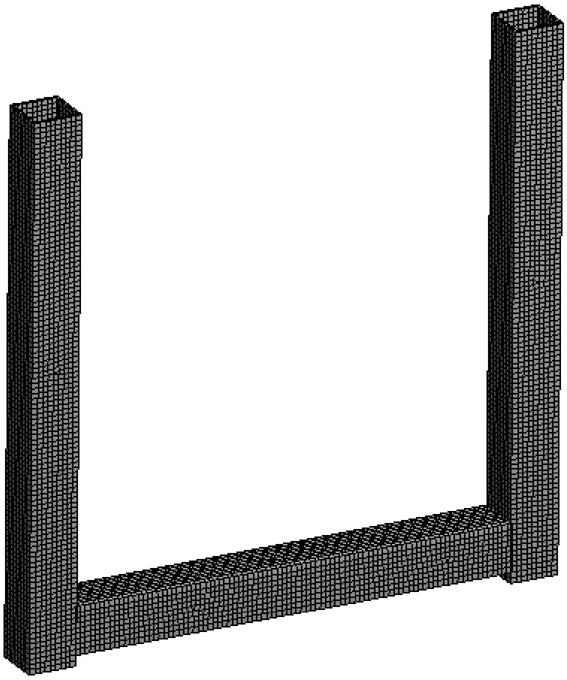
A-INSINÖÖRIT

Stalatube Oy

Mass comparison of pipe support brackets



Calculation report

7.8.2017

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Calculation report

In this calculation report, a comparison of two pipe support brackets made from different materials is presented. The used materials are the austenitic steel EN 1.4404 and the Duplex steel EDX2304 (EN 1.4362).

The support brackets were loaded with a force applied to the middle of the bracket. The magnitude of the force was increased until the plastic capacity of the bracket was reached.

The analysis was done with ANSYS Mechanical R17.1 FEM program.

Joonas Ahopelto

1 The capacity of the EN 1.4404 support bracket

1.1 Geometry and materials

A 100x100x6 tube was used in the geometry of the bracket.

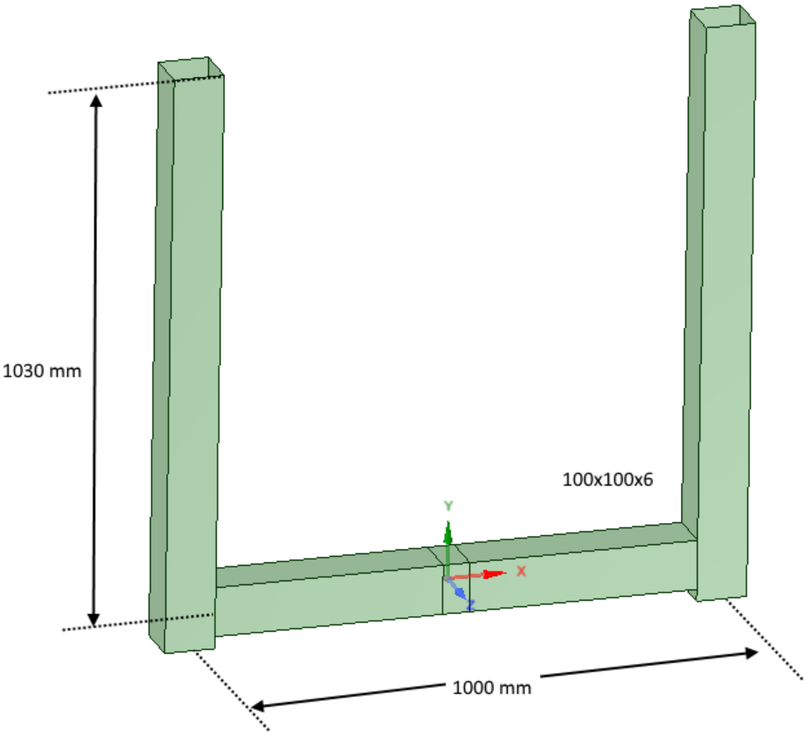
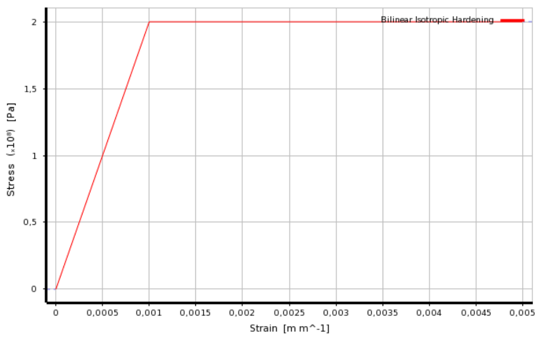


Figure 1. Used geometry.

A nonlinear material model of the EN 1.4404 was used in the analysis.
Yield strength 220 MPa was given as initial data. The partial design safety factor of the material 1.1 (SFS EN 1993-1-4), was taken into account by lowering the yield strength.

- E = 200 GPa
- ν = 0.3
- f_y = 200 MPa
- E_t = 0.5 MPa
- ρ = 8000 kg/m^3



1.2 Meshing

The model is meshed with the quadratic 8-node shell element.

Statistics	
Nodes	33235
Elements	11057

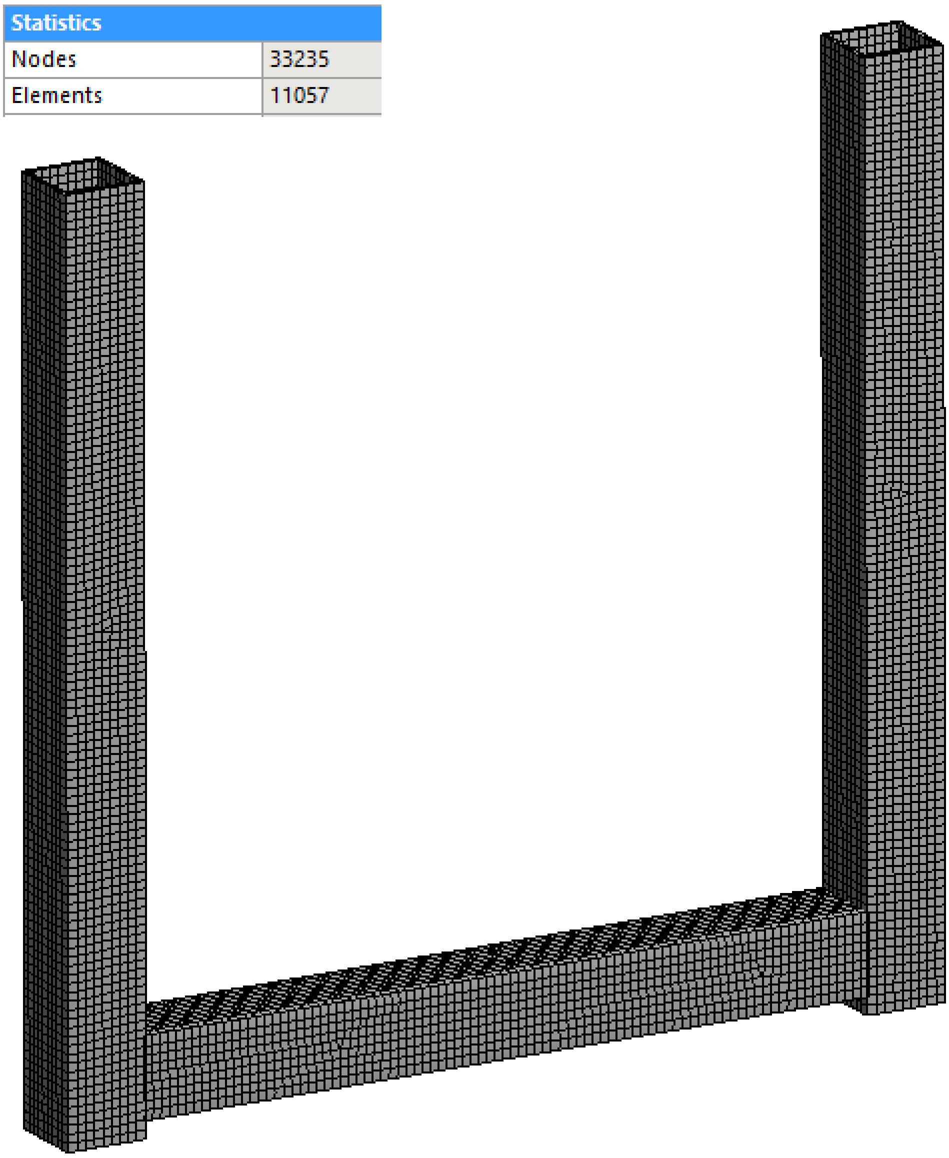


Figure 2. Meshing.

1.3 Loads and boundary conditions

The support bracket was loaded from the edges in the middle of the horizontal tube. The magnitude of the load was increased until the capacity of the structure was reached. The value t = 1 of the relative time (load) corresponds to a load of 1 kN.

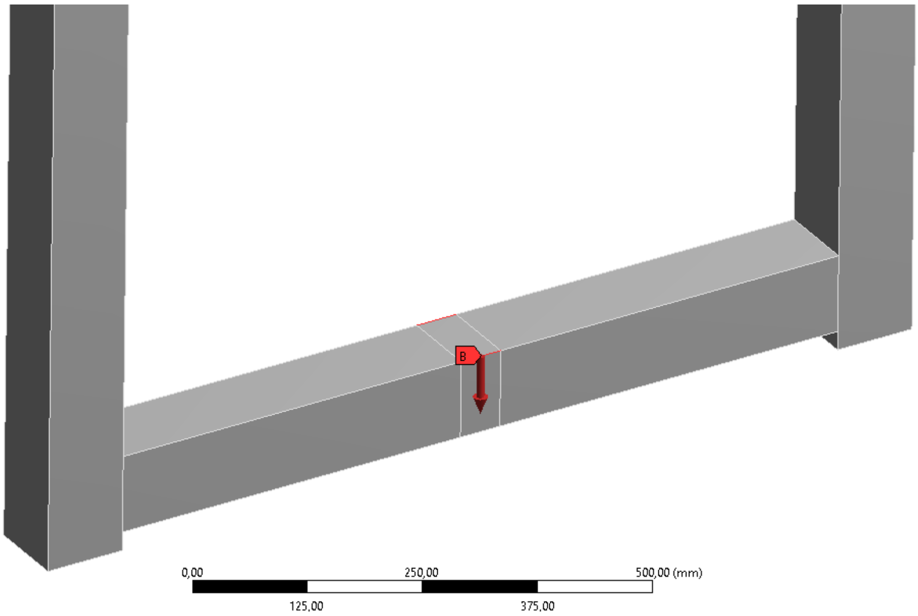


Figure 3. The load.

The bracket was supported from the top of one vertical tube with a fixed support and the vertical displacement (y-direction) of the top of another vertical tube was set to zero.

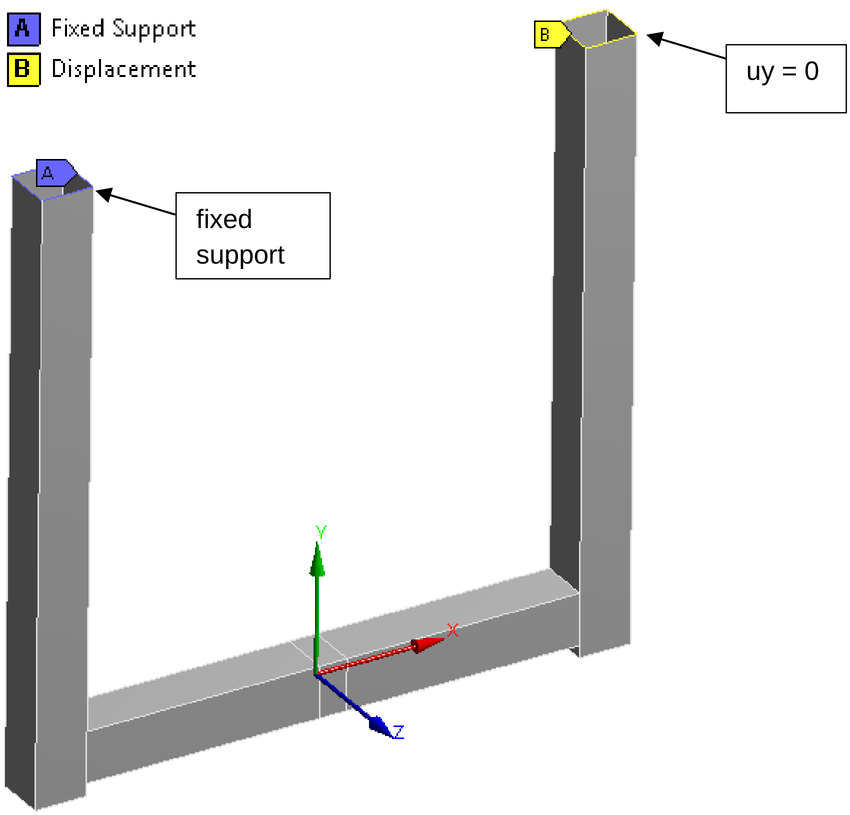


Figure 4. The boundary conditions.

1.4 Results

The fracture mechanism of the bracket can be seen from the displacement figure of the bracket shown below. The displacements begin to increase fast after a load of ca. 124 kN and a similar fast increasing of the plastic strain begins around 90 kN of load.

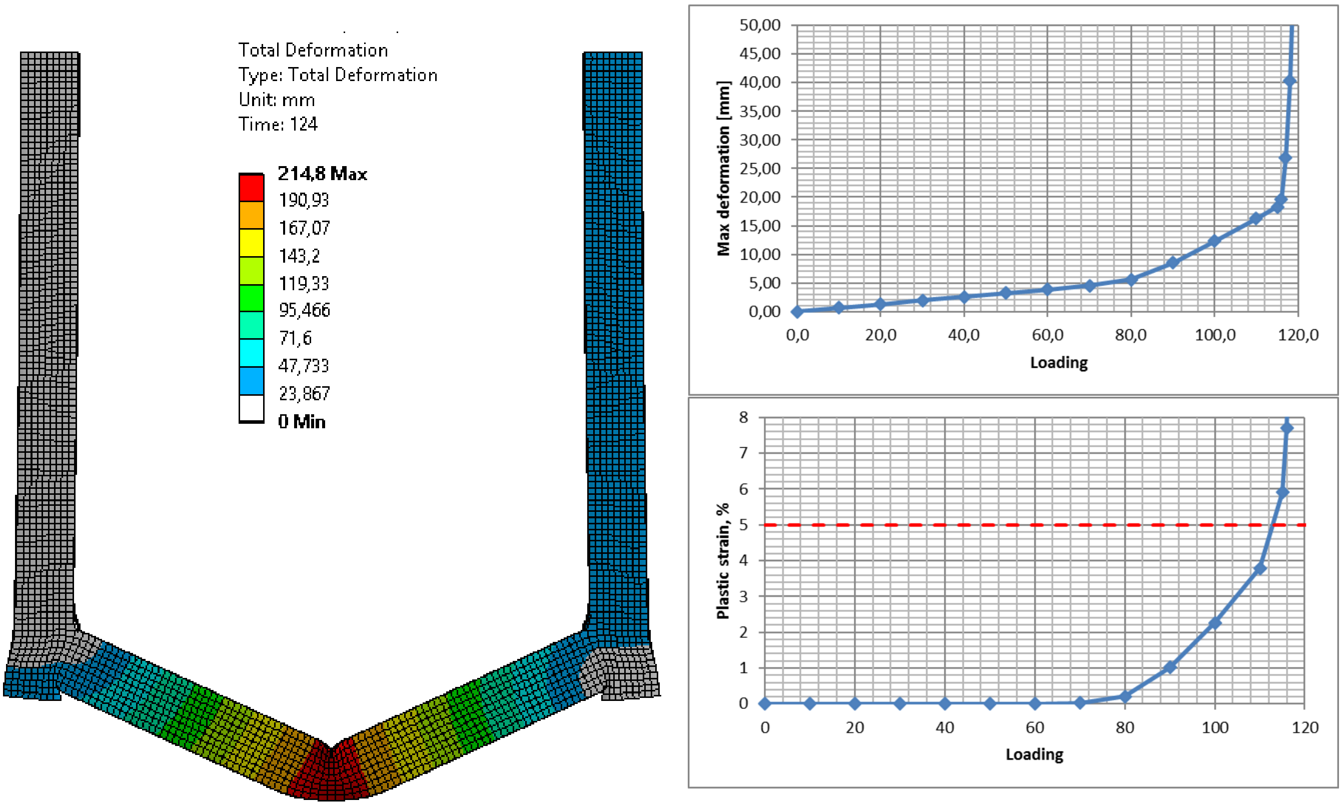


Figure 5. The displacements with a 124 kN load and the response of the displacement and the plastic strain as the function of the load.

2 The new profile of the EDX2304 bracket with the ultimate load of the previous analysis

2.1 Geometry and materials

An 86x86x4 tube was used with the EDX2304. The length of the lower tube and the distance from the upper surface of the horizontal tube to the supports above remained the same as in the previous analysis.

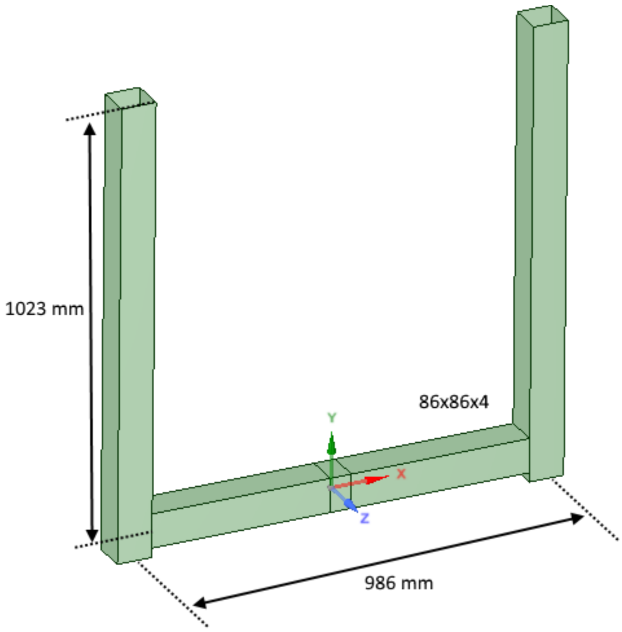
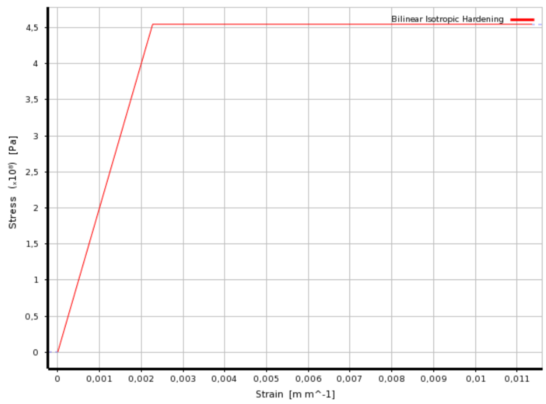


Figure 6. Used geometry.

The used material was EDX2304 Duplex (EN 1.4362) with a yield strength of 500 MPa (given as an initial data). The partial design safety factor of the material, 1.1 was taken into account by lowering the yield strength. The parameters of the nonlinear material model were

- E = 200 GPa.
- v = 0.3
- f_y = 454.5 MPa
- E_t = 0.5 MPa
- ρ = 7800 kg/m^3



2.2 Meshing

The model is meshed with the quadratic 8-node shell element.

Statistics	
Nodes	36121
Elements	12019

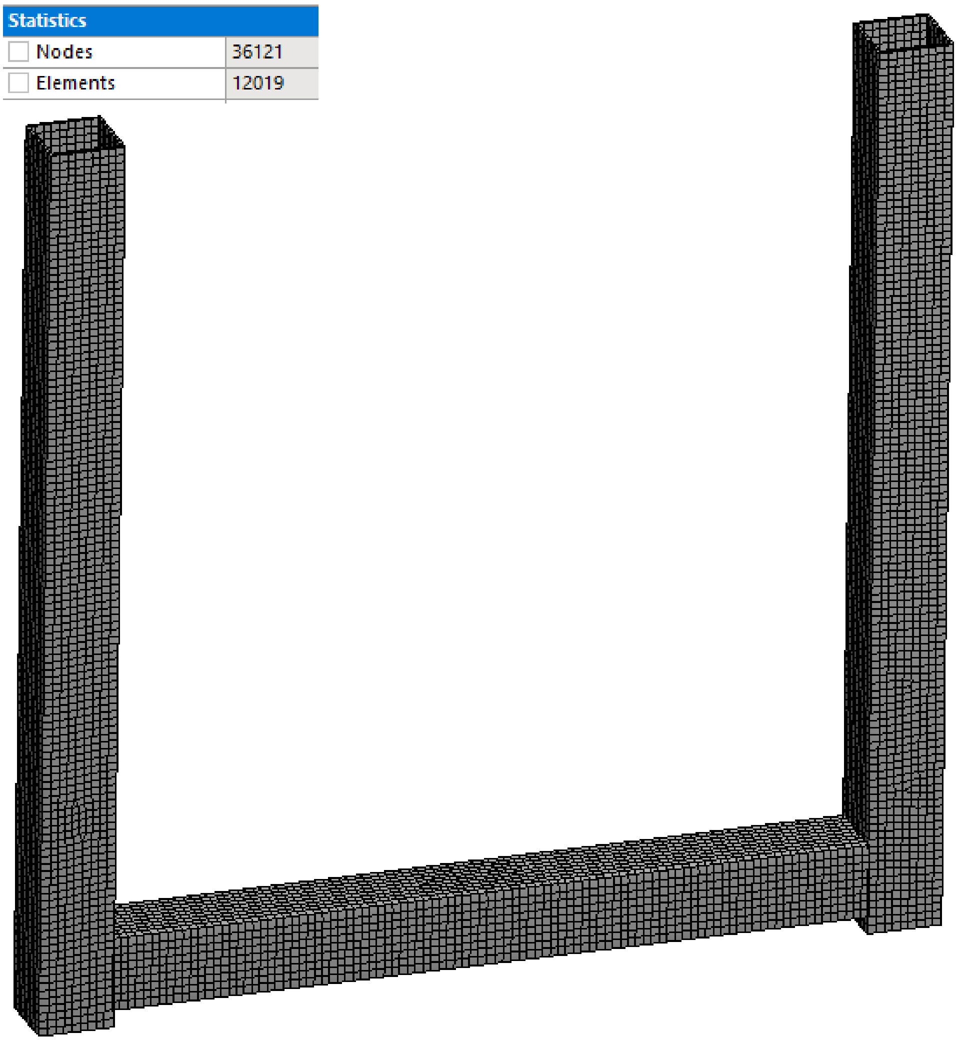


Figure 7. Meshing.

2.3 Loads and boundary conditions

The load and the boundary conditions are the same as in the previous analysis.

2.4 Results

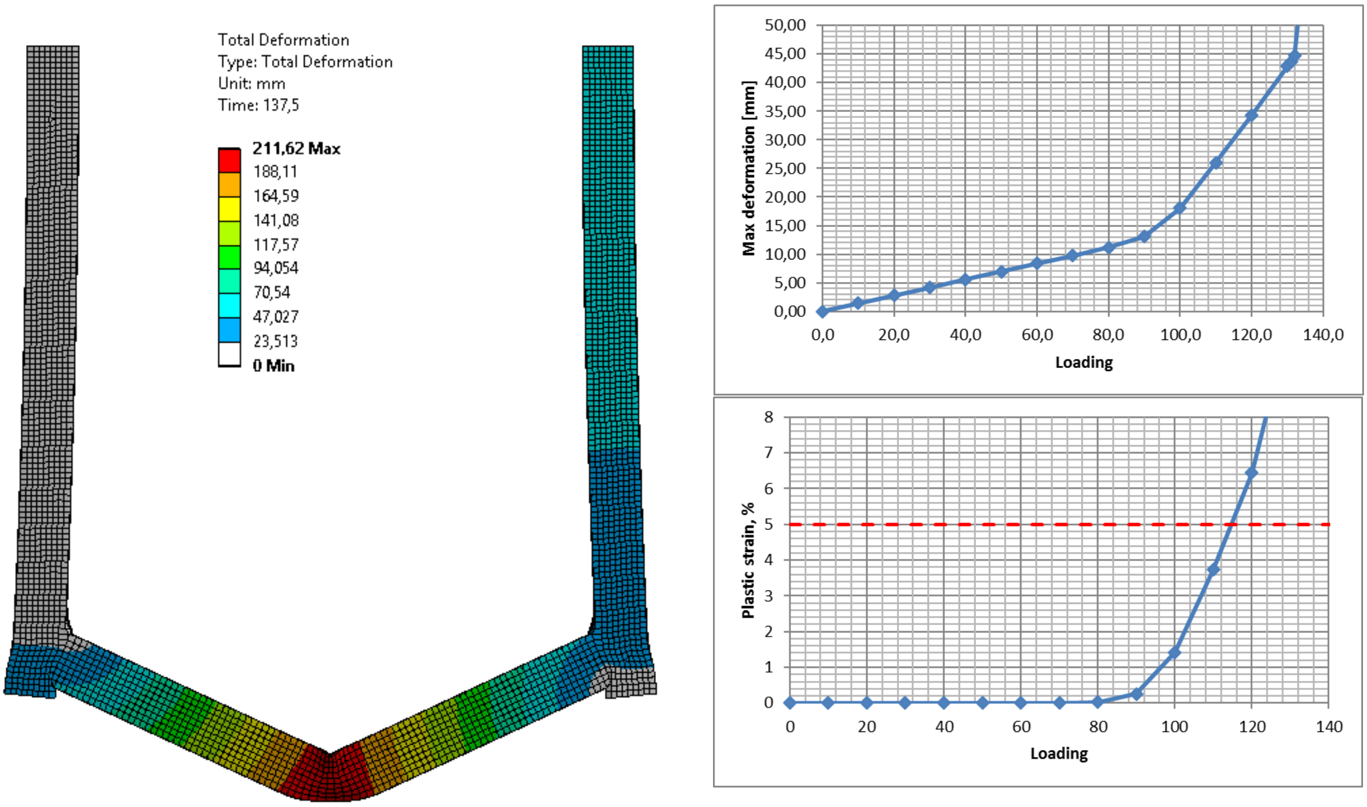
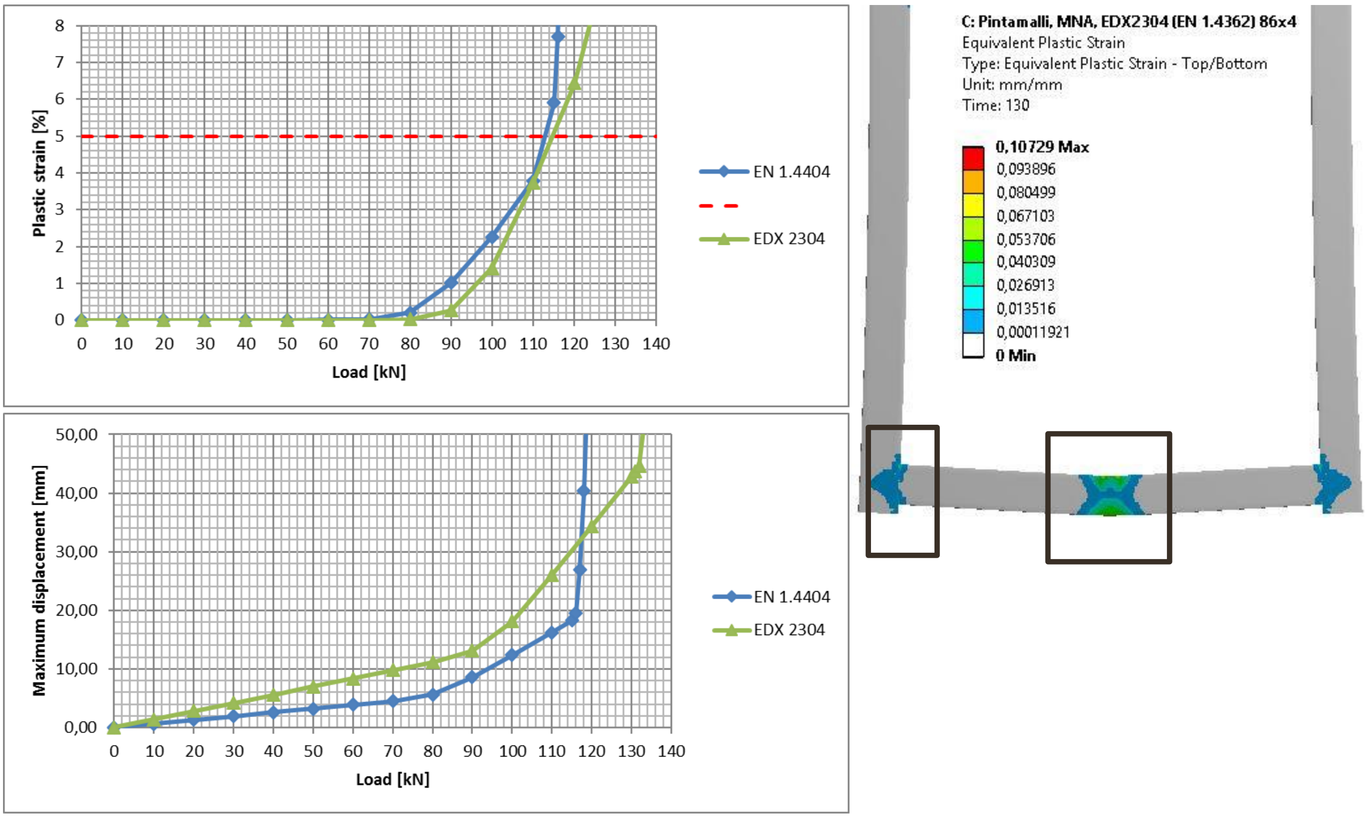


Figure 8. The displacement with a load of 137.5 kN to show the fracture mechanic of the structure. On the right the response of the displacement and plastic strain as a function of the load are shown.

3 Summary, comparison

The response of the plastic strain and displacement for both austenitic EN 1.4404 and Duplex EDX 2304 steels were plotted in the same graph and are shown below. The displacements of the Duplex support bracket increase faster than the displacements of the austenitic bracket because of the smaller cross section until the capacity of the austenitic bracket is reached. The plastic strain increases slower with the EDX 2304 bracket than with the EN 1.4404 bracket. Based on the results, the 86x86x4 Duplex support bracket can take at least the same amount of load than the austenitic 100x100x6 bracket.



Kuva 1. Austeniittisen ja Duplexista tehdyn kannakkeen plastisen venymän ja siirtymän vasteet.

The mass of the EN 1.4404 bracket is 56.057 kg and the mass of the EDX 2304 bracket is 31.479. It means that *by using the Duplex EDX 2304 instead of the austenitic EN 1.4404, a 43.84 % of save in weight can be obtained in this example case when the displacements are not restricted and the response curve of the plastic strain of the Duplex bracket must be at least as good as with the austenitic steel.*

If it's allowed that the plastic deformation of the Duplex bracket increases faster than the plastic deformation of the austenitic bracket, and only the ultimate load of the brackets is considered, ca. 15 % of extra capacity can be obtained for the Duplex bracket. This extra capacity can clearly be seen from the end part of the displacement graph, where the displacement of the austenitic bracket starts to increase almost vertically (the ultimate load is reached) before the corresponding fast increase of displacement of the Duplex bracket. Also the analytical examination of the cross sections gives the same result.

Maximum load analytically

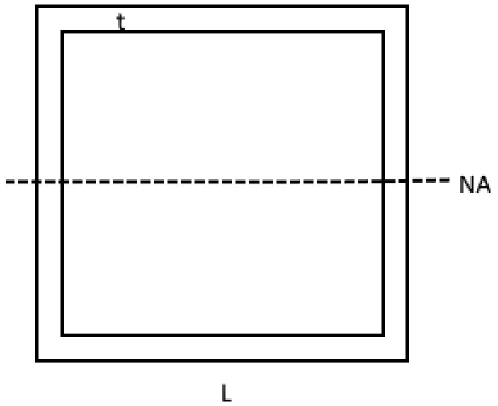
Plastic bending resistance, EN 1.4404

$L := 100mm \qquad t := 6mm$

$W_{pl} := 2 \cdot L \cdot t \cdot 0.5 \cdot (L - t) + 4 \cdot (0.5L - t) \cdot t \cdot 0.5(0.5 \cdot L - t) = 7.963 \times 10^{4} \cdot mm^{3}$

$f_y := 200MPa$

$M_{pl.Rd.1} := W_{pl} \cdot f_y = 15.926 \cdot kN \cdot m$



Plastic bending resistance, EDX 2304

$L := 86mm \qquad t := 4mm$

$W_{pl} := 2 \cdot L \cdot t \cdot 0.5 \cdot (L - t) + 4 \cdot (0.5L - t) \cdot t \cdot 0.5(0.5 \cdot L - t) = 4.038 \times 10^{4} \cdot mm^{3}$

$f_y := 454.5MPa$

$M_{pl.Rd.2} := W_{pl} \cdot f_y = 18.351 \cdot kN \cdot m$

$$\boxed{\frac{M_{pl.Rd.2}}{M_{pl.Rd.1}} = 1.152}$$