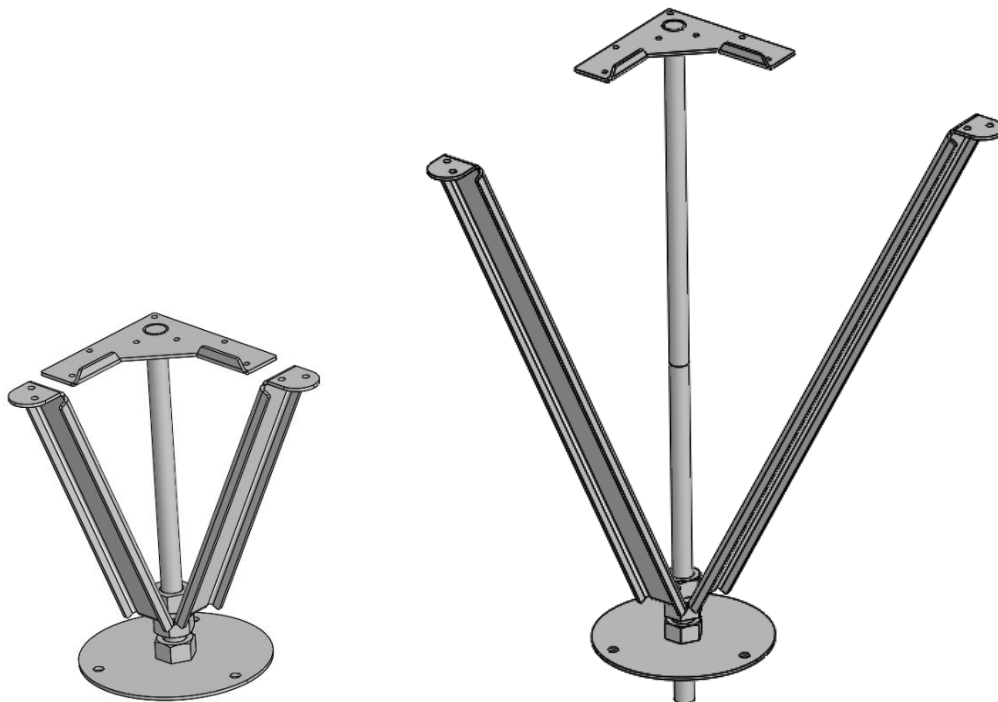




Revismo Engineering

Adjustable pile foundation structural analysis

03.06.2025

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1. General information

Project name: 1675 – Adjustable pile foundation structural analysis
Project number: 1675
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Revismo OÜ takes responsibility for the strength of the design / technical solution only if all the information in this report, general drawing(s) and general construction standards have been followed.

Under no circumstances can the loads specified in this report be exceeded.

In case of any questions regarding this report or the drawings, please contact Revismo OÜ.

Prepared: 03.06.2025 	Approved: 03.06.2025 
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2. Definitions

Base load – A realistic load without a safety margin that is used to determine the extreme load. This is the maximum load that the system should ever see at normal circumstances.

Extreme load – An exceptional load that is used in the calculation, containing necessary partial safety margins that apply for the base load. This is the maximum load that can theoretically occur at extreme circumstances.

Elastic deformation – Deformations under load that disappear after removal of the load.

Plastic deformation – Deformations under load that will not disappear after removal of the load.

Yield strength – The material property defined as the stress at which a material begins to deform plastically.

Ultimate strength – The material property defined as the stress at which a material may break.

Partial safety margin – The appropriate margin of safety that is used for a (set of) load(s).

Factor of safety – Expresses how much stronger a system is than it needs to be for a (set of) extreme load(s).

Stress – Maximum stress (MPa) at extreme load(s).

Displacement – Maximum resulting deformation at extreme load(s).

Calculating factors of safety

1. Factor of safety (yield) – Expresses how many times stronger a system is in reference to the point where plastic deformations appear at the most extreme load case.

$$\text{Factor of Safety (yield)} = \frac{\text{yield strength}}{\text{stress}}$$

3. Analysis information

Purpose of the analysis:	To calculate the strength of the feet under horizontal and vertical forces.
Software:	<i>SolidWorks Simulation Premium 2024</i>
Type of the analysis:	Linear static; Buckling
Geometry:	This report will consider the assembly of the feet.
Materials:	All steel parts – S355J2 Threaded bar – 4.8 Nuts – 8.8

Material mechanical properties:

Material	Young's modulus E (GPa)	Poisson's ratio ν	Yield strength R_e (MPa)	Ultimate tensile strength R_m (MPa)	Density ρ (kg/m ³)
S355J2 (1.0577)	210	0.3	355	470 - 630	7850
4.8	210	0.3	320	400	7850
8.8	210	0.3	640	800	7850

Table 1 – Material properties

Location of installation:	-
Surface treatment:	Zinc
Corrosion allowance:	0 mm (corrosion has not been accounted for)

4. Model

Geometry of the model is derived from the info sent by Cupella.

Since corrosion allowance has not been accounted for, model modifications to reflect corrosion have not been introduced.

Two models are used for calculations. One model is for leg height 0-300 mm and the other is for leg height 0-600 mm. Models are changed so that they would reflect the highest measurement.

Also, there are pair of feet in one calculation model. This is needed to get more precise results when applying forces.

For the analysis, the model has been added rigid block on top of the feet. This is needed to apply the forces correctly.

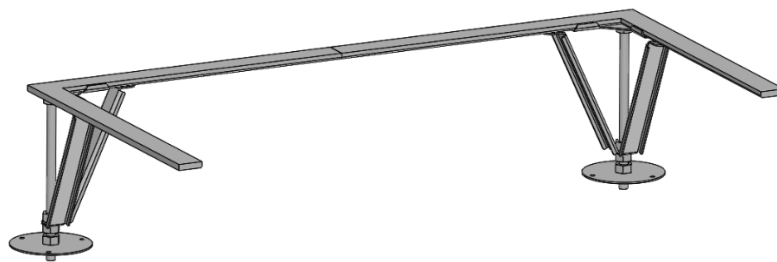


Image 1 - Calculation model A



Image 2 - Calculation model B

5. Connectors

No connectors have been assigned.

6. Interactions

Calculation A and calculation B

Interactions (1):

Type: Global *bonded*, tolerance 0.1 mm

Global bonded interactions have been assigned to all connections between threaded bar and nuts. Also between nuts and detail between them. This results in a realistic behaviour between bodies, holding different parts together.

Interactions (2):

Type: Bonded

All the screw holes are fixed to "house". Same for both calculations.

Interactions (3):

Type: Contact

All touching surfaces with "the house" are contacts. These surfaces can't move through each other but can move away from each other. Same for both calculations.

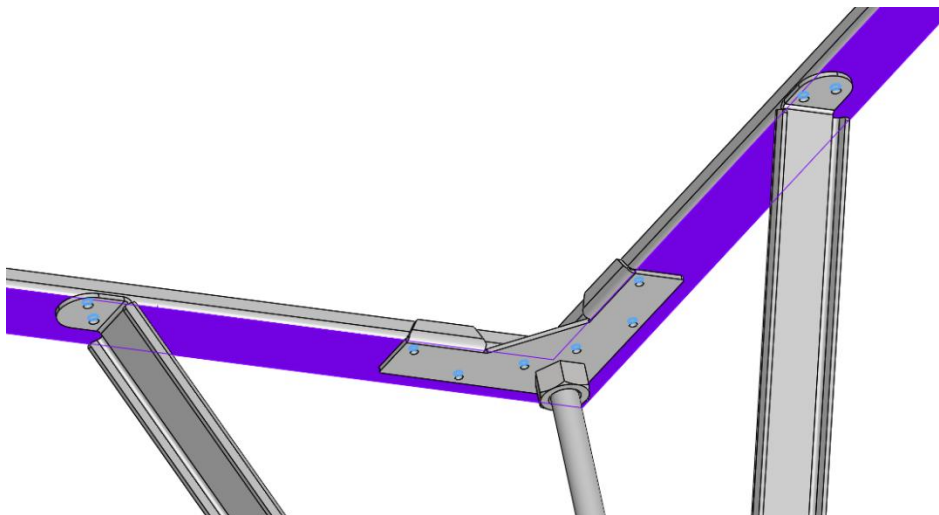


Image 3 – Interactions (2)

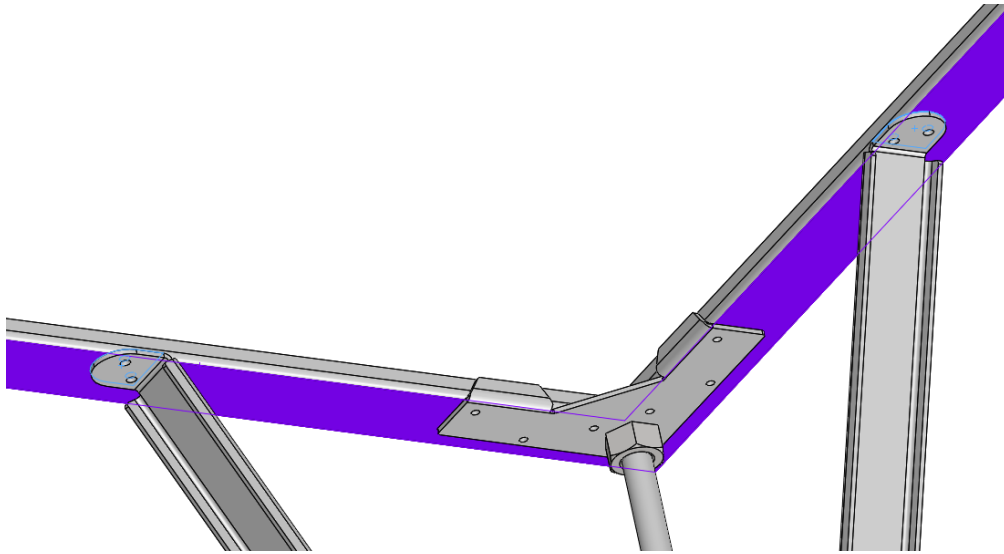


Image 4 - Interactions (3)

7. Mesh

Type: High quality solid mesh, parabolic tetrahedral
(second-order) solid elements⁽¹⁾

Configuration: Blended curvature-based mesh⁽²⁾

Calculation A

Maximum element size: 6 mm
Minimum element size: 1 mm
Number of elements: 85 163
Number of nodes: 172 395 mm

Calculation B

Maximum element size: 6 mm
Minimum element size: 1 mm
Number of elements: 124 724
Number of nodes: 252 288

(1) Parabolic elements yield better results than linear elements because they represent curved boundaries more accurately, and they produce better mathematical approximations.

(2) Automatically adapts the element size to the local curvature of the geometry to create a smooth mesh pattern. There are cases where the Blended curvature-based mesher can overcome mesh failure, generating a solid mesh with higher-quality elements (lower Jacobian and Aspect ratios) than the Standard or the Curvature-based meshers.

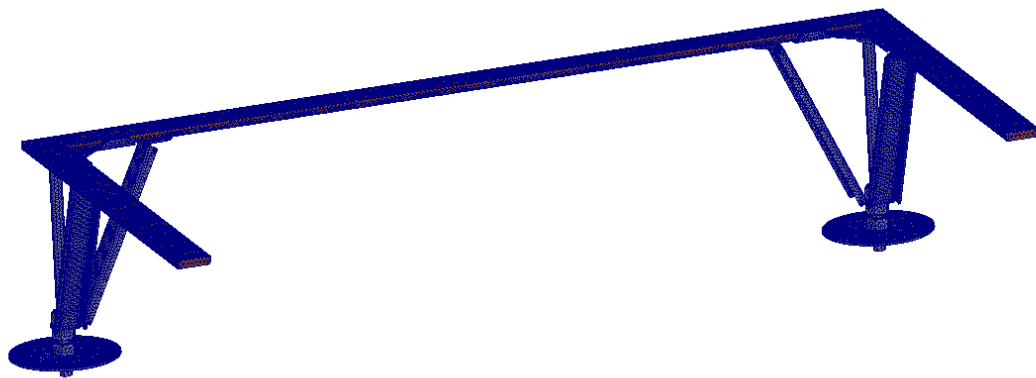


Image 5 - Meshed model - A

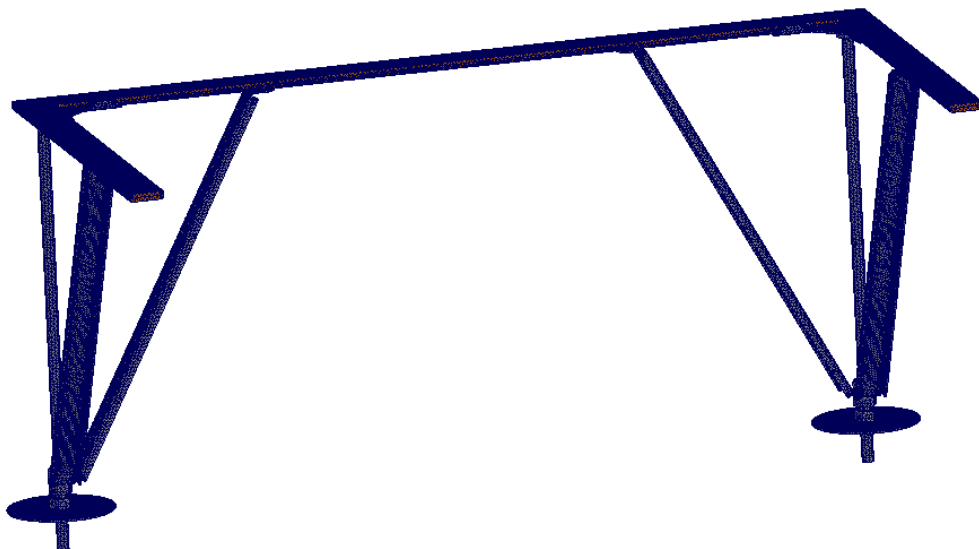


Image 6 - Meshed model - B

Aspect ratio must be under 3 for crucial areas and under 10 for rest of the construction.

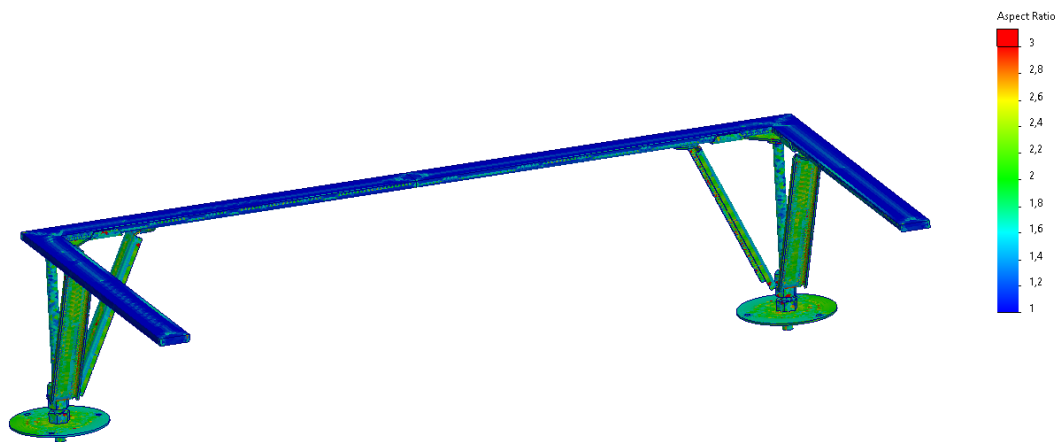


Image 7 - Aspect ratio - A

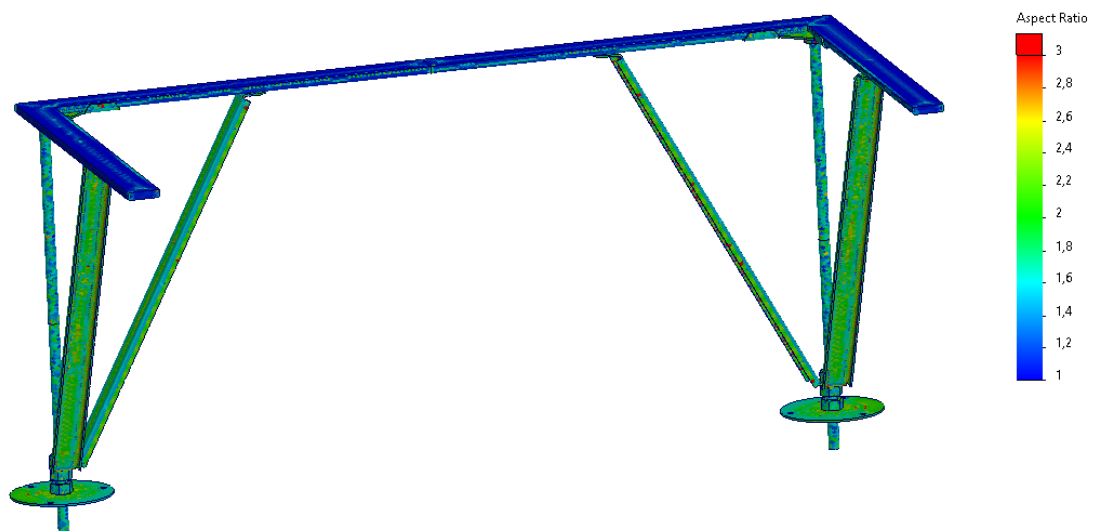


Image 8 - Aspect ratio - B

8. Loads

The analysis consists of two main load cases:

- a. Calculation A (0-300 mm) - includes self-weight loads, horizontal and vertical force
- b. Calculation B (0-600 mm) - includes self-weight loads, horizontal and vertical force

For imposed loads, the sizes are taken to achieve maximum payload while obtaining safety factor of 2 compared to yield strength. Thus partial safety margin of two is added.

Loads:

0-300 mm leg – vertical load 14 000 N (1400 kg) and horizontal load 2 800 N (280 kg).

0-600 mm leg – vertical load 8 000 N (800 kg) and horizontal load 1 600 N (160 kg).

Base loads are multiplied by two, because there are two feet in the calculations.

Calculation A (0-300)			
Load type	Base load	Partial safety margin	Extreme load
Gravity (A1)	9,81 m/s ²	2.0	19,62 m/s ²
Vertical load (A2)	28 000 N	2.0	56 000 N
Horizontal load (A3)	5 600 N	2.0	11 200 N

Table 2 – Calculation A loads

Calculation B (0-600)			
Load type	Base load	Partial safety margin	Extreme load
Gravity (B1)	9,81 m/s ²	2.0	19,62 m/s ²
Vertical load (B2)	16 000 N	2.0	32 000 N
Horizontal load (B3)	3 200 N	2.0	6 400 N

Table 3 – Calculation B loads

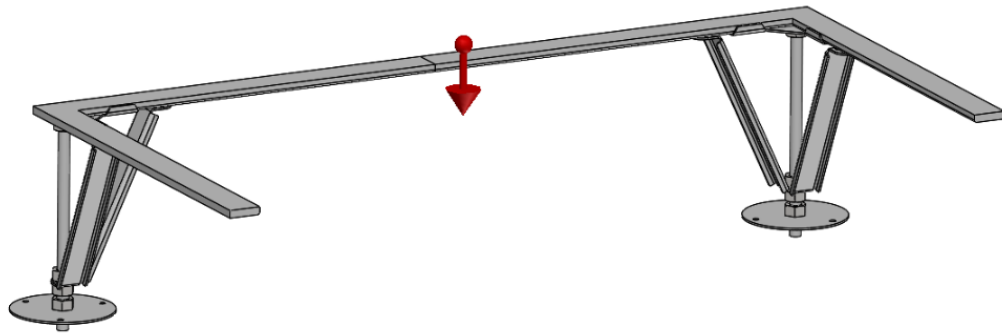


Image 9 – Load A1

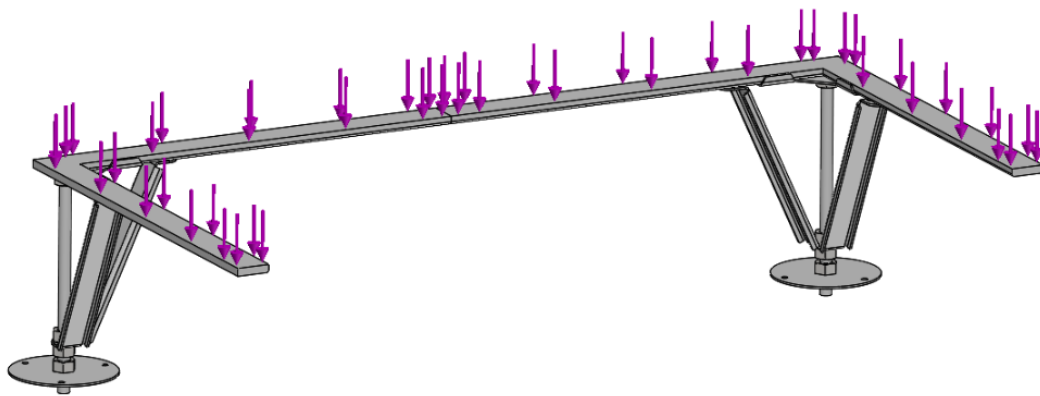


Image 10 – Load A2

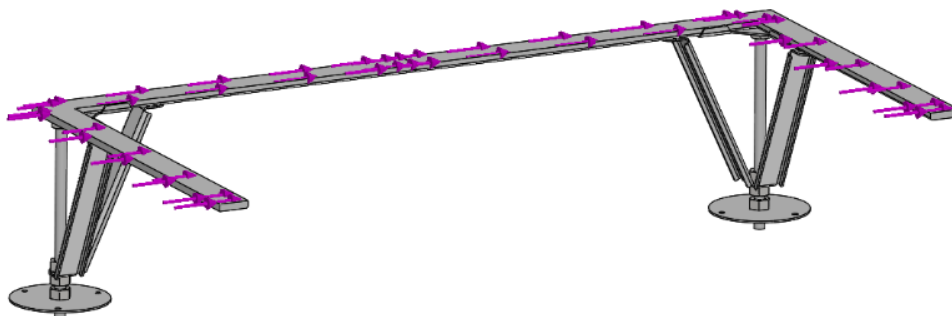


Image 11 – Load A3

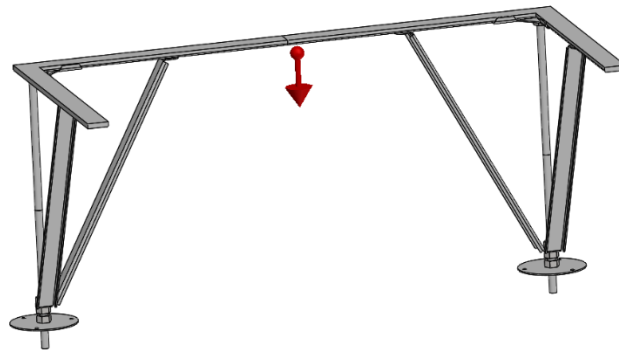


Image 12 – Load B1

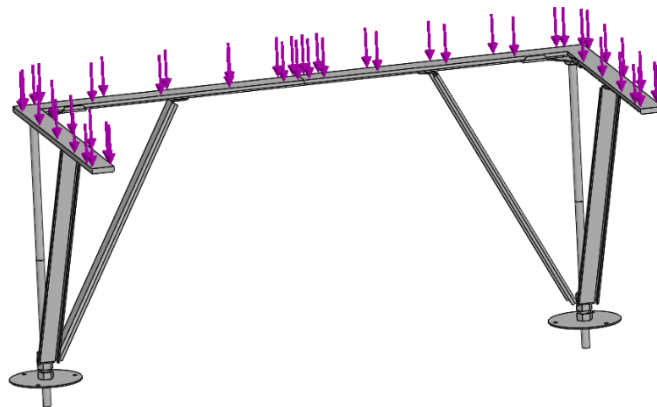


Image 13 – Load B2

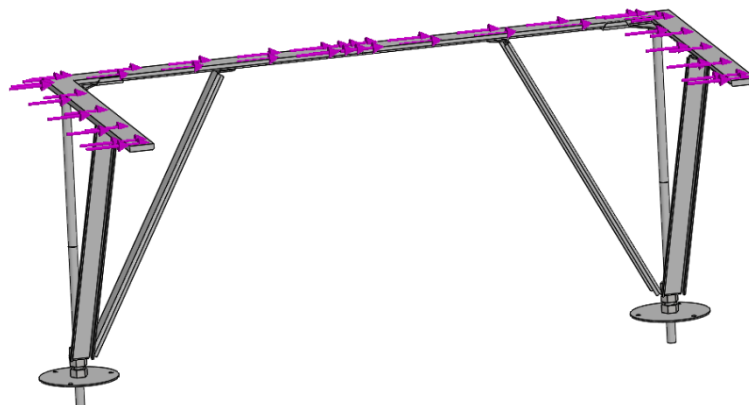


Image 14 – Load B3

9. Fixtures

Calculation A and calculation B

Fixture (1): *Type: Symmetry*

Shown surfaces are used as symmetry planes for entire assembly. Same for both calculations.

Fixture (2): *Type: Virtual wall with friction 0,4*

Virtual wall is used to simulate the ground.

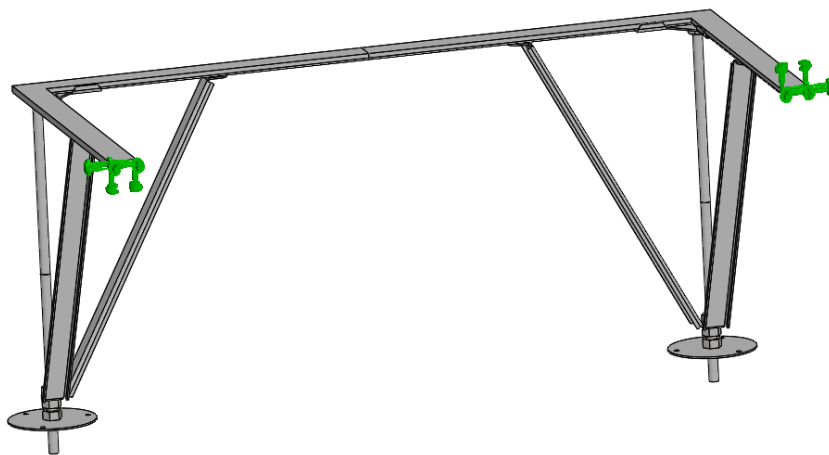


Image 15 – Fixture (1)

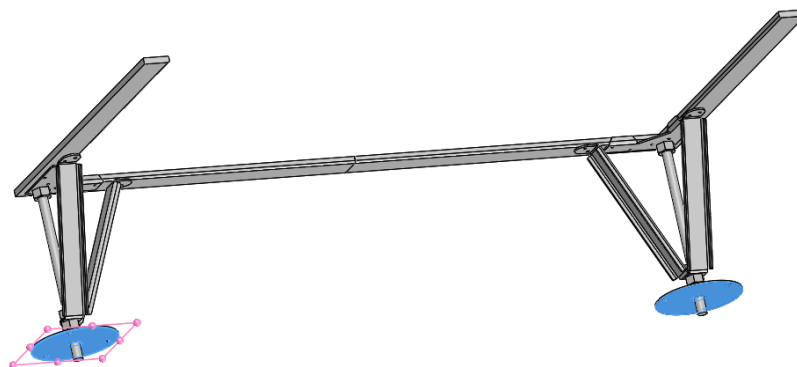


Image 16 – Fixture (2)

10.Results

Calculation A

Stress (von Mises):

Maximum von Mises stress calculated for the structure in calculation A is 355 MPa.

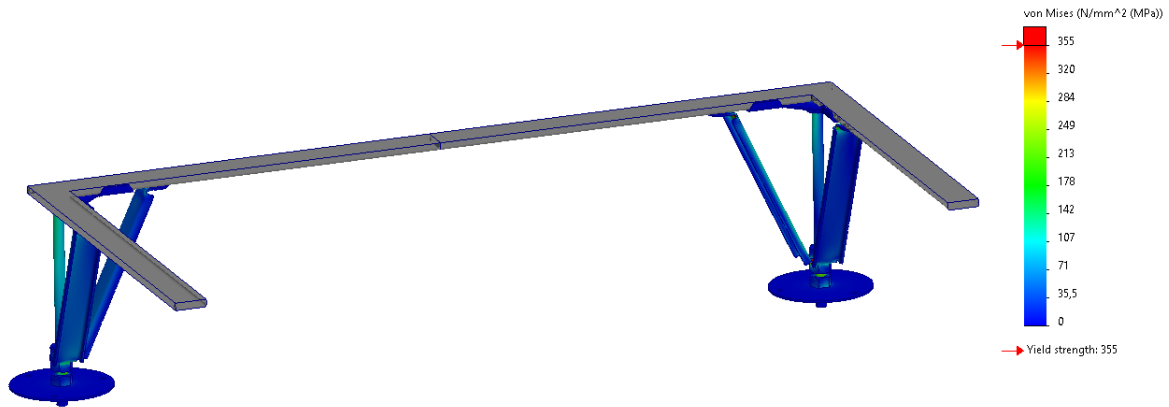


Image 17 – Calculation A von Mises stress

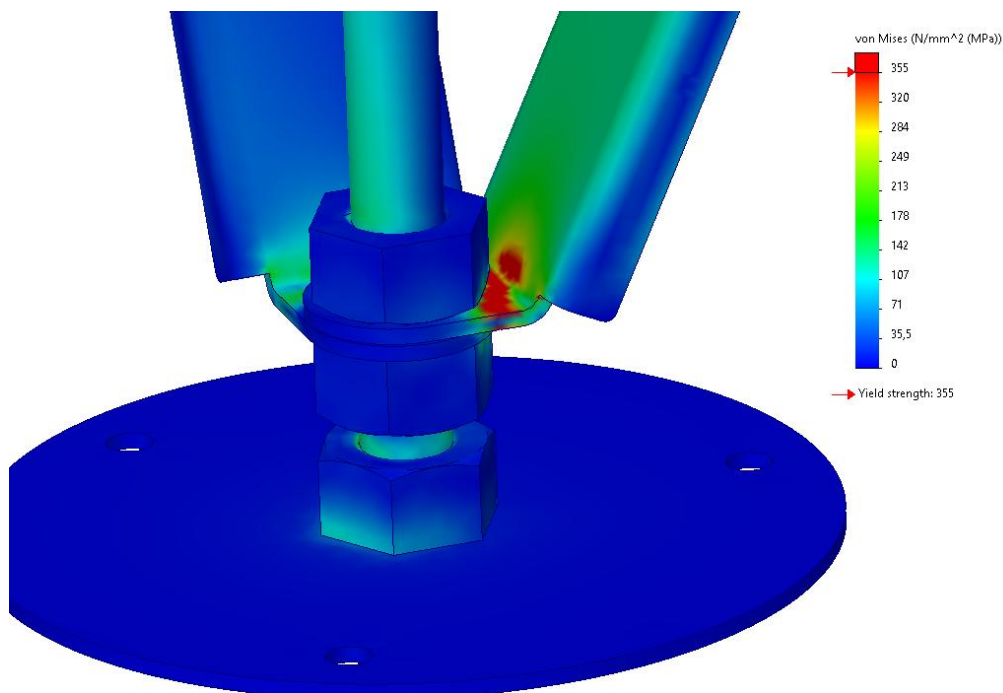


Image 18 – Calculation A von Mises stress (close-up)

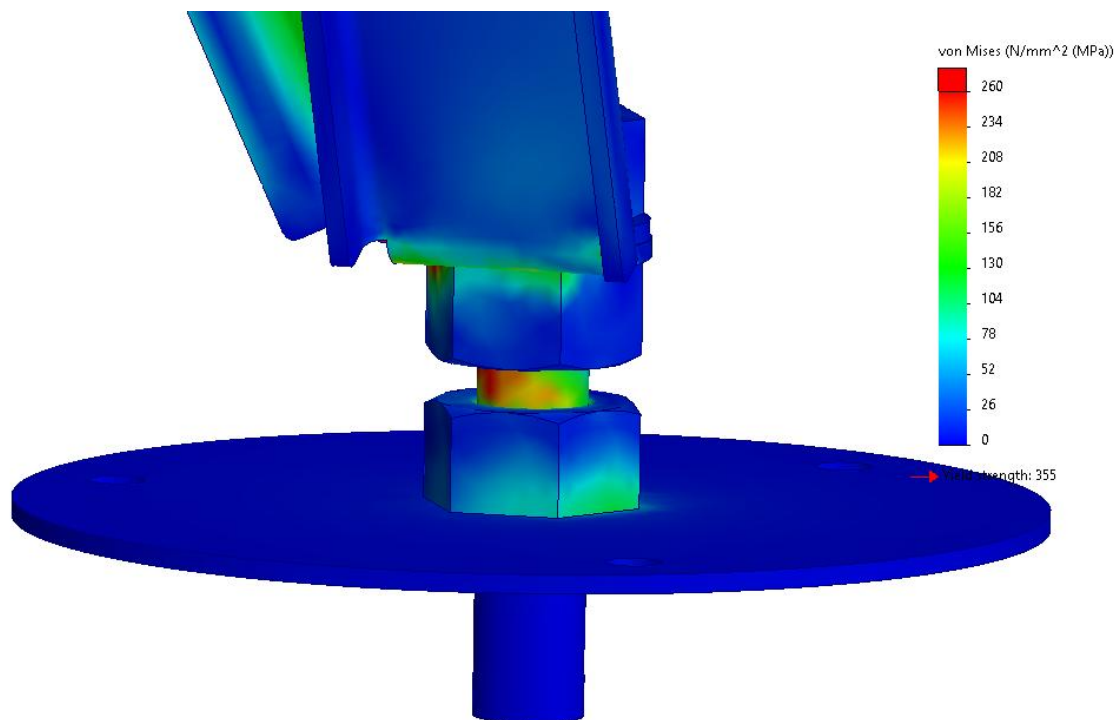


Image 19 - Calculation A von mises stress for threaded bar

Deformations: Maximum occurring displacement in calculation A is 0,54 mm.

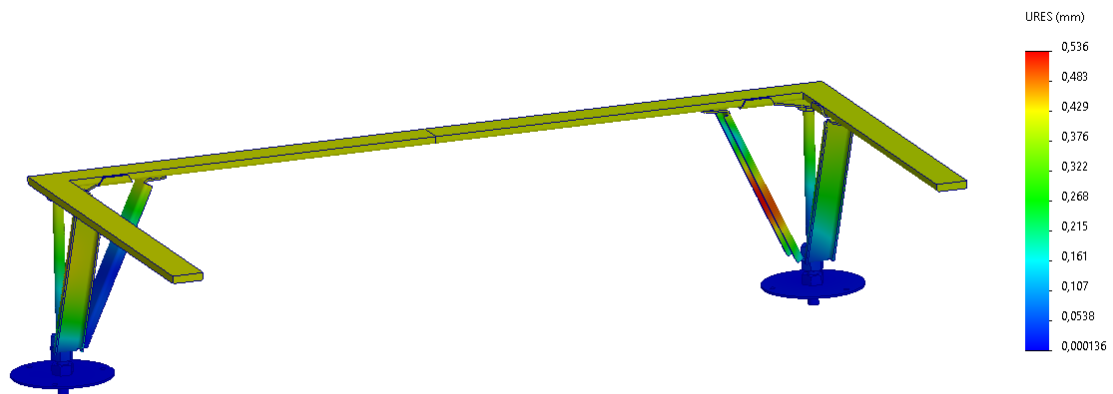


Image 20 - Calculation A displacement

Buckling:

Buckling effects have been evaluated and load factor is 5,0.

Model name: jalg_lyh
Study name: Buckling 1 (-Tald_yleval-)
Plot type: Buckling Amplitude
Mode Shape: 2 Load Factor = 4,9751
Deformation scale: 0,7,2019

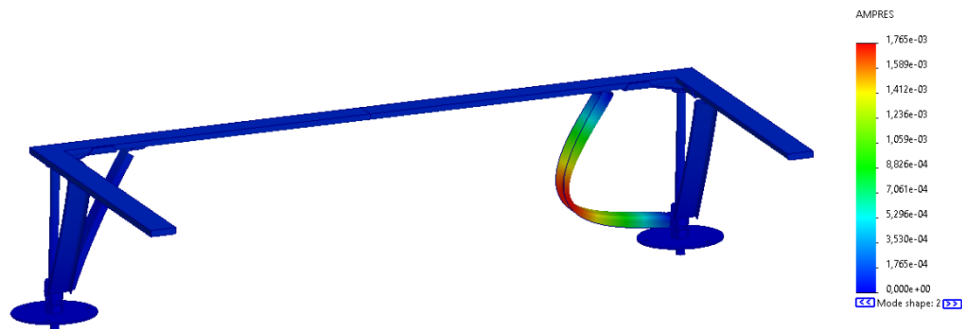


Image 21 - Calculation A - Buckling

Calculation B

Stress (von Mises):

Maximum von Mises stress calculated for the structure in calculation B is 270 MPa.



Image 22 - Calculation B von Mises stress

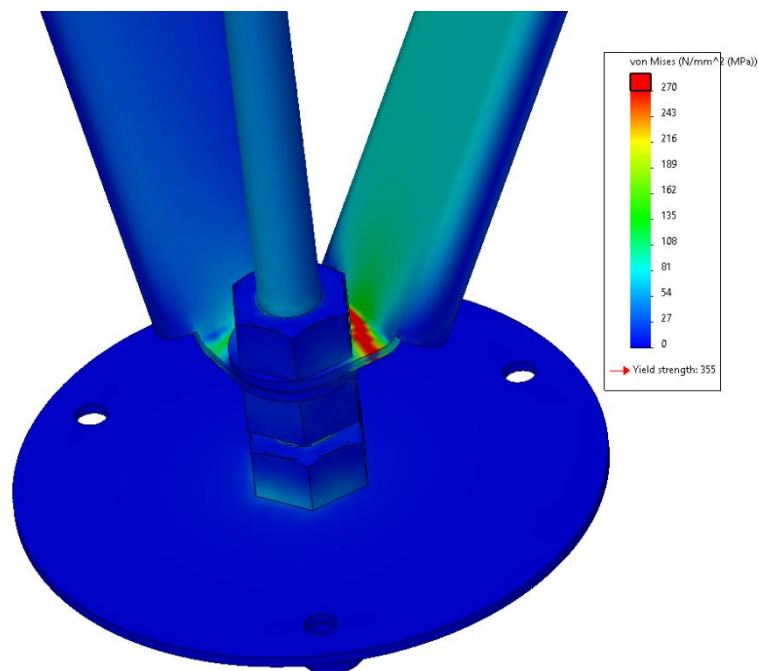


Image 23 – Calculation B von Mises stress (close-up)

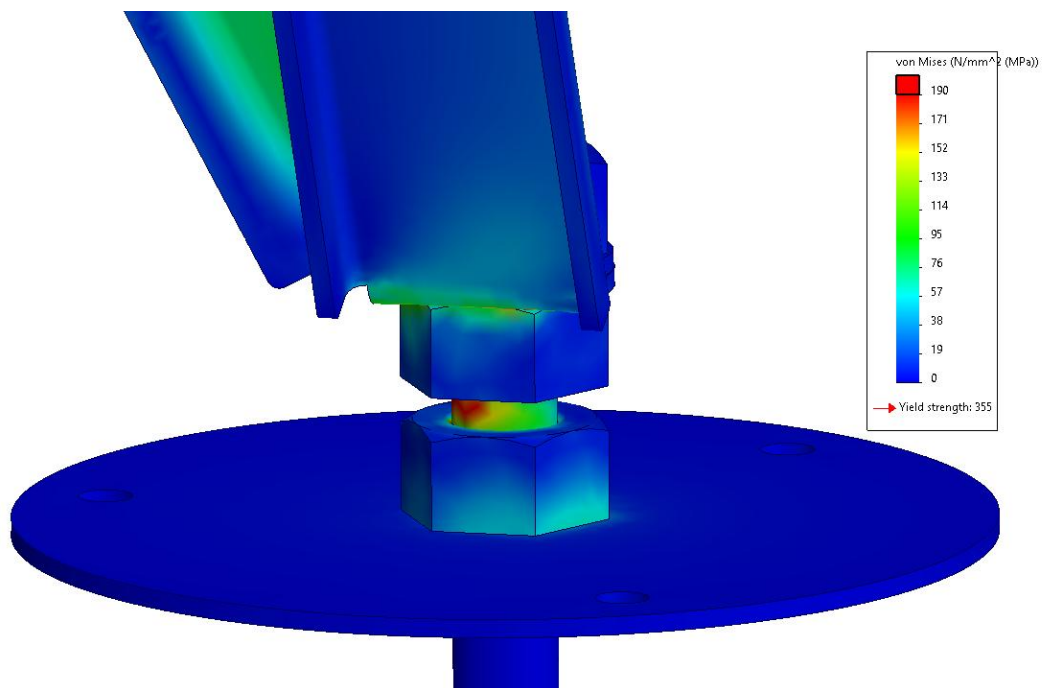


Image 24 - Calculation B von mises stress for threaded bar

Deformations: Maximum occurring displacement in calculation B is 1,41 mm.

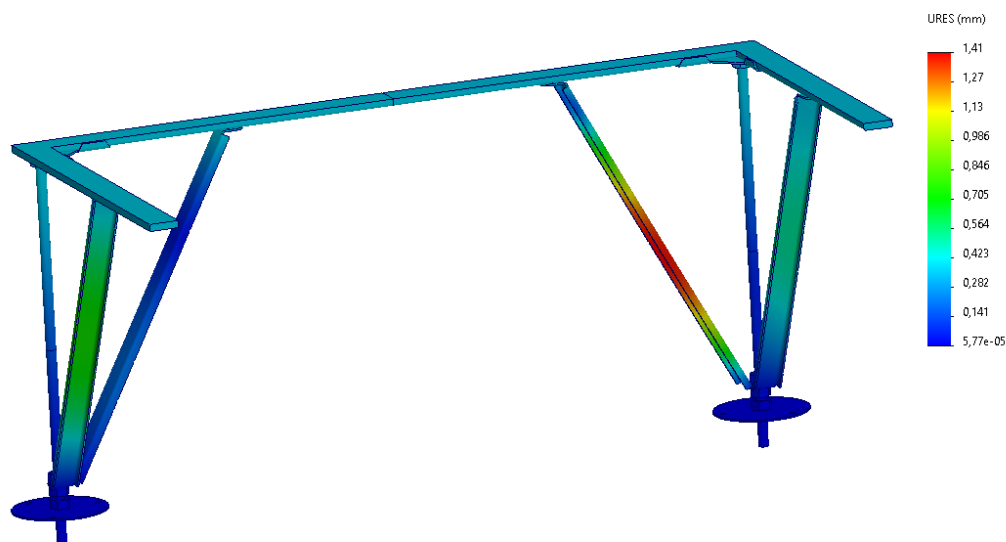


Image 25 – Calculation B displacement

Buckling: Buckling effects have been evaluated and load factor is 2,0.

Model name: jalg_pikem
Study name: ilma_rytke(-Tald_yleval-)
Plot type: Buckling mode shape
Mode Shape: 5 Load Factor = 1,9885
Deformation: 1,41 mm

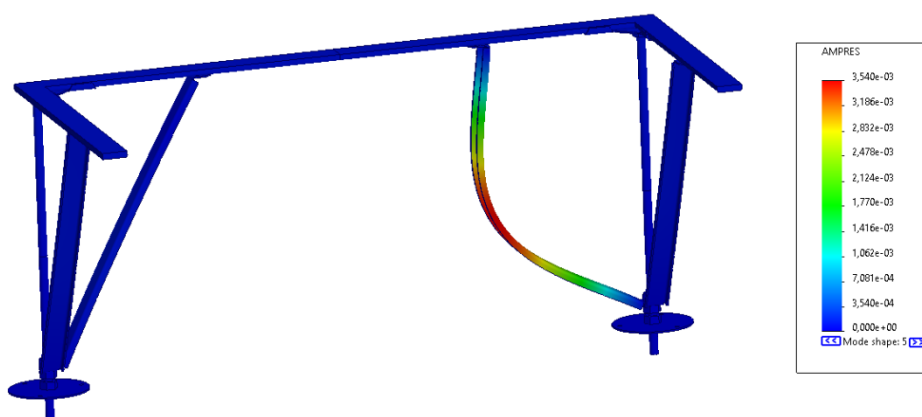


Image 26 - Calculation B - Buckling

11. Conclusions and general drawing(s)

All factors of safety must exceed 1 in order to comply with the strength sufficiency criteria.

For buckling, factor of safety must exceed 2 in order to comply with recommended load factor. Recommended load factor is over 4, but we have already raised nominal loads with partial safety margin of 2. Thus safety factor of 2 is needed.

Calculated Factor of Safety:

$$\text{Calculation A (sheet metal parts) Factor of safety (yield)} = \frac{355}{355} = 1,00 \geq 1$$

$$\text{Calculation A (threaded bar) Factor of safety (yield)} = \frac{320}{260} = 1,23 \geq 1$$

$$\text{Calculation A (buckling) Factor of safety} = 5,0 \geq 2$$

$$\text{Calculation B (sheet metal parts) Factor of safety (yield)} = \frac{355}{270} = 1,31 \geq 1$$

$$\text{Calculation B (threaded bar) Factor of safety (yield)} = \frac{320}{190} = 1,68 \geq 1$$

$$\text{Calculation B (buckling) Factor of safety} = 2,0 \geq 2$$

All resulting deformations occur in the zone of elastic deformation of steel, thus no critical stresses occur at given loads and conditions.

Results show stresses and displacements during extreme load cases where a safety margin has already been accounted for.

Under no circumstances can the base loads specified in Tables 2 and 3 be exceeded.