	4,76	2,62	6,88
Transportation + wind Max	8.8	M12	6,13	7,31	10,94
Static + wind min	8.8	M12	-6,99	-2,84	-6,71
Transportation + wind min	8.8	M12	-6,35	-5,67	-10,74

Bolt verification Procedure (according to EC3)

Type	Bolt						Nominal Tensile Strength	Yield strength	Resistance factor	Partial Safety factor
	Bolt Class	Bolt diameter	A_{bolt}	A_{res}	A_{res}/A_{bolt}	k2 for normal bolts	f_{tb}	f_{yb}	α_v	γ_{M2}
		[mm]	[mm2]	[mm2]			[MPa]	[MPa]		
Static + wind Max	8.8	M12	113	84,3	0,746	0,9	895	585	0,6	1,25
Transportation + wind Max	8.8	M12	113	84,3	0,746	0,9	895	585	0,6	1,25
Static + wind min	8.8	M12	113	84,3	0,746	0,9	895	585	0,6	1,25
Transportation + wind min	8.8	M12	113	84,3	0,746	0,9	895	585	0,6	1,25

Bolt verification Procedure (according to EC3)

Type	Bolt Class	Bolt diameter	Tension demand $F_{t,Ed}$	Shear demand $F_{v,Ed}$	Tension resistance $F_{t,Rd}$	Shear resistance $F_{v,Rd}$
		[mm]	[kN]	[kN]	[kN]	[kN]
Static + wind Max	8.8	M12	2,62	6,88	54,32	36,22
Transportation + wind Max	8.8	M12	7,31	10,94	54,32	36,22
Static + wind min	8.8	M12	2,84	6,71	54,32	36,22
Transportation + wind min	8.8	M12	5,67	6,35	54,32	36,22

Bolt verification Procedure (according to EC3)

Type	Bolt Class	Bolt diameter	Tension check $F_{t,Ed}/F_{t,Rd} < 1$	Shear check $F_{v,Ed}/F_{v,Rd} < 1$	Combined Shear and tension check $F_{v,Ed}/F_{v,Rd} + F_{t,Ed}/1,4\,F_{t,Rd} \leq 1,0$
		[mm]			
Static + wind Max	8.8	M12	Ok	Ok	Ok
Transportation + wind Max	8.8	M12	Ok	Ok	Ok
Static + wind min	8.8	M12	Ok	Ok	Ok
Transportation + wind min	8.8	M12	Ok	Ok	Ok

3.8 CONCLUSIONS

The analysis shown that the stresses are below the allowable ones, in each of the load combination cases.

- the maximum calculated Von Mises Stress is equal to 192,405 MPa

- the maximum calculated First Principal Stress is equal to 246,163 MPa

- the maximum calculated Third Principal Stress is equal to 58,114 MPa

The displacement can be considered negligible.

Safety factor is 1,82.

The actual design of the structure can be considered acceptable.

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