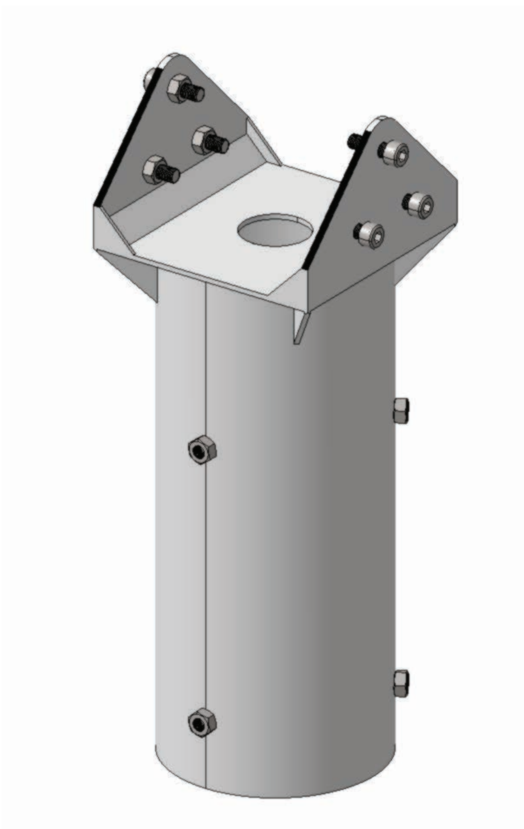
STRESS REPORT:

CAPE / POLLUX / NATRON

	CUSTOMER: Beyond Solar SUBJECT: CAPE / POLLUX / NATRON NEW BRACKET TOOL NB:	STUDY: 2649/MS STRESS NOTE NB: 2649-DCO-



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1 Presentation

1.1 Overview

Brackets concerned by the study are designed to support solar panel on a street lightning pole. Dimension of a solar panel is 1770 x 1060 x 150 mm and weight of 48kg. In this report will be studied newly designed reinforced version of a bracket. Brackets is composed of a round tube that is slided and bolted to the pole, and welded clevis. Solar panel is fixed to the clevis by a six bolt and can be adjusted angularly.

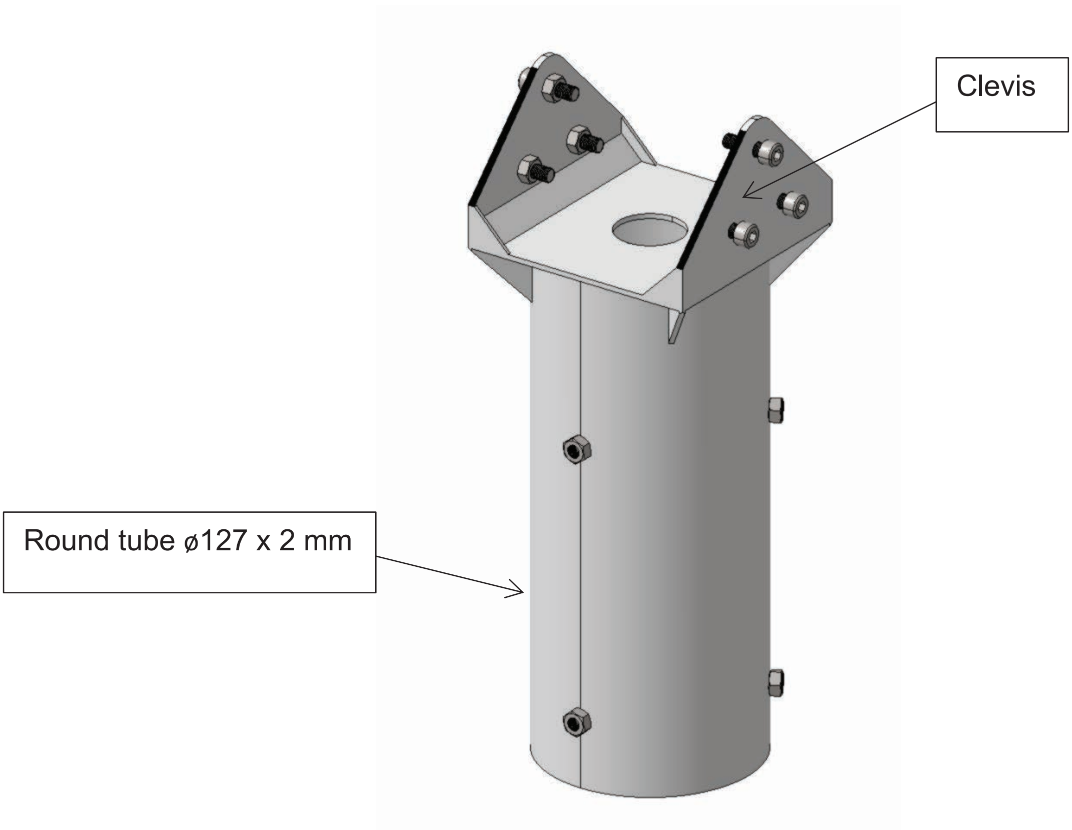


Fig. 1: Assembly of a new SSLX PRO barcket

1.2 Specifications

The aim of this stress report is to justify the strength of a CAPE / POLLUX / NATRON BRACKET against the wind load

CAD reference:

- CAPE / POLLUX / NATRON 270w-114mm Connexion Part Nouvelle version 2023 .STEP

Working Load:

The loading to be applied, according to Eurocode, is detailed in **§3.2**.

To be performed:

Is to be demonstrated the static strength of the structure, following the norm Eurocode as defined in **Ref 3**, in the presence of an approved body.

Design rules main hypotheses are the following:

- The structure of the brackets must respect these safety factors to comply with standard Eurocode (**Ref 3**)

1.3 References

Ref 1 : Siemens – NX Nastran User's Guide

Ref 2 : Siemens – Element Library Reference

Ref 3 : Eurocode 0, 1 and 3

2 Calculation hypothesis and methods

2.1 Hypothesis and modelling of elements

A finite element model has been created to determine stress and forces throughout the structure.

Simcenter Femap V2020.1. has been used to model and analyse results.

Simcenter Nastran has been used to solve the analyses.

Details of hypothesis and elements used in the finite element modelling are explained in **Ref 1** and **Ref 2**.

As a summary:

- Beam elements are modelized by 1D elements and follow beam's theory (PROD for traction/compression/torsion element, otherwise PBAR/PBEAM).
- Shell elements are modelized by 2D elements and follow shell/plate theory (PSHELL).
- Volume elements are modelized by 3D elements (PSOLID).
- Fasteners elements are often modelized by 1D or 0D elements (PBUSH), depending of the need

2.2 Materials characteristics

Hereunder are detailed the main material characteristics used in the stress report, as well as parts/materials assignations.

Designation	E (MPa)	G (MPa)	Nu	Re (MPa)	Rm (MPa)	ρ (kg/m³)
Inox 316L [(1)]	193000	74231	0.3	220	530	7800
Inox A2-70	193000	74231	0.3	450	700	7800

(1) Values acc. to EN-10088-2

2.3 Safety margins specification

Safety margin policy is specified in Eurocode (**Ref 3**) and is defined as follow:

<u>Ultimate limit states: U.L.S.</u> : It is considered that a structure reaches an Ultimate Limit State when at least one of the resistance criteria is not proven such as: a lack of static equilibrium, an achievement of the limit of elasticity or a plasticity criterion.

<u>Elements to be dimensioned:</u>

Minimum safety factor SF_{Re} ≥ 1.0 with respect to the elastic limit (under U.L.S.):

$$CS_{Re} = \frac{elastic\ limit}{calculated\ stress * \gamma_M} \geq 1.0$$

Minimum safety factor SF_R ≥ 1.0 with respect to the ultimate strength (under U.L.S.):

$$CS_{Re} = \frac{ultimate\ strength}{calculated\ stress * \gamma_M} \geq 1.0$$

Where γ_M is a partial factor covering strength uncertainties regarding modelling or material properties. According to the Eurocodes:

$\gamma_{M0} = 1.0$ - for structures
$\gamma_{M2} = 1.25$ - for connecting elements

<u>Commercial elements</u>

Minimum safety factor SF_{Re} ≥ 1.0 with respect to the nominal catalog load (under U.L.S.):

$$CS_{Re} = \frac{nominal\ catalog\ load}{calculated\ load} \geq 1.0$$

The safety coefficients specific to the commercial elements are not taken into account in the calculation.

2.4 Calculation methods and hypotheses

2.4.1 Metallic Parts sizing

For metallic parts sizing, Eurocode 3 defined in **Ref 3** is applied

2.4.2 Metallic Junction sizing

For metallic junction sizing (part and fastener), Eurocode 3 defined in **Ref 3** is applied

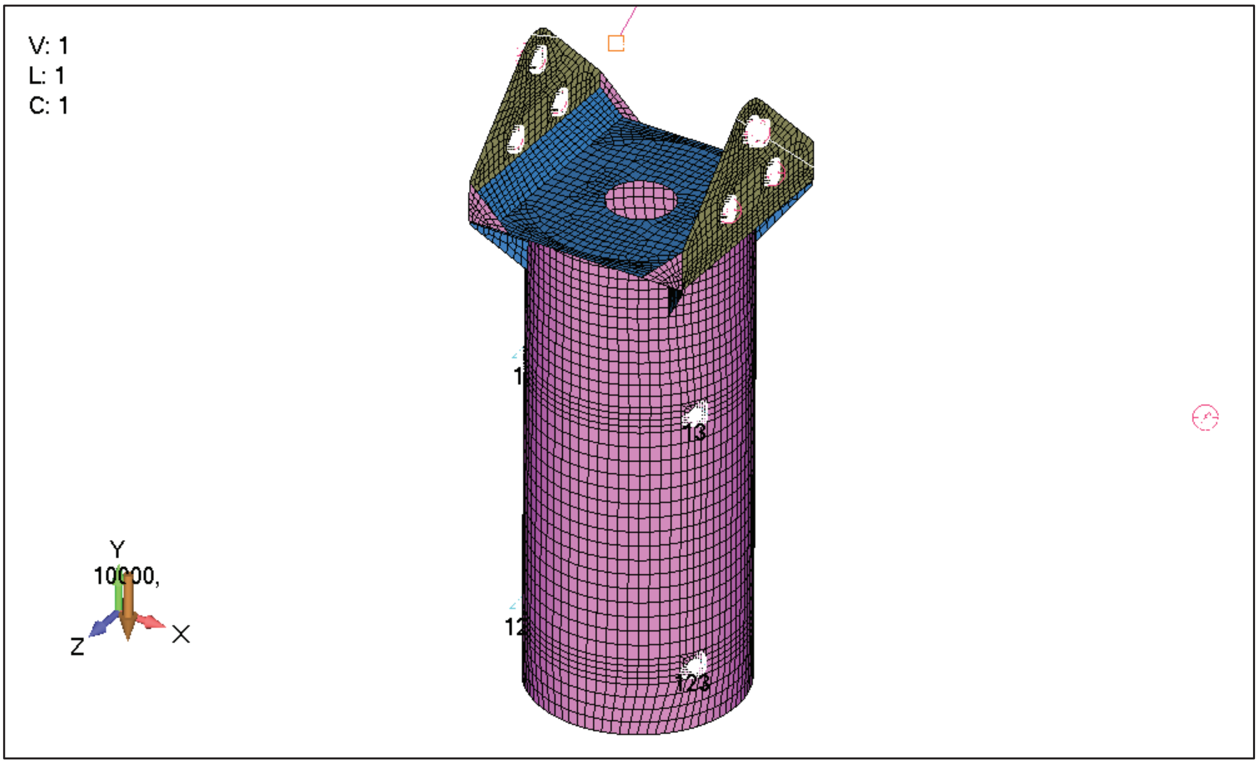
2.4.3 Commercial parts

For every commercial part, it must be checked that the applied force is lower than the allowable value provided by the manufacturer:

$$SF = \frac{F_{adm}}{F} \geq 1.0$$

3 Finite element model

3.1 Model presentation



The entire structure is modeled using plate (2d) and CBAR (1d) elements.

Point mass elements have been added for non-structural elements

Surface contact has been defined between the different parts.

CBUSH and CBAR elements are used to represent bolt connections.

3.2 Boundary conditions

Loads are classified regarding their variation during time as follow:

- Permanent actions (G), for instance weight of structures…
- Variable actions (Q), for instance imposed loads on floors, beams or building roofs, wind loading, or snow loading…
- Accidental loads (A), for instance explosion or a vehicle impact

Combination of loading for Ultimate States (U.L.S.):

$$\sum_{j\geq 1} \gamma_{G,j} G_{k,j} \text{"+"} \gamma_{P} P \text{"+"} \gamma_{Q,1} Q_{k,1} \text{"+"} \sum_{i>1} \gamma_{Q,i} \psi_{0,i} Q_{k,i}$$

Where “γ“ is a partial factor, covering potential difference in load values or uncertainties of modelling loadings

Loading values must be conform to table A1.2 (B) of Appendix A1 of Eurocode, where:

$$\gamma_{G,j} = 1.35$$

$$\gamma_{Q,j} = 1.50$$

Combination of loading for Serviceability States (S.L.S.):

$$\sum_{j\geq 1} G_{k,j} \text{"+"} P \text{"+"} Q_{k,1} \text{"+"} \sum_{i>1} \psi_{0,i} Q_{k,i}$$

3.2.1 Wind loads

Pressure of the wind on a solar panel is calculated acc to Eurocode 1 (**Ref 3**).

Basic wind speed	V_b =	22	m/s
Terrain category		III	
Air density	ρ =	1,25	kg/m^3
Basic wind pressure	q_b =	302,5	Pa
Maximum height	h =	8	m
Exposure factor	$c_e(z)$ =	1,55	
Maximum wind pressure	$q_p(z)$ =	468,875	Pa
Total solar panel Area (1770*1060)	Ar =	1,88	m^2
Drag Coefficient	C_f =	-1,8	
Total effort on a panel (S.L.S.)	Fw_{sls} =	-1583	N
Total effort on a panel (U.L.S.)	Fw_{uls} =	-2375	N

3.2.2 Load case 1

For this load case brackets are loaded with a wind loads, self weight and mass of the solar panel:

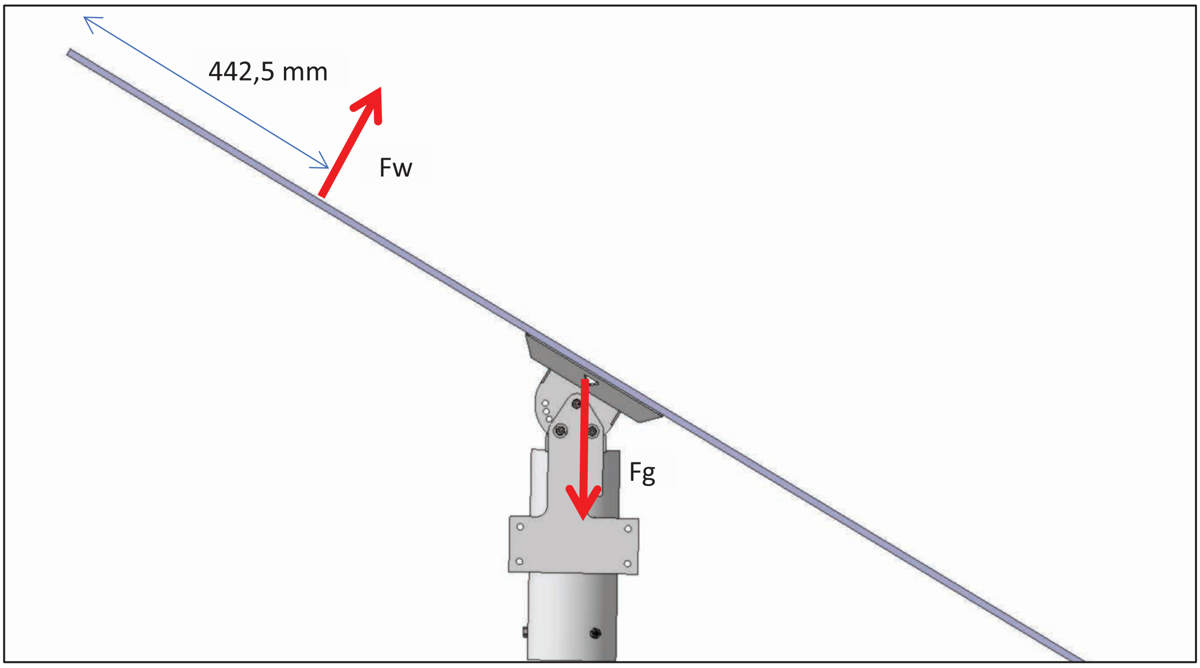
Serviceability Limit States (S.L.S.)

- Bracket is fixed on a pole
- Wind Load - Fw_{sls}
- Solar panel mass – 48kg
- Self weight

Ultimate Limit States (S.L.S.)

- Bracket is fixed on a pole
- Wind Load – Fw_{uls}
- Solar panel mass – 48kg * 1,35
- Self weight * 1,35

Mass of the solar panel and self weight are considered as a permanent action therefore partial factor of 1.35 are applied.



4 Margin summary

§	Description	Criteria	Material	Stress (σ_{vm}) /Forces	Allowable		SF_{Re}		SF_R	
					Re	Rm	Calc.	Required	Calc.	Required
6.1	Bracket	VM	Acier Inox 316L	175 MPa	220 MPa	530 MPa	1,3	1	3,03	1
6.2	Bolt M8	Comb	Acier Inox A2-70	-	-	-	-	-	2,21	1

VM = Von Mises B = Bearing PS = Punching Shear

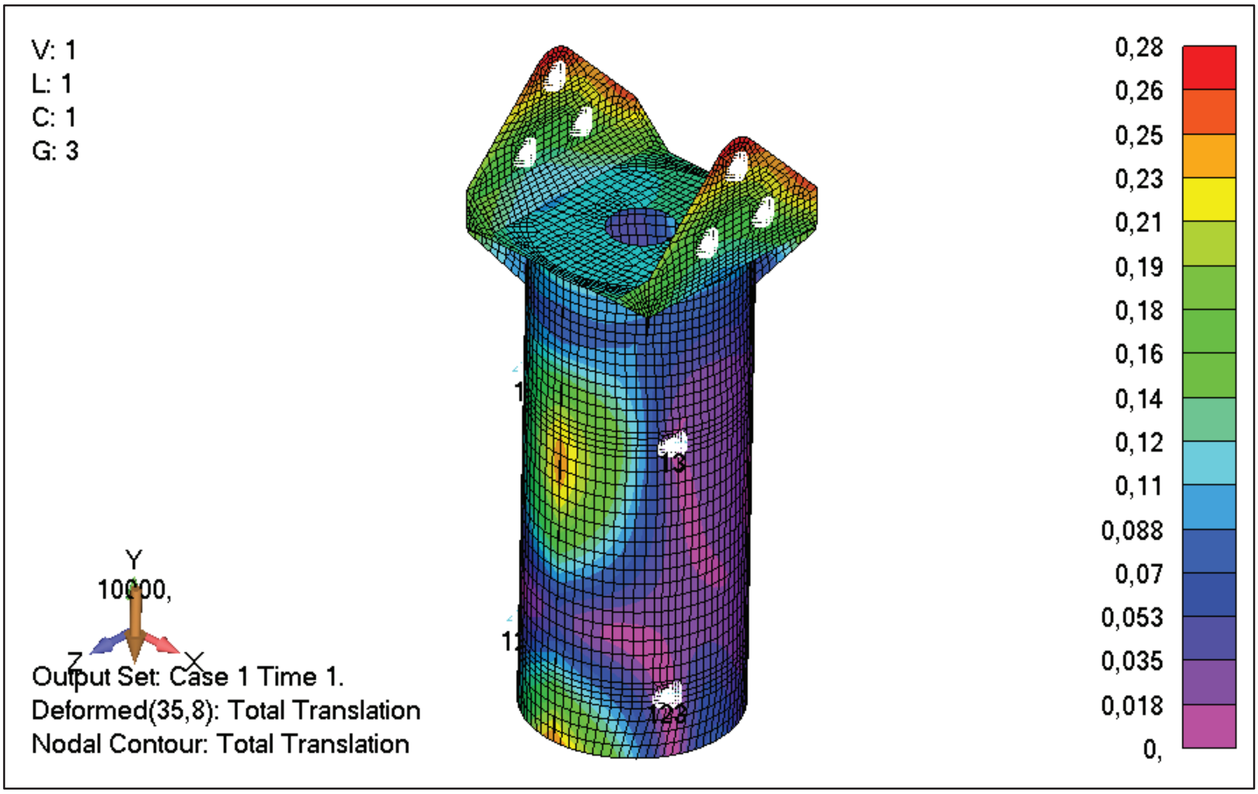
T = Tension S = Shear Comb = combined

POR = Pull-Out Resistance CCR = Concrete cote resistance SR = Steel Resistance

CED = Concrete Edge Distance PF = Pryout Failure SR = Steel Resistance

5 Deformation

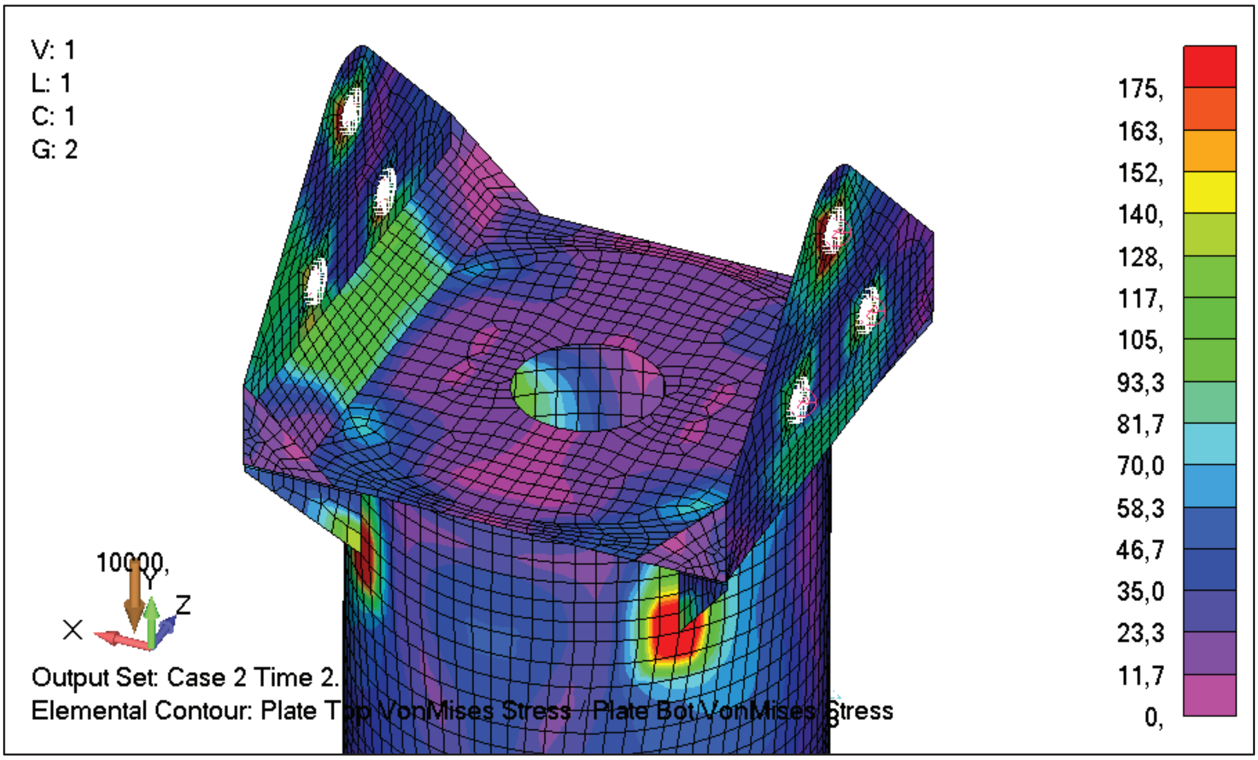
(S.L.S.) mm



6 Static Analysis

6.1 Bracket

VM Stresses (U.L.S.) MPa



$\sigma_{VM} = 175\ MPa$

Material : Acier Inox 316L

$\sigma_{Re} = 220\ MPa$ et $\sigma_{Rm} = 530\ MPa$

$$SF_{Re} = 1{,}3$$

$$SF_{R} = 3{,}03$$

6.2 Bolt M8

Material : Acier Inox A2-70

$F_{\mathrm{t,\,Ed}} = 868\,N$ et $F_{\mathrm{v,\,Ed}} = 4300\,N$

$F_{\mathrm{t,\,Rd}} = 18446\,N$ et $F_{\mathrm{v,\,Rd}} = 10248\,N$

$$SF_R = 2{,}21$$

6.3 Other elements

Effort in other parts or junctions are much lower than the one presented hereinabove and margin are very comfortable.

Therefore, details of these element will not be presented in the report.

7 Conclusion

C1. Structural analysis was performed considering linear material behaviour and static load character.

C2. Stress analysis shows that all elements meet safety criteria presented in section **2.3.**

C3. Analysis shows that bolt connections meet safety criteria.