

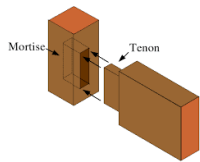
Introduction

During the semester 6 project at the HAN, where the students tasked to do some individual side research. The subject of the research needed to help the semester 6 project directly or help the upcoming project at the circular lab.

For this research option B, help the upcoming projects at the circular lab, was chosen. The research could have helped the semester 6 project, if it was done prior to the start. The research is to determine the effect of different forces on different joinery's compared to each other. This would help further projects choose joinery's quicker and more easily, due to having more information on them.

A joinery is an non-permanent connection using only the shapes of the joint parts and friction. For this research the choice has been made make the connecting parts beams, this due to a early concept from the semester 6 project. The joinery's tested are:

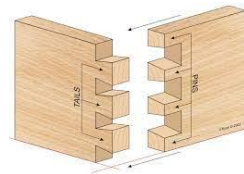
Mortise and tenon



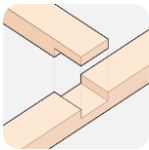
Dowel



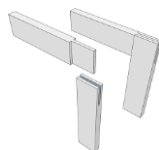
Dovetail



Cross lap



Bridle



Methodology

To determine the effect of different forces on different joinery's compared to each other, multiple simulations were made. Because simulating the joinery's would take less time than physically making them. For the simulations the programme Solidworks was used, because within this programme assemblies can be simulated.

To start an simulation firstly the assemblies had to be made (seen in appendix A). Each assembly consists of a fixed beam, an lose beam and sometimes an connection piece. Between each beam an gap of 1mm gap was placed, with only the joinery section bridging this gap, due to the assembly otherwise counting as a solid brick. The intersection area of the bridging joinery has made the same, so that the joinery's could be compared.

Afterwards the simulation settings have to be set. For the mesh size, 2mm was chosen, due to crashes with a smaller size. Four types of forces where set, one per simulation: on the end in the y axis, on the end in the x axis, on the side a shared force in the y axis and on the side a shared force in the x axis. The x and y axis to determine if the orientation of the joinery mattered and the force on the end and shared force to determine if the location of the force mattered. All the forces where set to 100 newton.

Lastly the material was chosen. The chosen material is PS Medium/High Flow (material properties can be seen in appendix B). This has been chosen due to being easily recyclable and in abundant for use at the circular lab.

Results

The results of the simulation (seen in appendix C, the simulations themselves can be seen in appendix D) show that there is a direct correlation between the effect of the force on the end and the shared force in the same direction, the force on the end having a twice as large effect. Therefore for the comparison the shared force will be left out. The same can be said for the displacement.

So taking all that in consideration, the test results concludes that with from these joinery's:

- The Dowel is the overall best. Due to the lowest stress in both directions.
- The Dovetail and bridle joinery's are second in one direction but third in the other.
- Mortise and tenon is equal in both directions second in one and third in the other
- The Cross lap joint is the overall worst in all directions

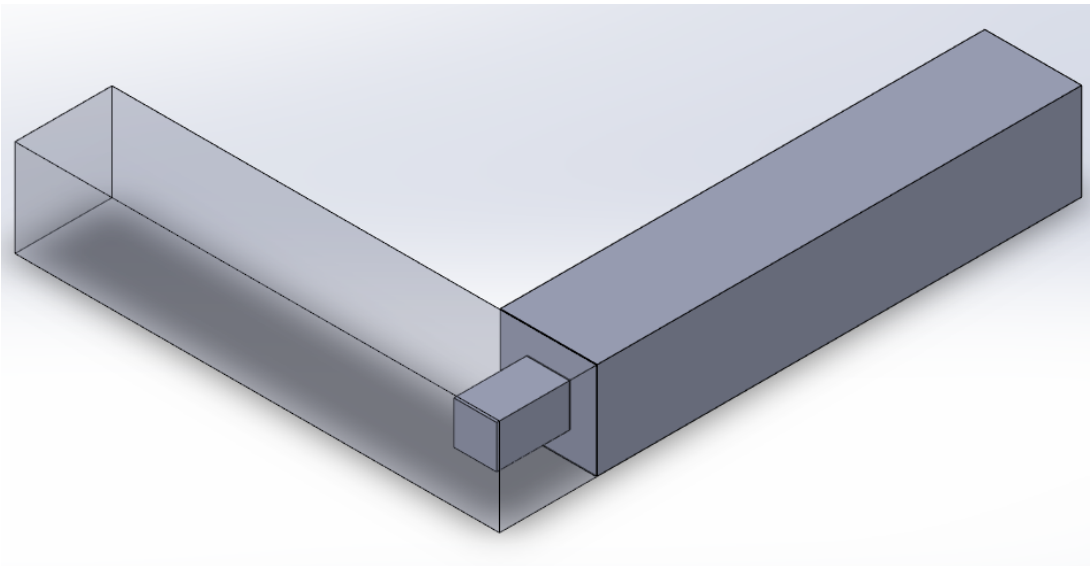
Advise

As seen in the results, the Dowel joint is the overall the best. However due to taking up a lot of space, make that the Dowel and Dovetail joinery's are difficult to improve. The lesser joinery's, the Bridle, Mortise and tenon and Cross lap joinery's, are much easier to improve, because they take up a lot less space. This due to making the intersection area within the 1mm gap equal to each other.

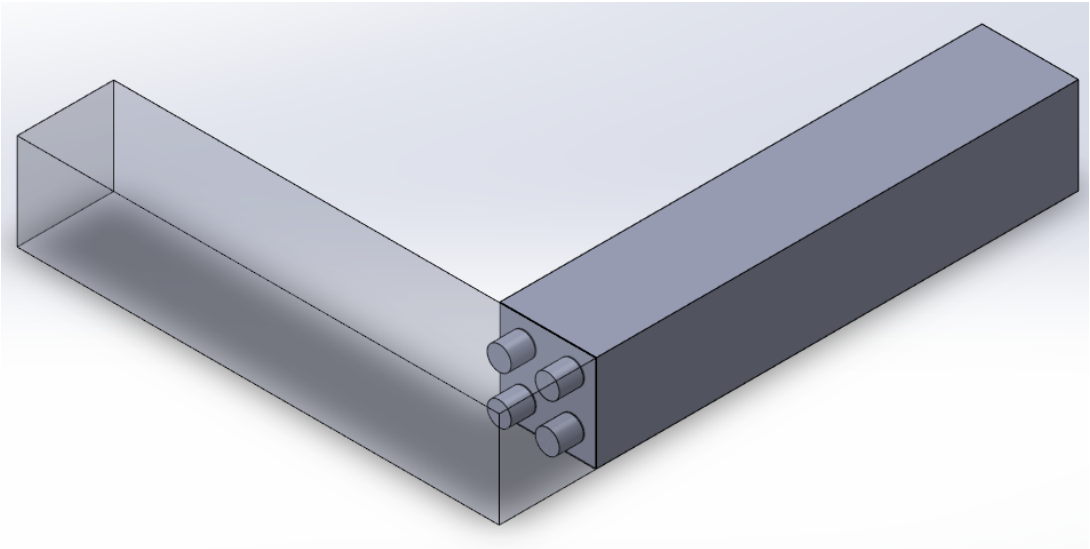
Try to make a perfect connection. The 1mm gap is chosen to make the simulation less perfect. In reality you want to make the gap as small as possible so that the joinery counts as a single piece.

Each joinery has its place. Due to the fact that each joinery slots different together, makes that they all have different strength and weaknesses. For example the dowel joint is weaker when pulled (a force in the z axis) on than the Cross lap joint.

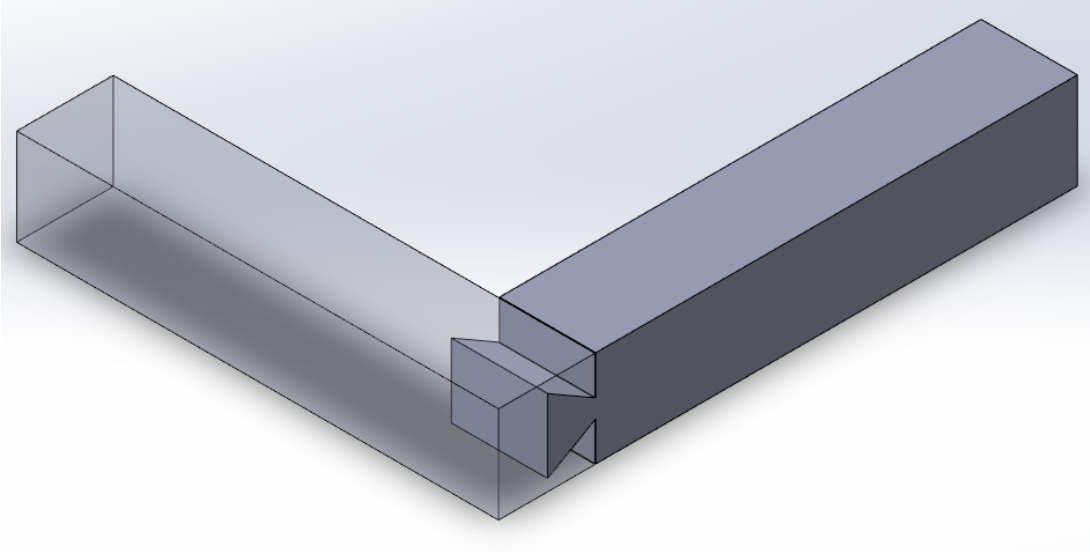
Appendix A the joinery



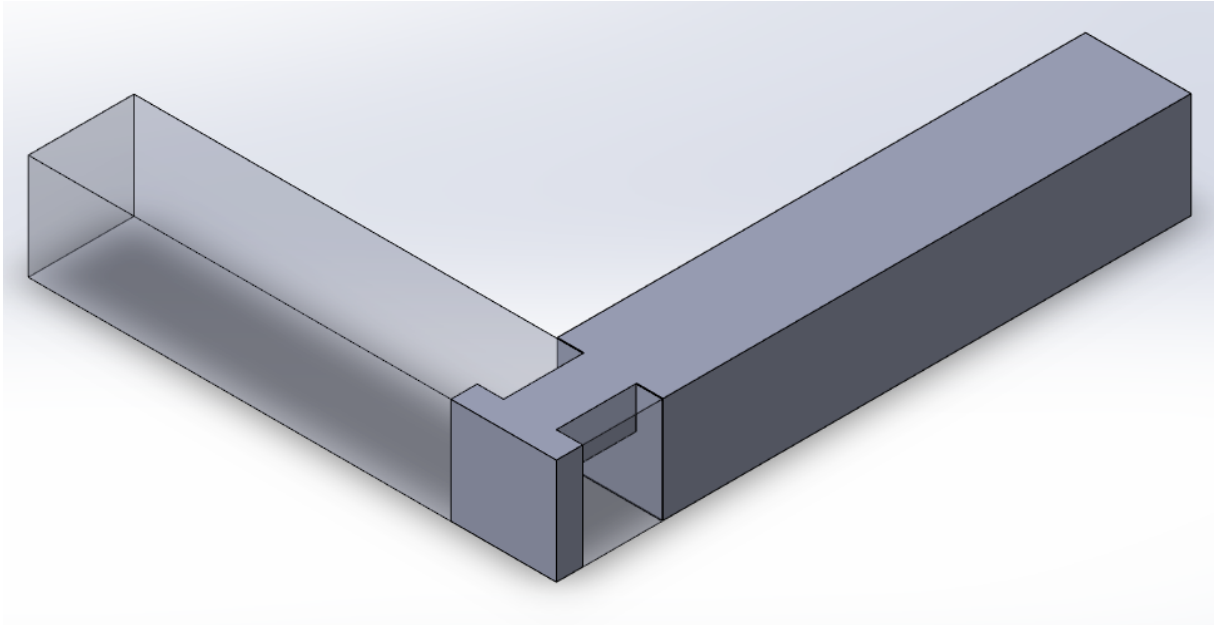
Mortise and tenon



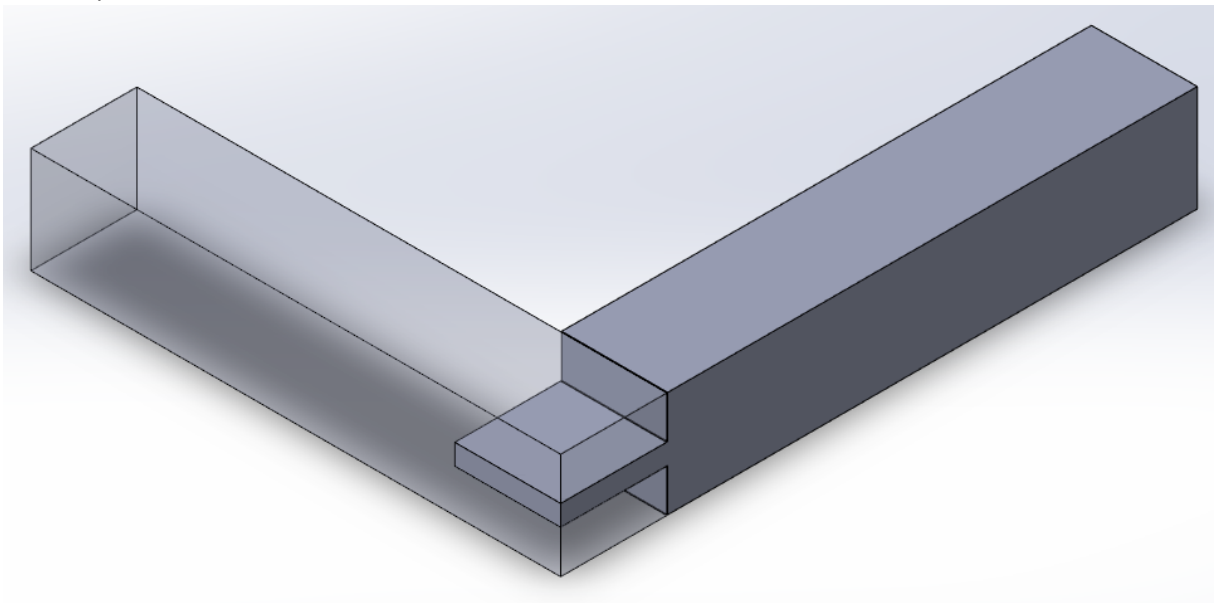
Dowel



Dovetail



Cross lap



Bridle

Appendix B Material properties of PS

Material properties PS	
Elastic Modulus	2280000000 N/m ²
Poisson's Ratio	0.387
Shear Modulus	817300000 N/m ²
Mass Density	1040 kg/m ³
Tensile Strength	35900000 N/m ²
Thermal Conductivity	0.121 W/(m·K)
Specific Heat	1691 J/(kg·K)

Appendix C The simulation results

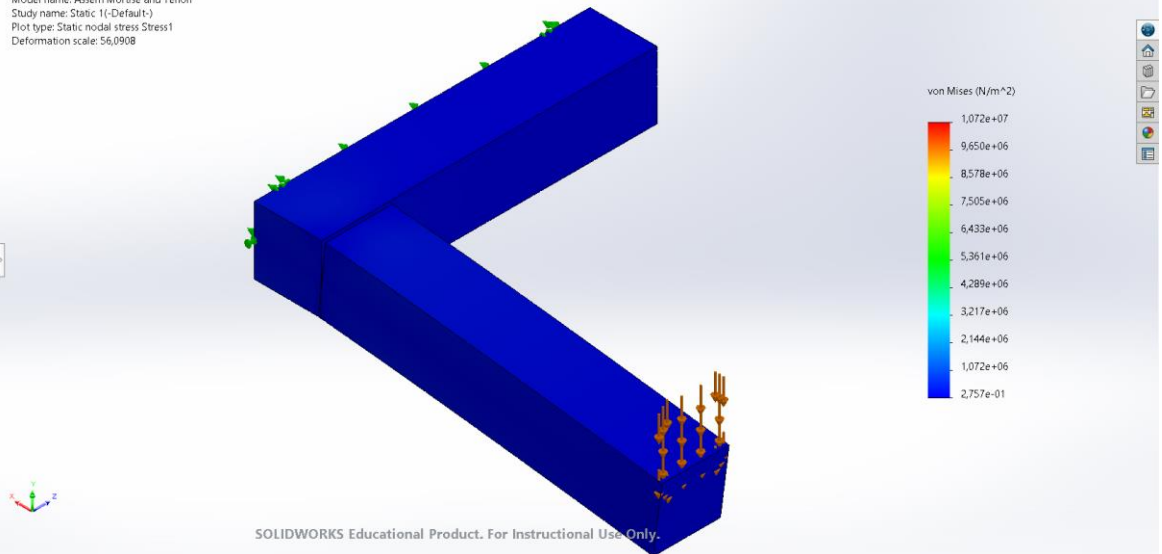
Pressure	Force Y (Pa*E6)	Force X (Pa*E6)	SForce Y (Pa*E6)	SForce X (Pa*E6)
Mortise and tenon	10,72	10,56	5,385	5,286
Dowel	2,796	2,886	1,407	1,517
Dovetail	13,16	5,451	6,573	2,746
Cross lap	13,54	12,10	6,031	6,157
Bridle	13,86	5,281	6,940	2,620

Displacement	Force Y (mm)	Force X (mm)	SForce Y (mm)	SForce X (mm)
Mortise and tenon	1,078	1,042	0,518	0,497
Dowel	0,4063	0,3764	0,163	0,163
Dovetail	2,908	0,4747	1,433	0,2022
Cross lap	1,698	1,080	0,7361	0,5205
Bridle	2,765	0,4708	1,362	0,2018

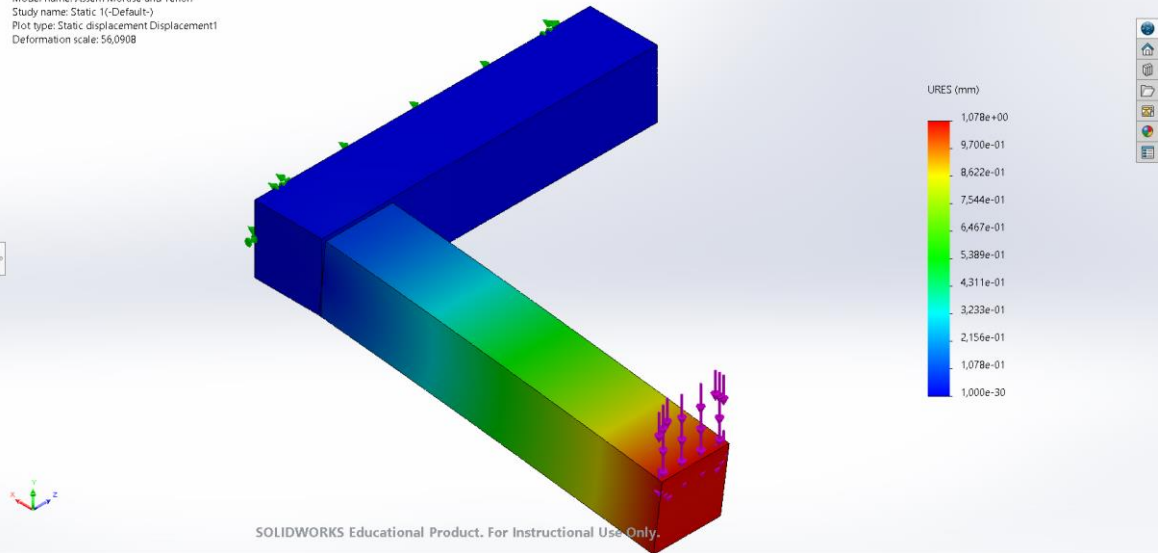
Appendix D The simulations

Force end y Mortise and tenon joinery

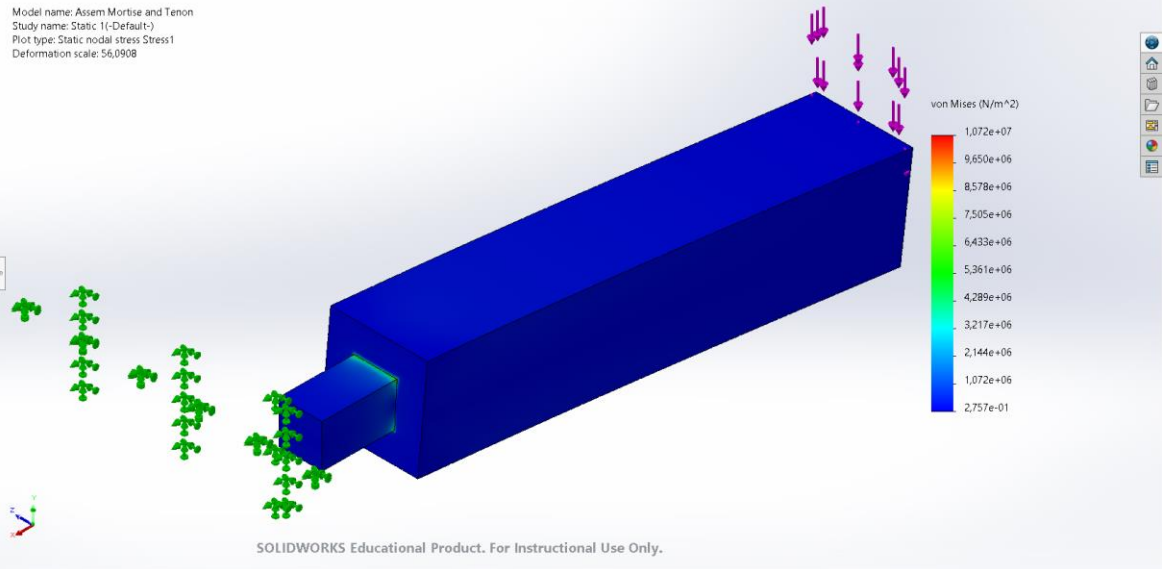
Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 56,0908



Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 56,0908

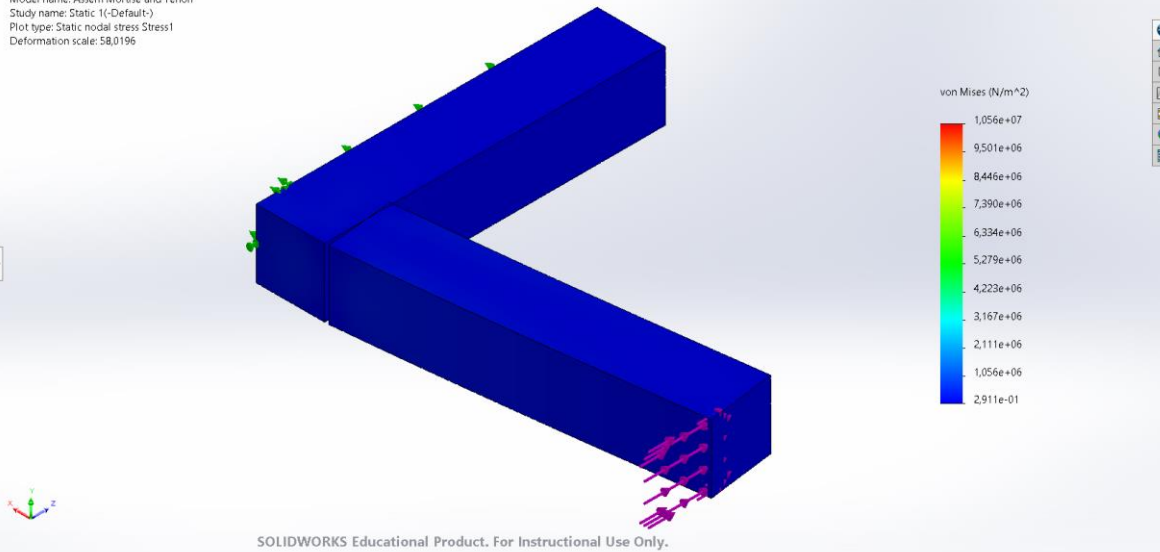


Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 56,0908

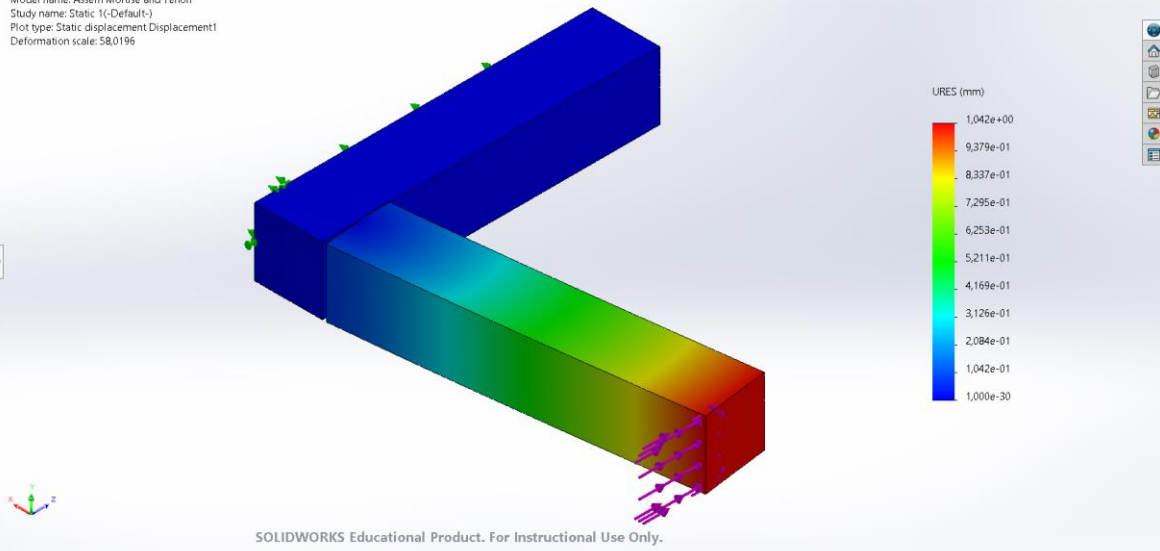


Force end x Mortise and tenon joinery

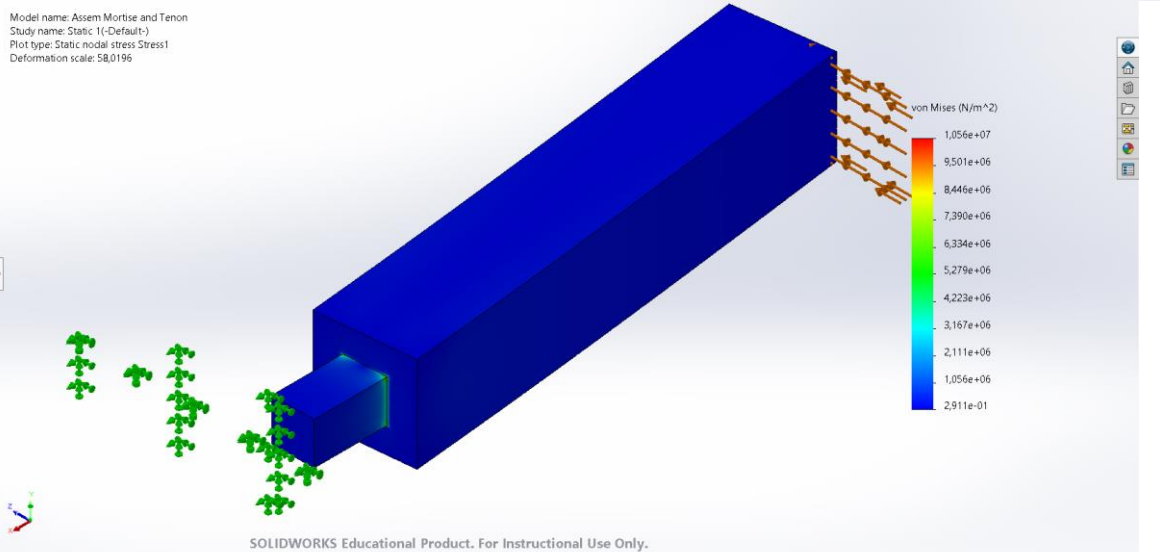
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Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 58,0196



Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 58,0196

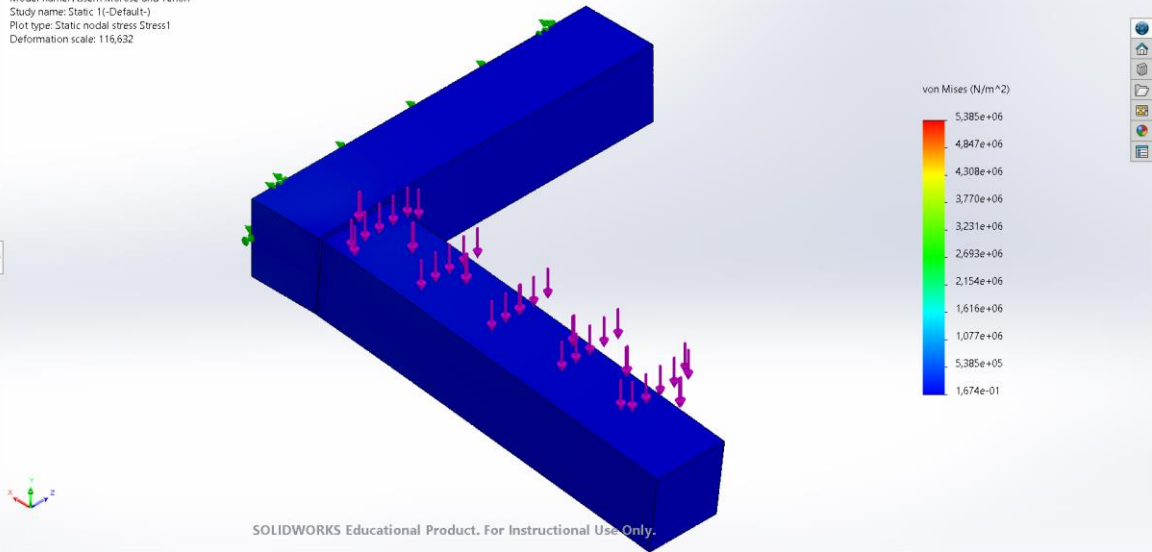


Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 58,0196

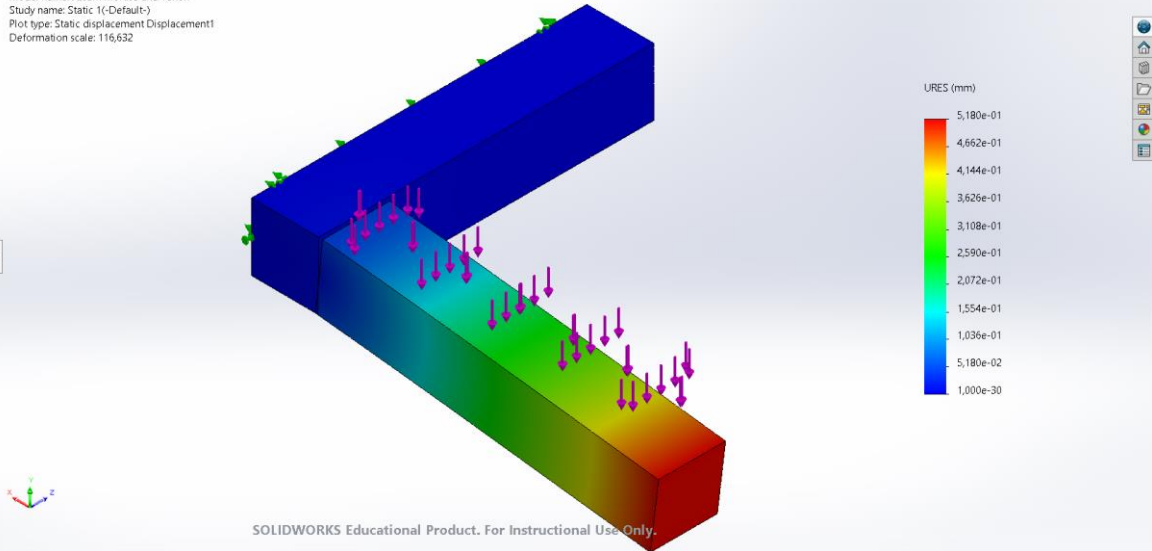


Shared force y Mortise and tenon joinery

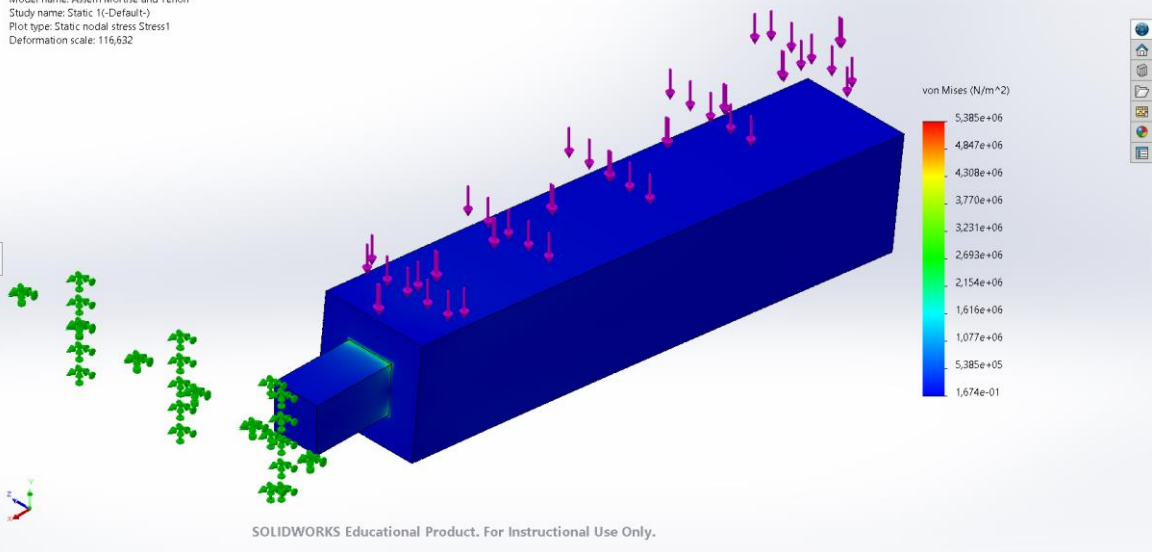
Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 116,632



Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 116,632

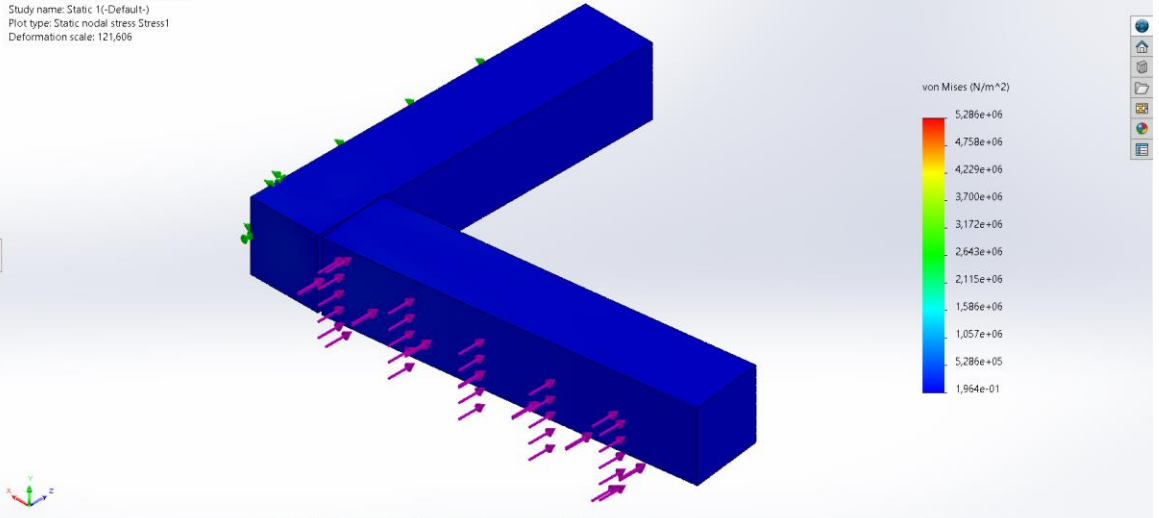


Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 116,632



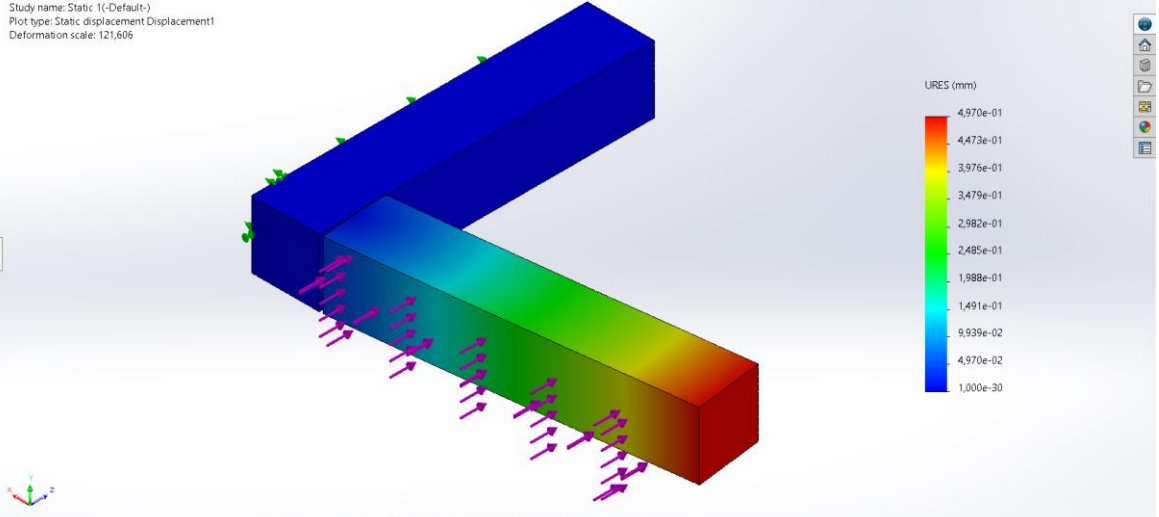
Shared force x Mortise and tenon joinery

Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 121,606



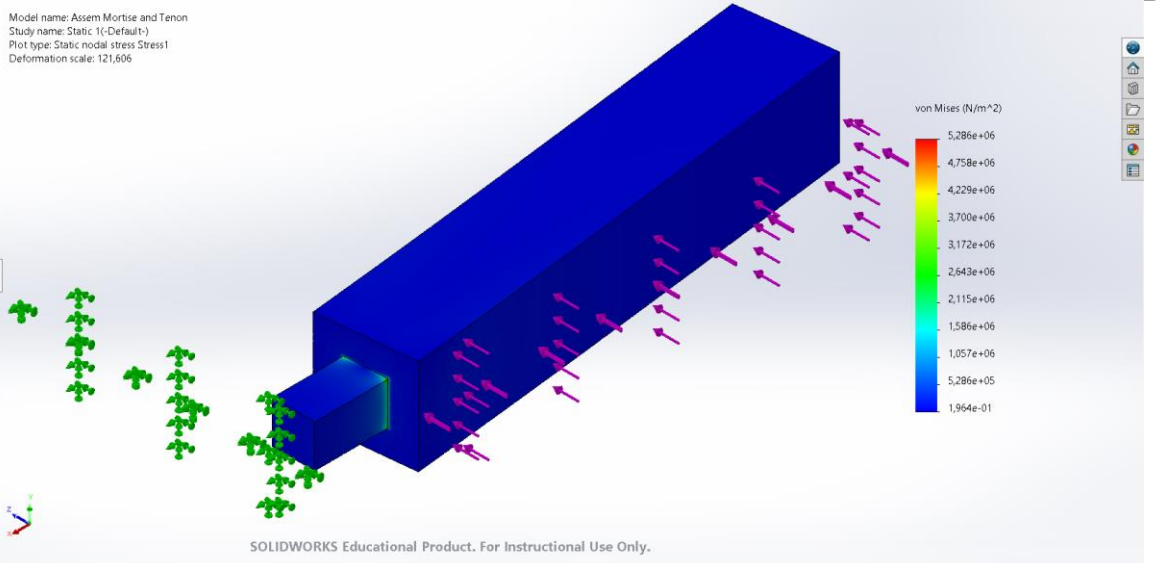
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Model name: Assem Mortise and Tenon
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 121,606



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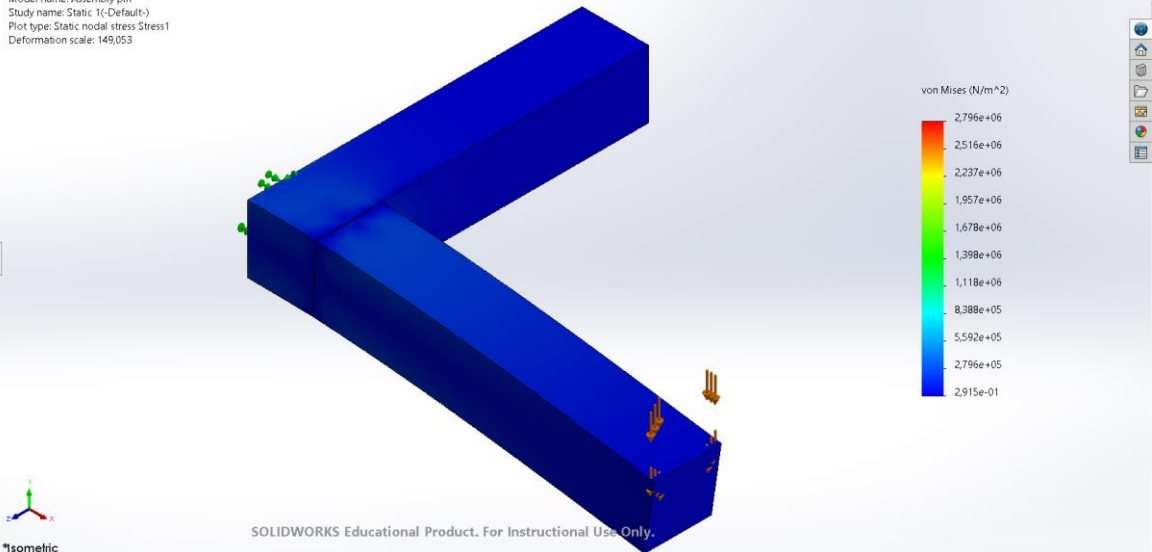
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Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 121,606



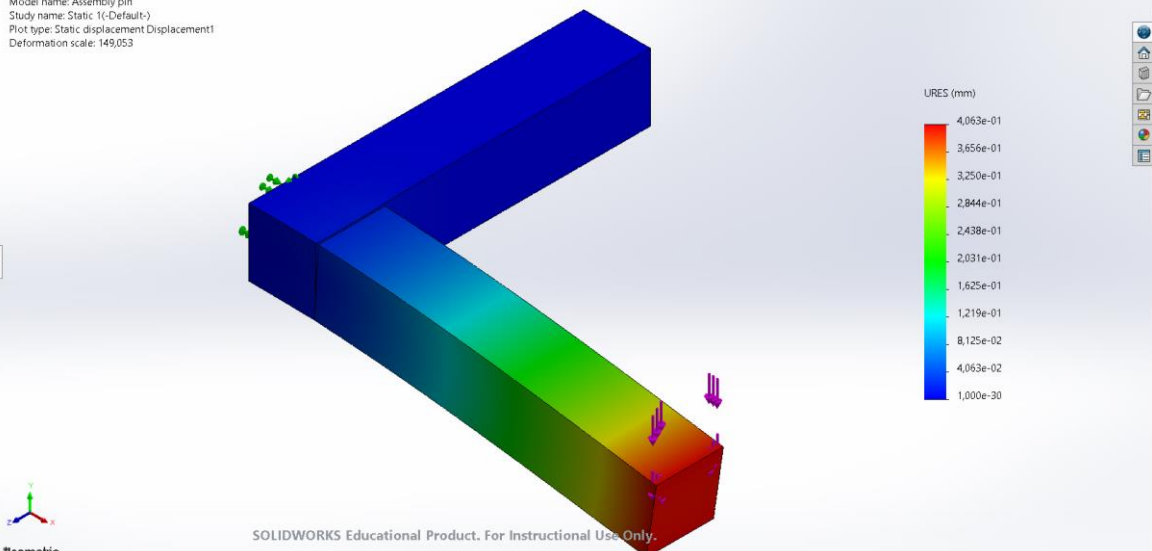
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Force end y Dowel

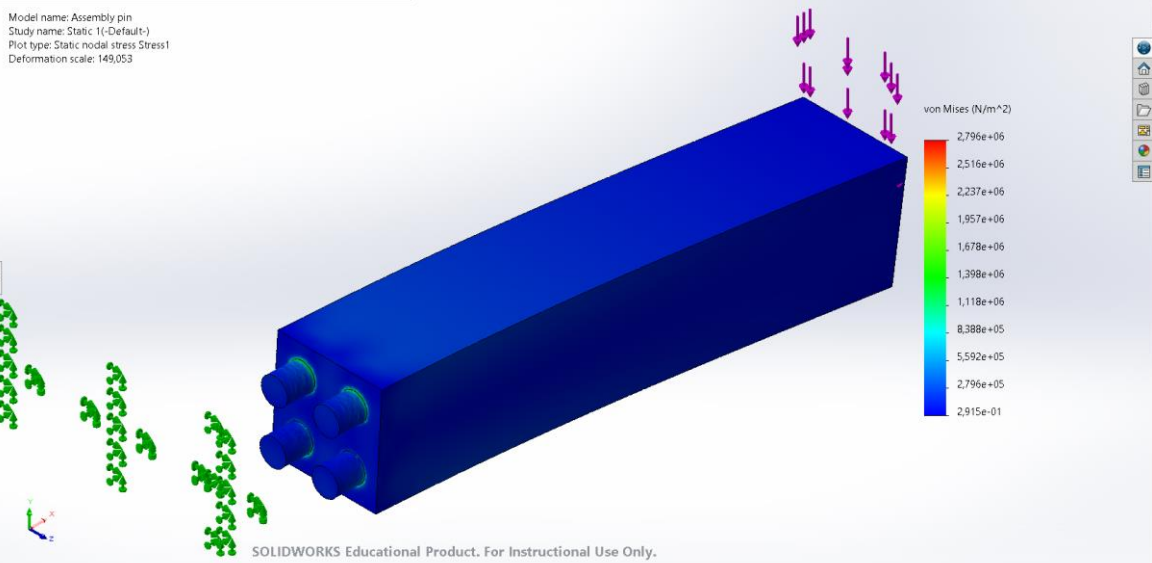
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Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 149,053



Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 149,053

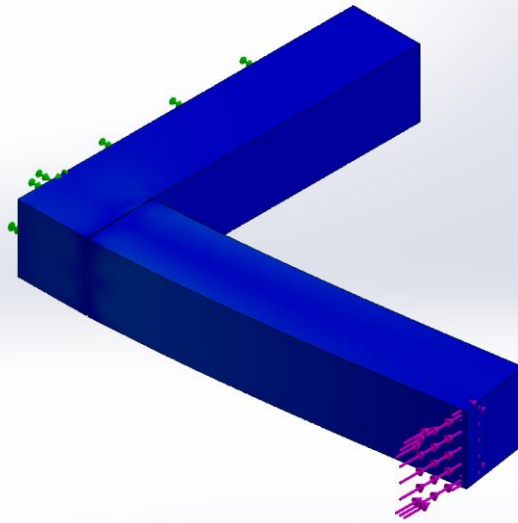


Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 149,053



Force end x Dowel

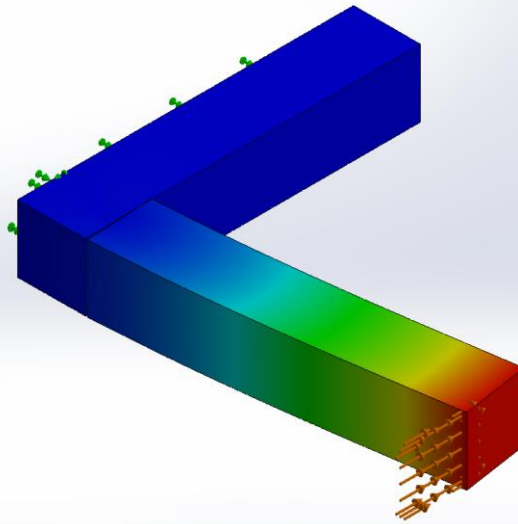
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 161,016



*Isometric

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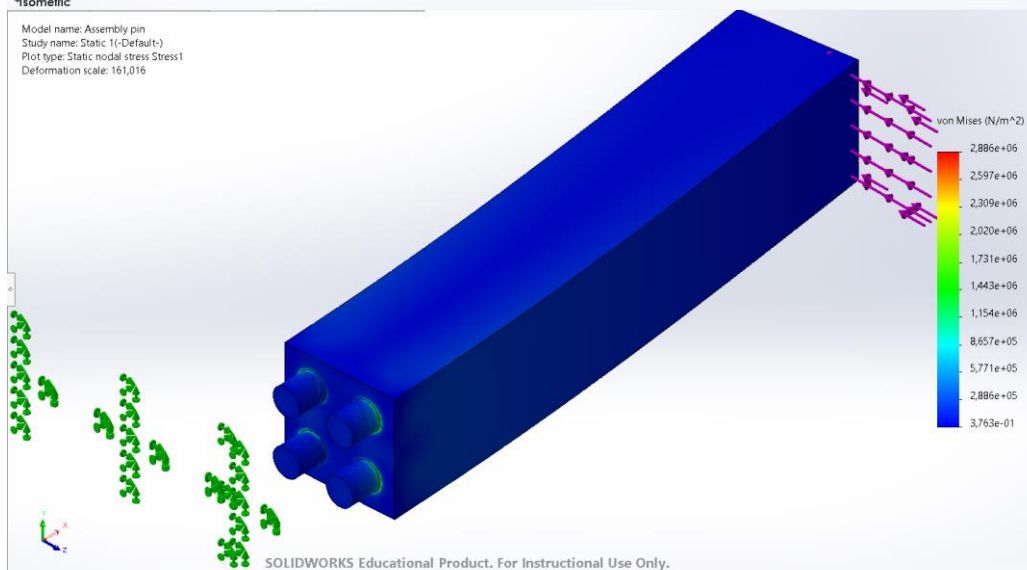
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 161,016



*Isometric

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Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 161,016

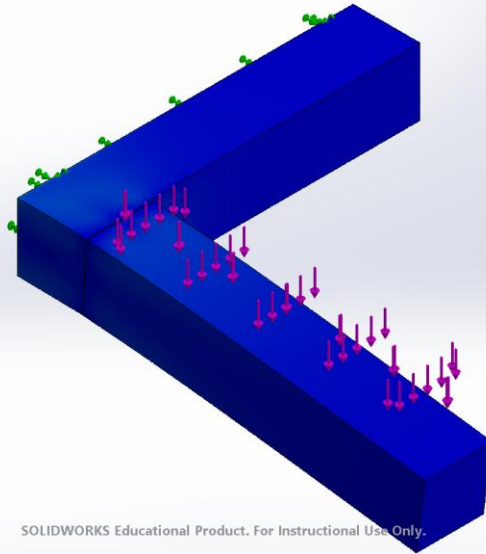


*Isometric

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Shared force y Dowel

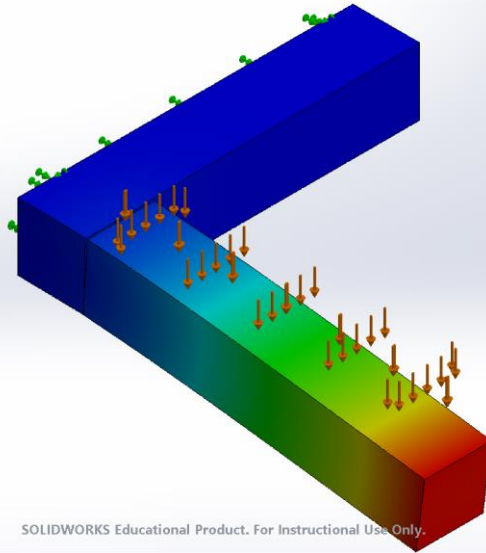
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 333,825



*Isometric

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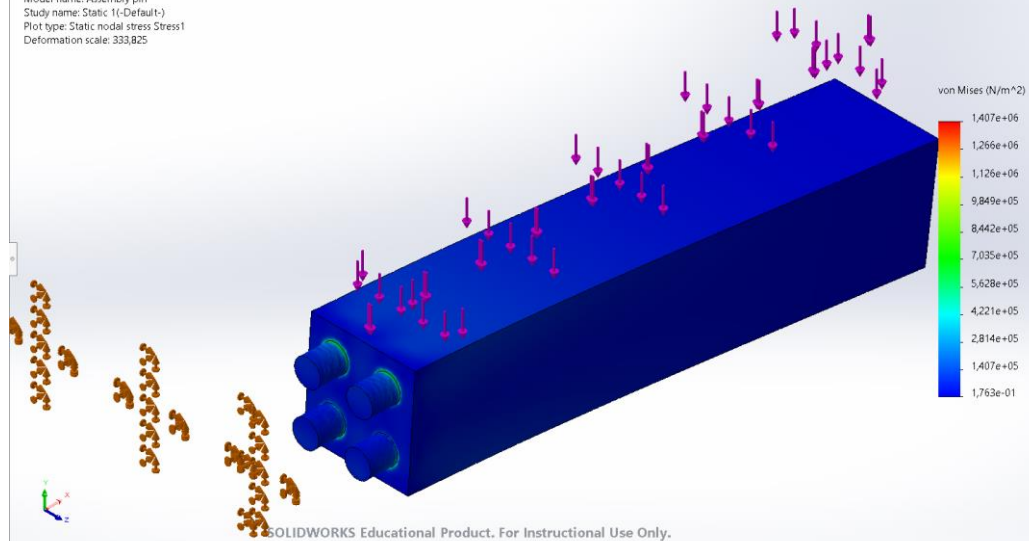
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 333,825



*Isometric

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Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 333,825

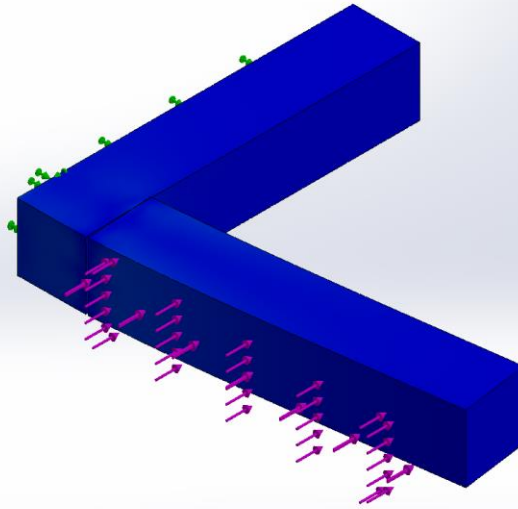


*Isometric

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Shared force x Dowel

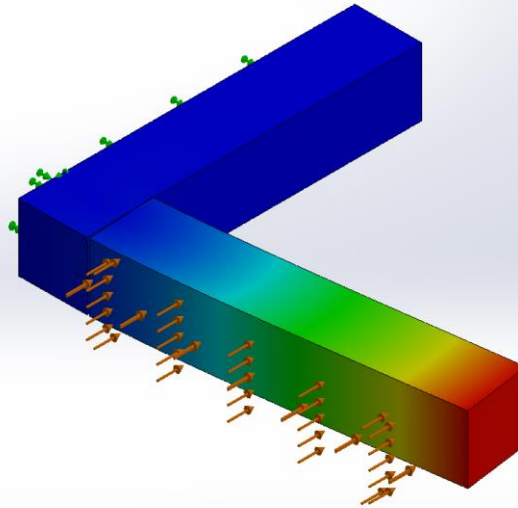
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 371,268



*Isometric

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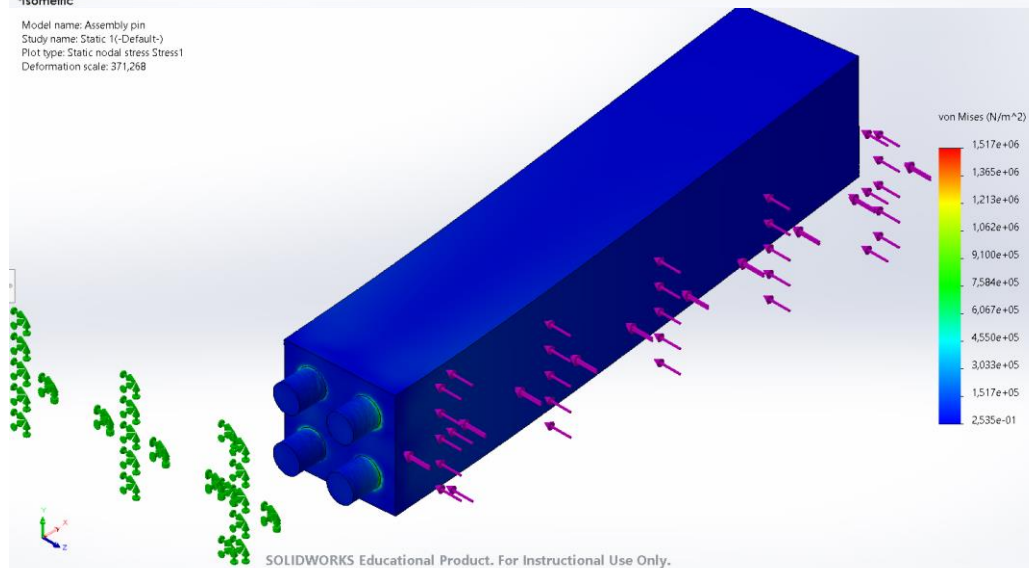
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Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 371,268



*Isometric

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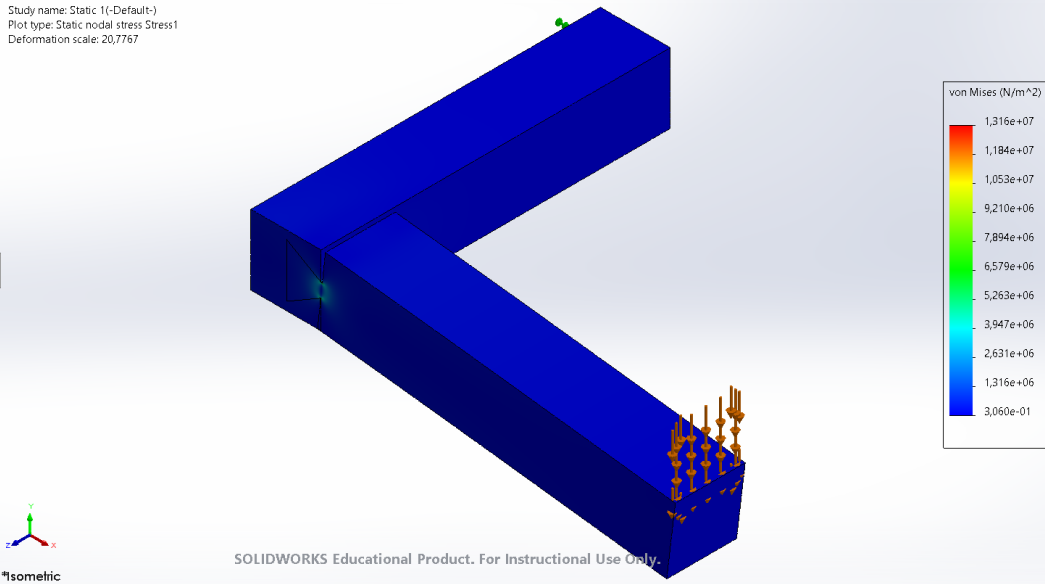
Model name: Assembly pin
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 371,268



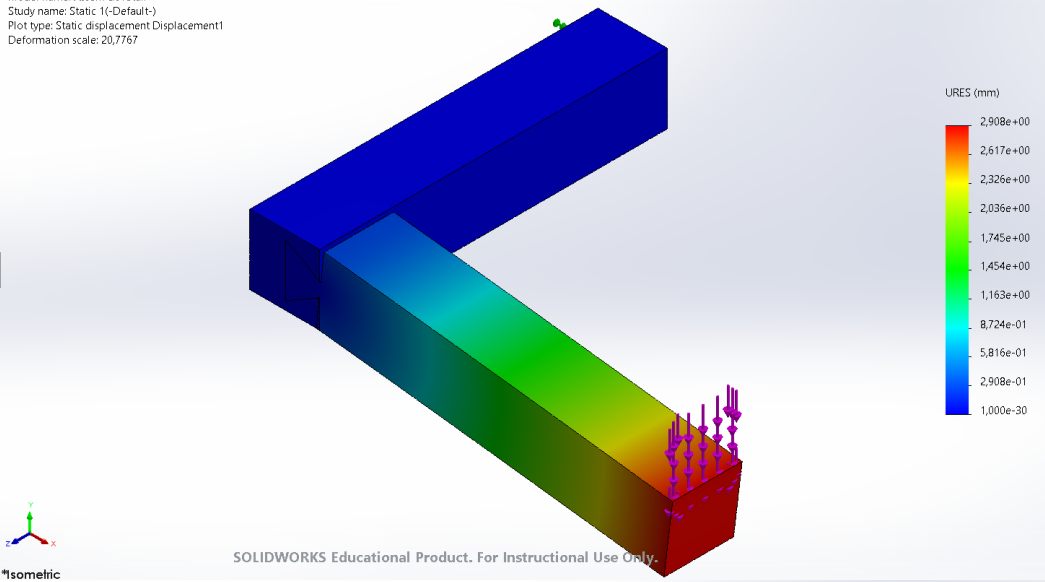
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Force end y dovetail

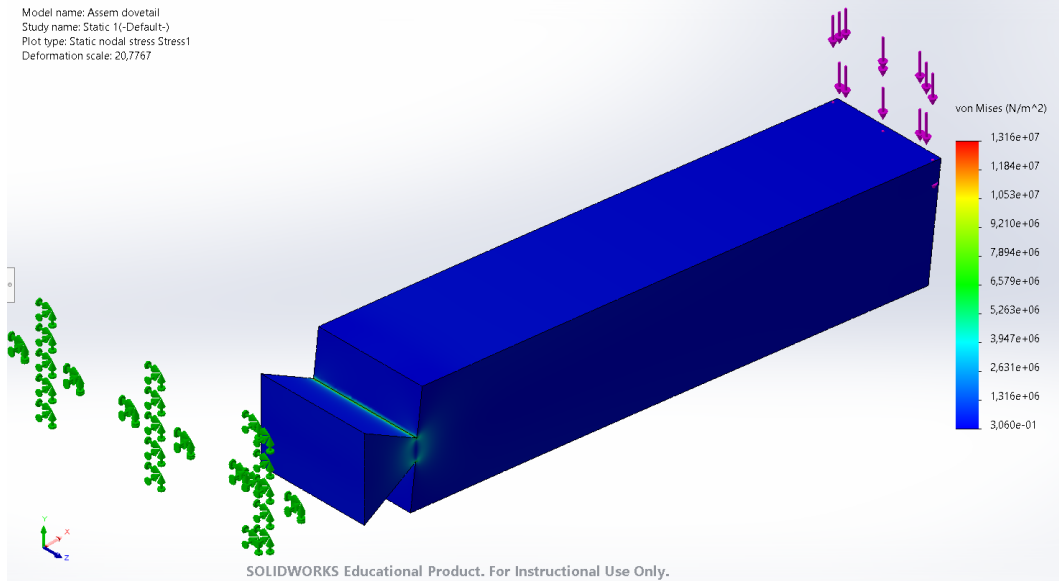
Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 20,7767



Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 20,7767

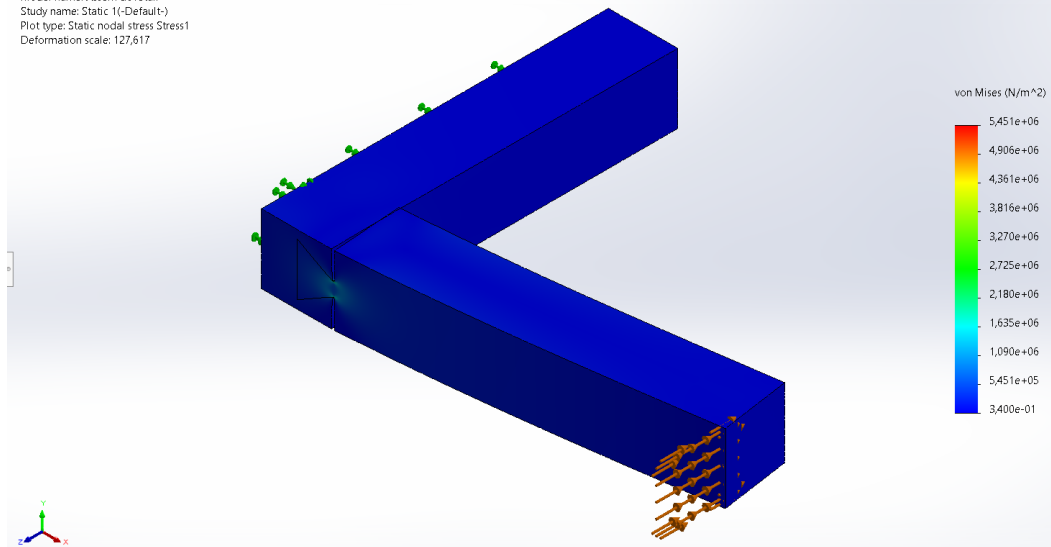


Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 20,7767



Force end x dovetail

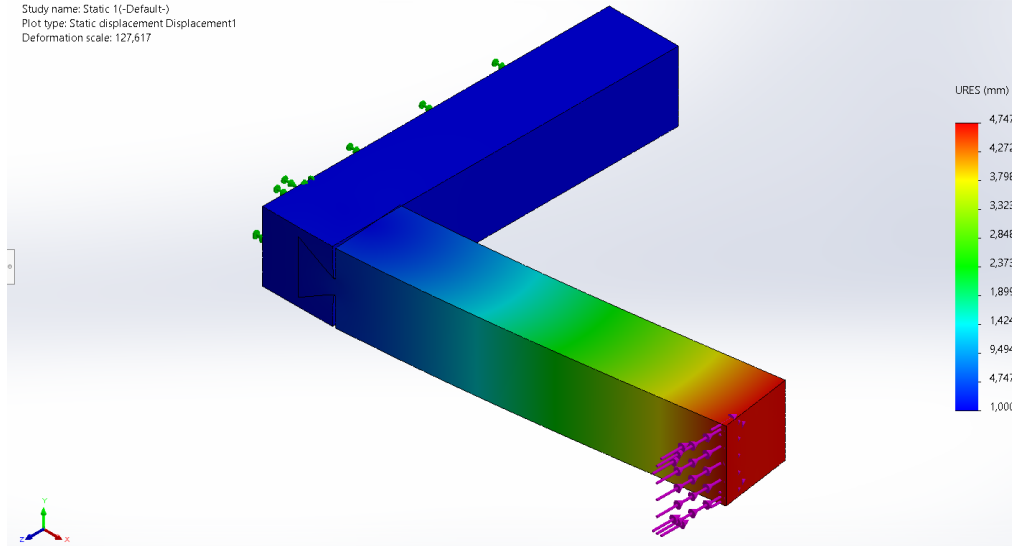
Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 127,617



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*Isometric

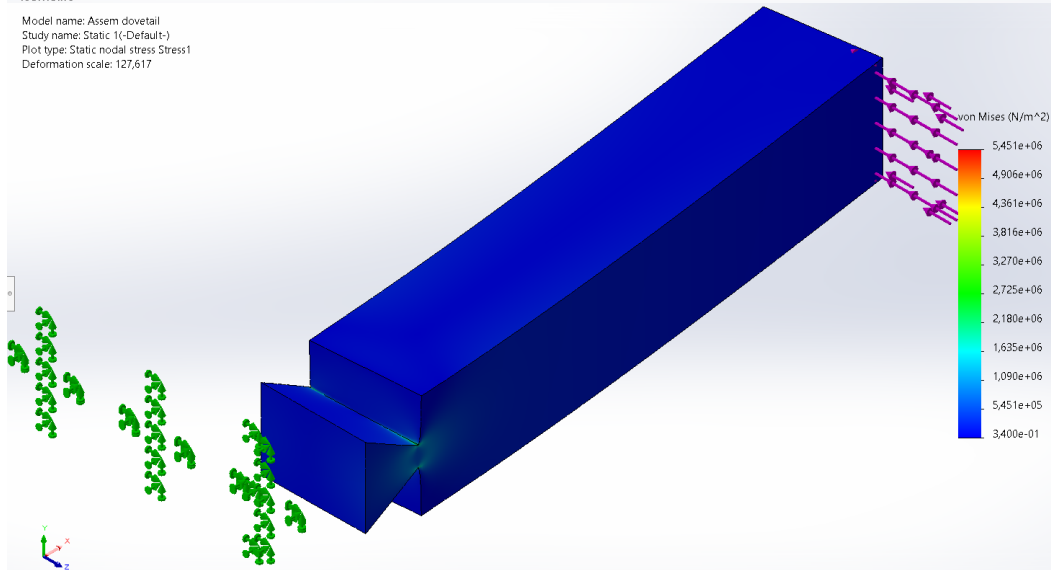
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Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 127,617



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*Isometric

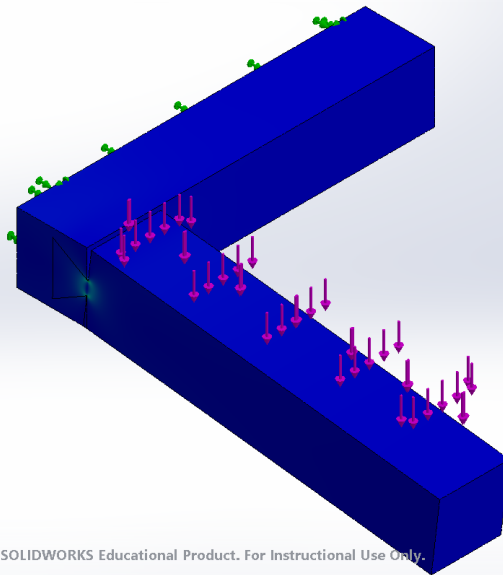
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Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 127,617



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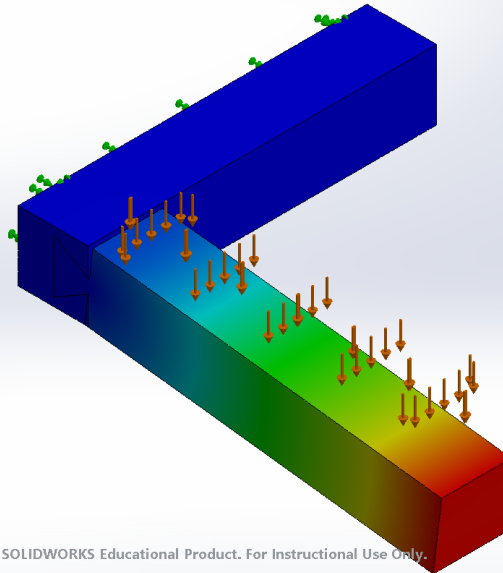
Shared force y dovetail

Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 42,1509



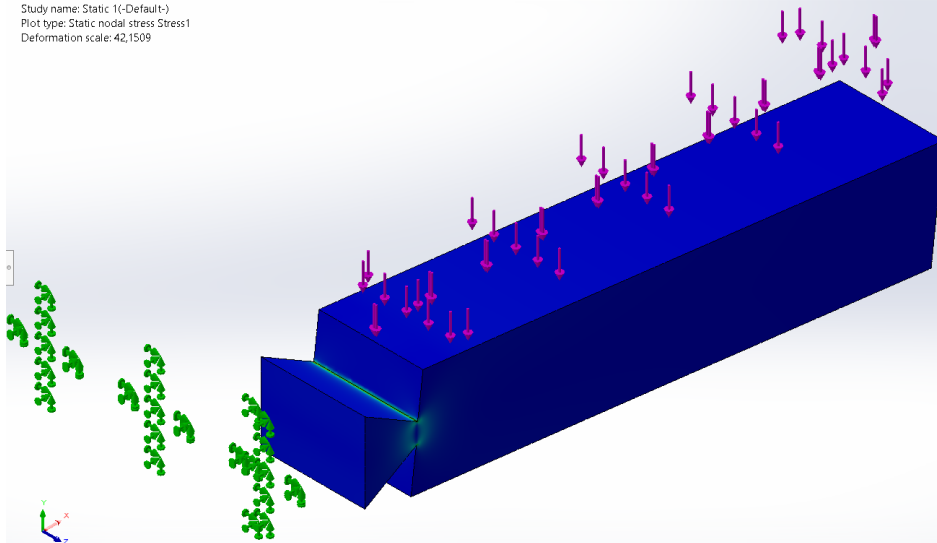
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Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 42,1509



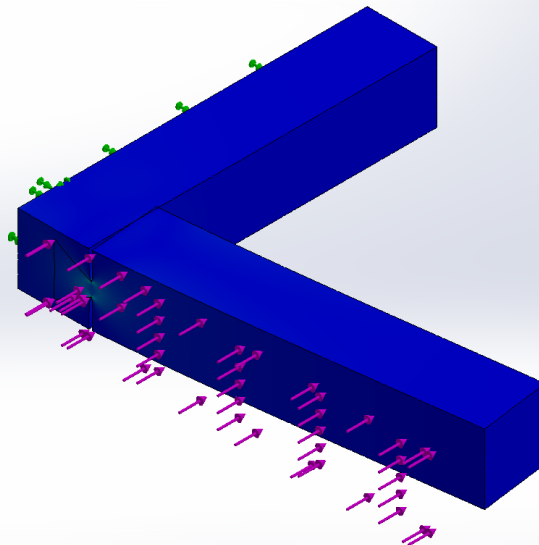
*Isometric

Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 42,1509

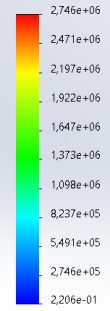


Shared force x dovetail

Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 299,327



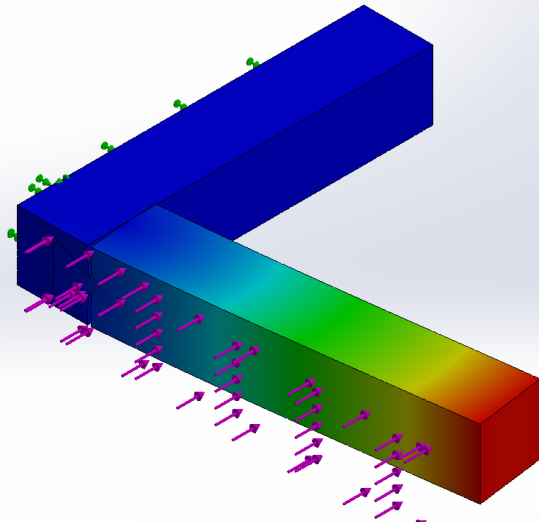
von Mises (N/m²)



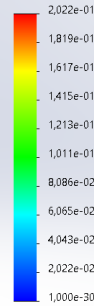
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Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 299,327



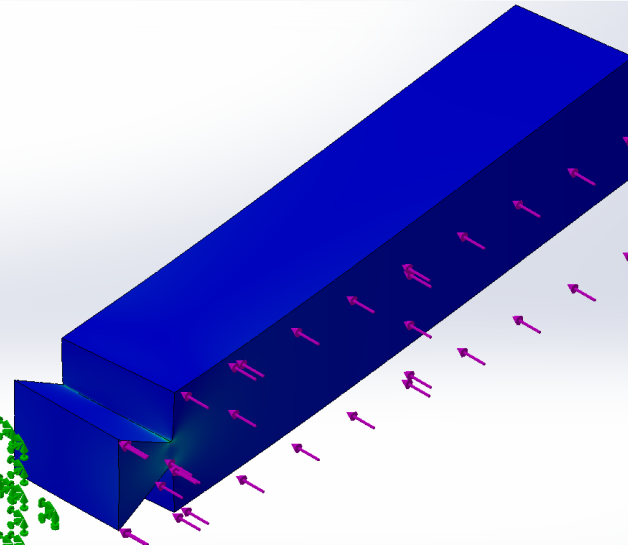
URES (mm)



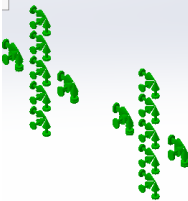
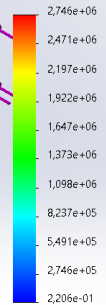
*Isometric

SOLIDWORKS Educational Product. For Instructional Use Only.

Model name: Assem dovetail
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 299,327



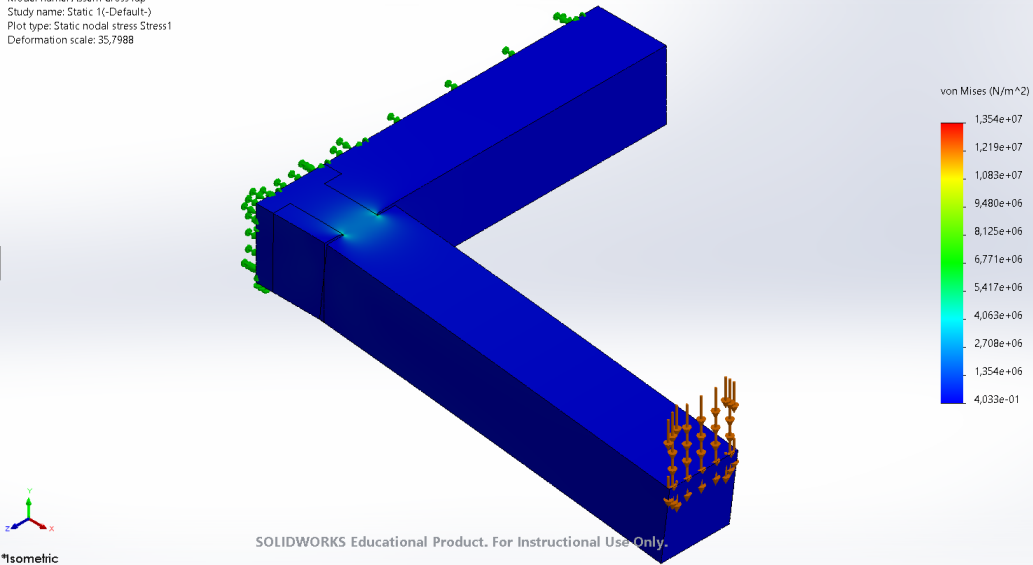
von Mises (N/m²)



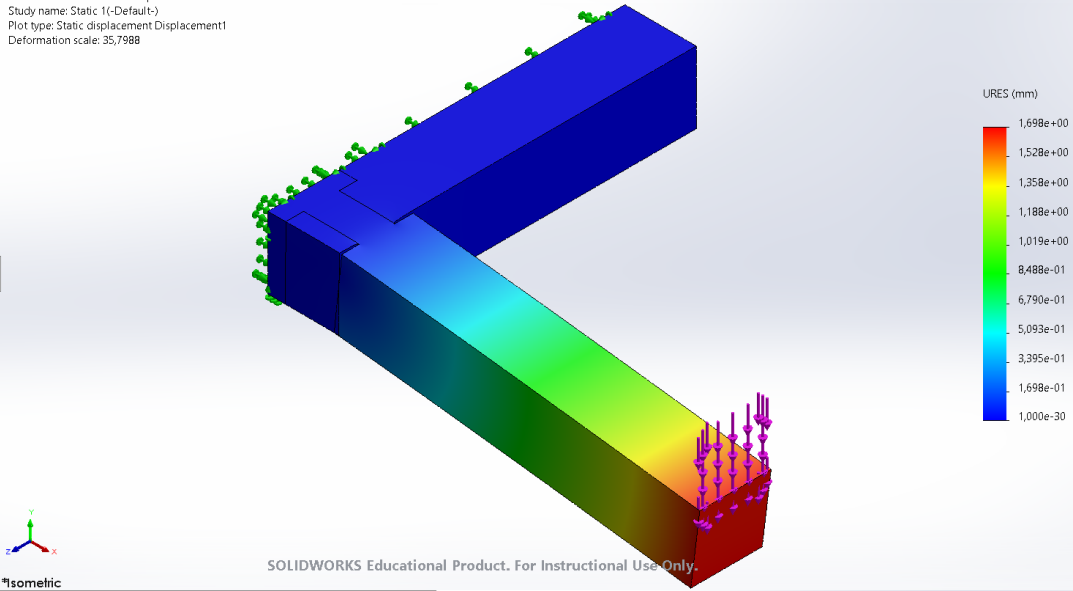
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Force end y Cross lap

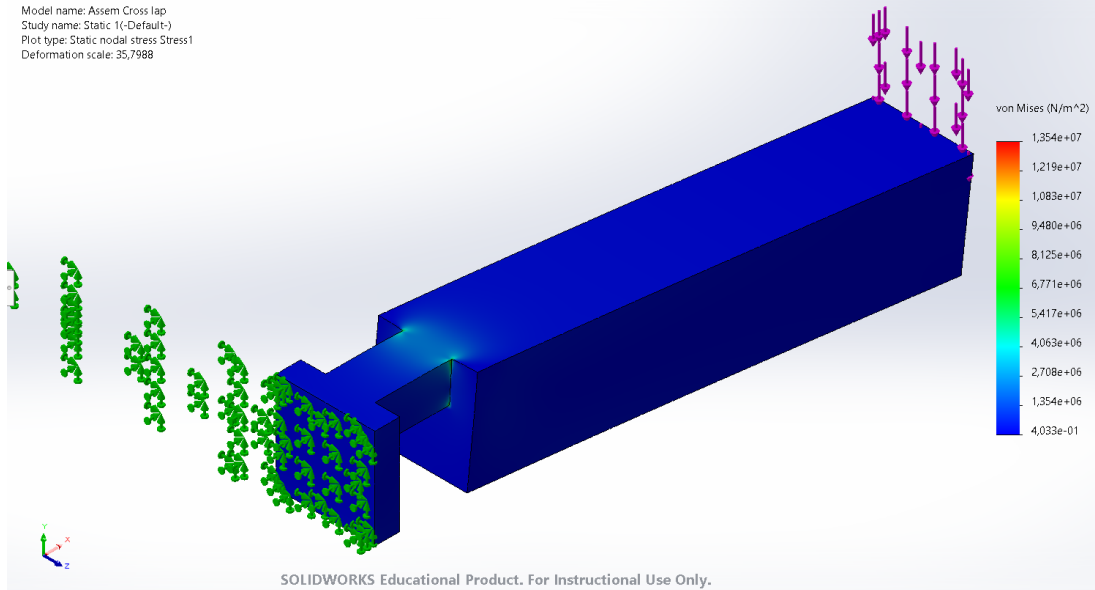
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 35,7988



Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 35,7988

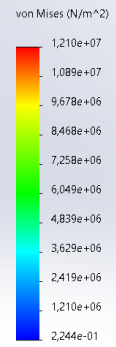
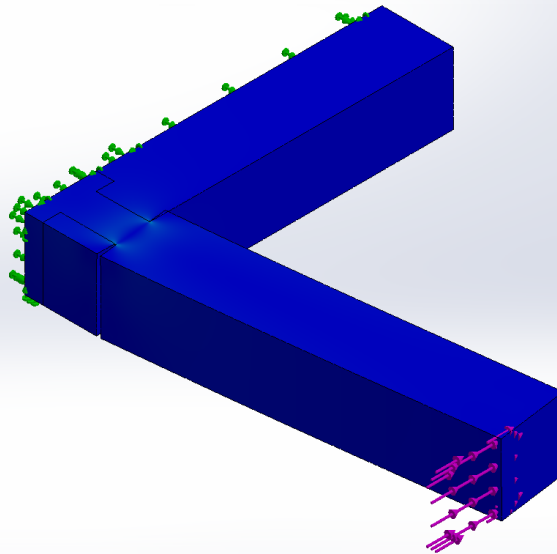


Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 35,7988



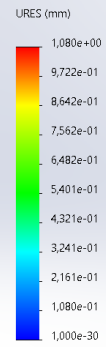
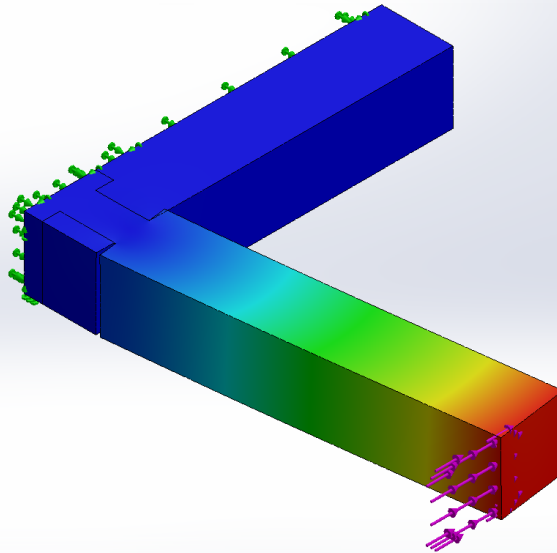
Force end x Cross lap

Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 55,9664



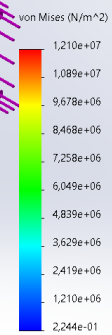
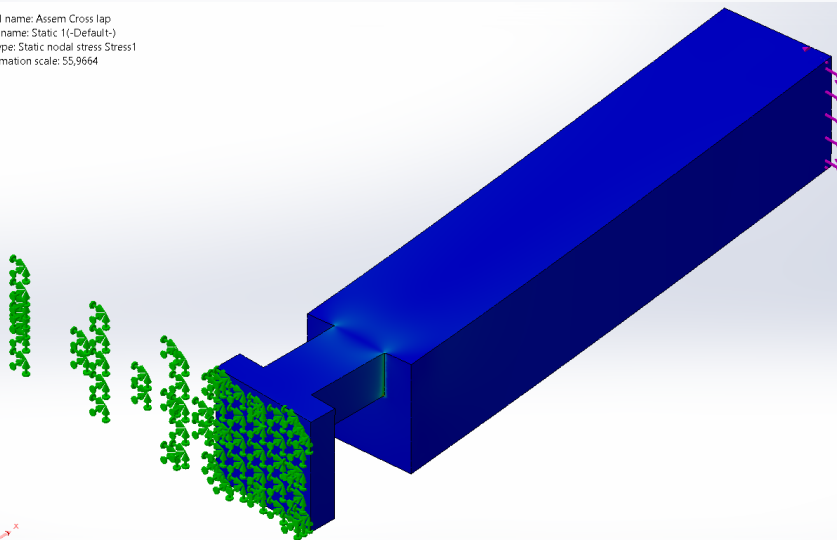
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Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 55,9664



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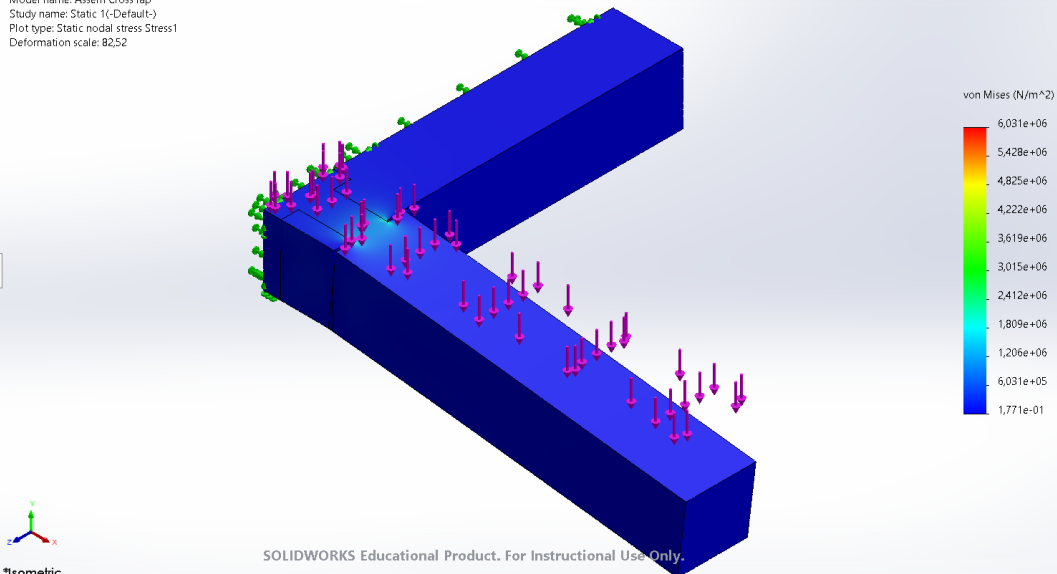
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 55,9664



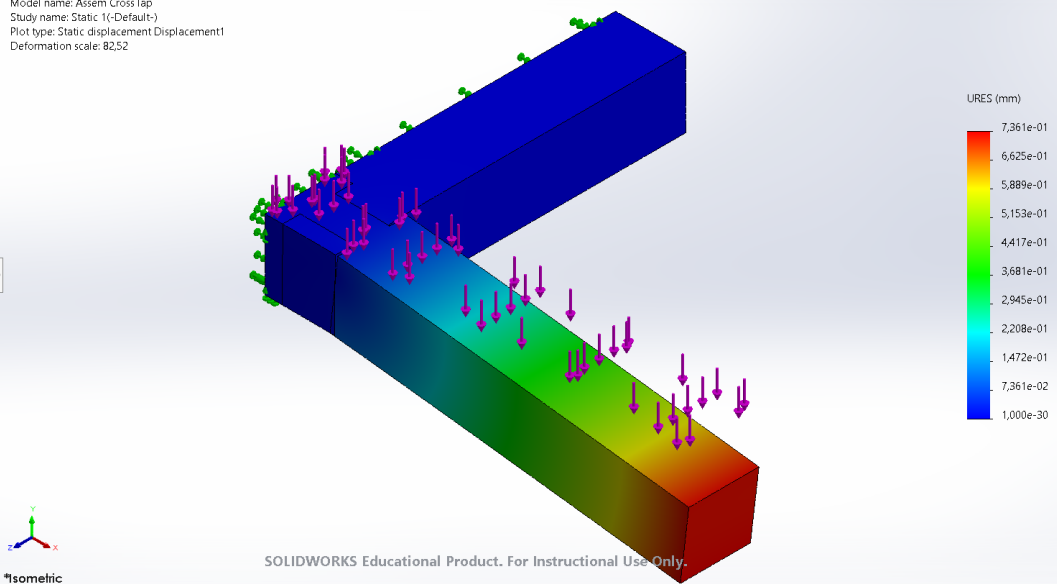
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Shared force y Cross lap

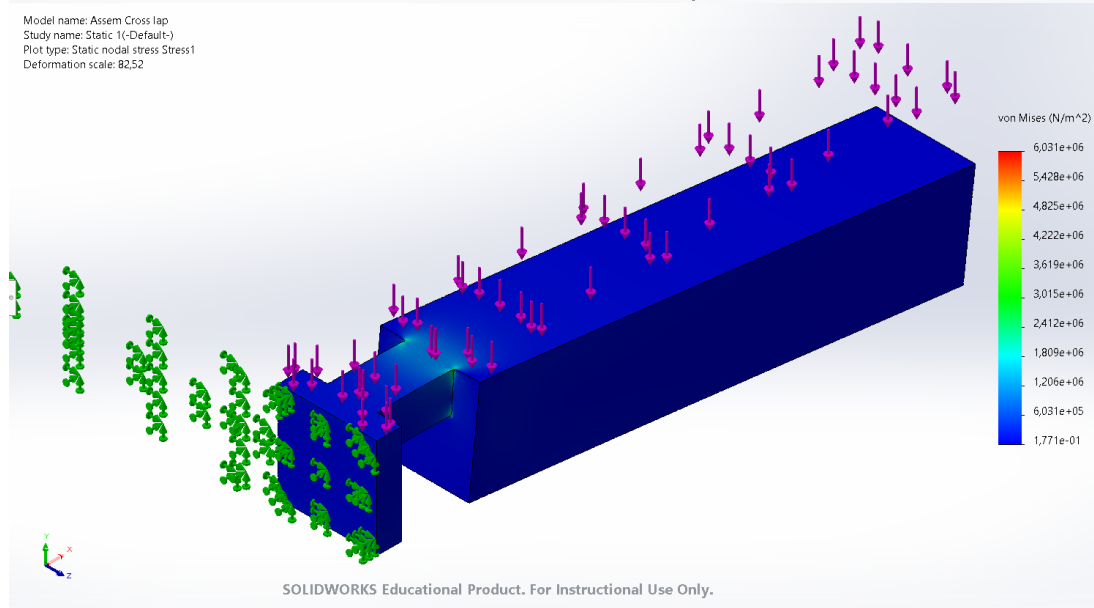
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 82.52



Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 82.52

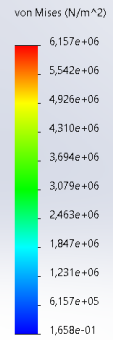
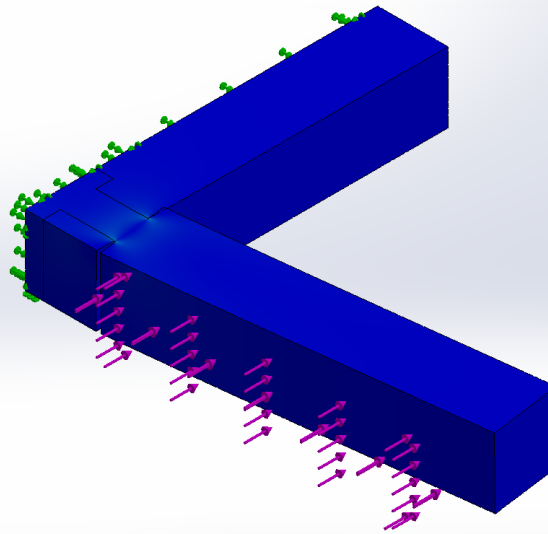


Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 82.52



Shared force x Cross lap

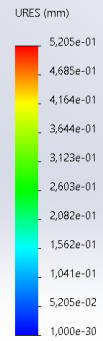
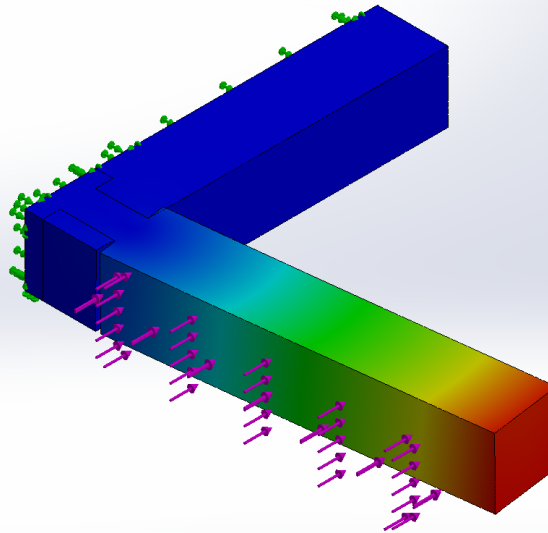
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 116,09



*isometric

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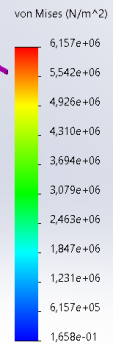
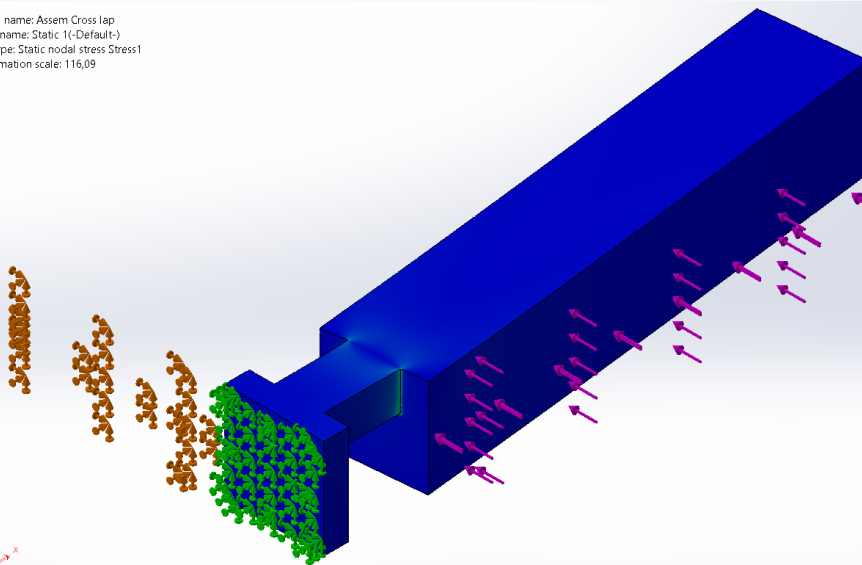
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 116,09



*isometric

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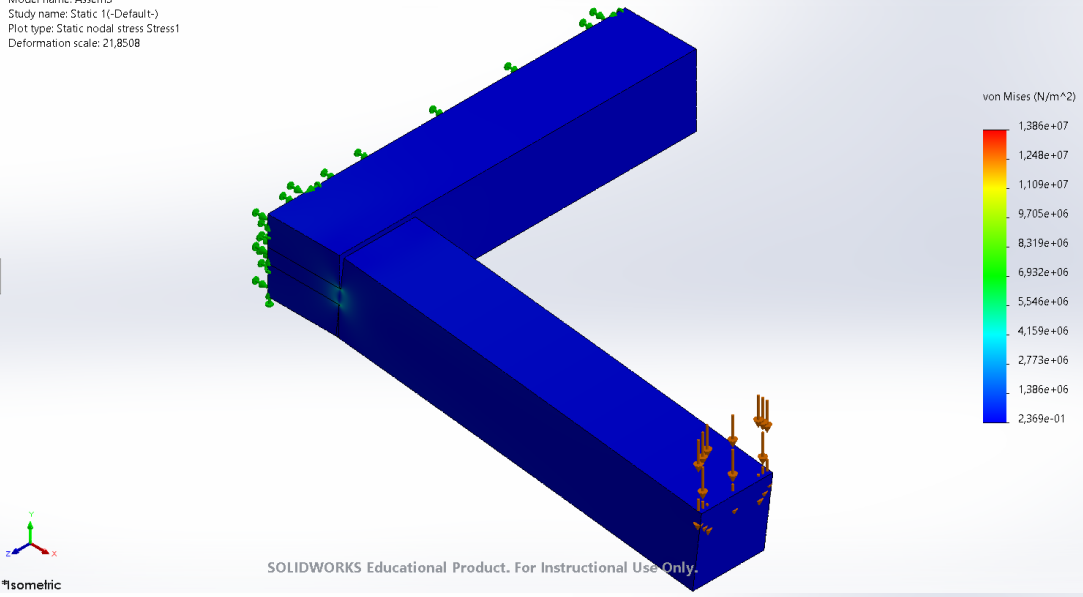
Model name: Assem Cross lap
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 116,09



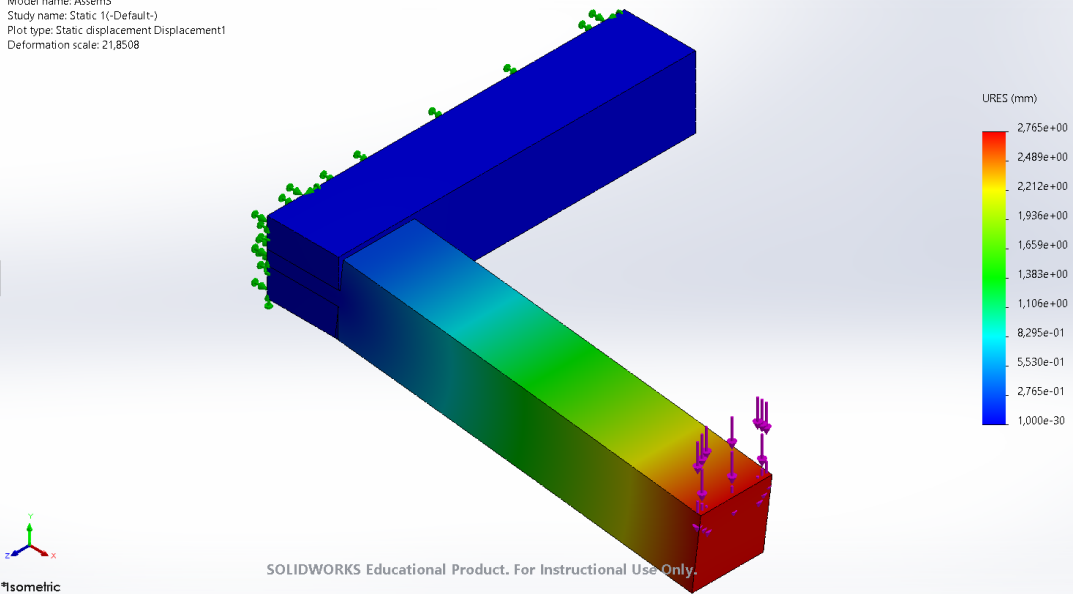
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Force end y Bridle

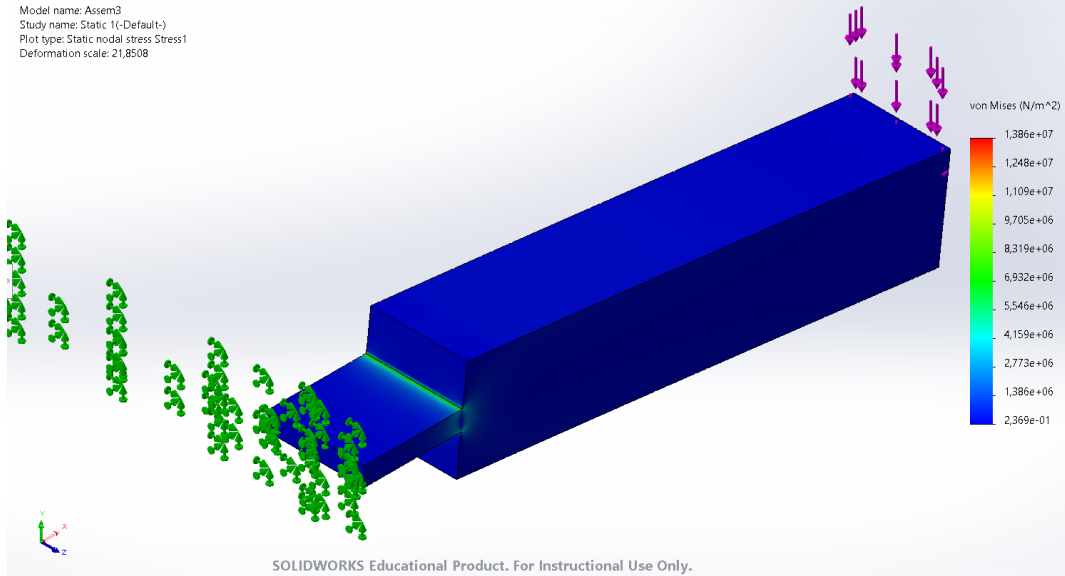
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 21,8508



Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 21,8508

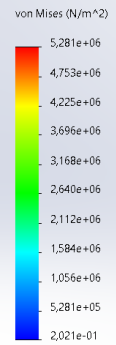
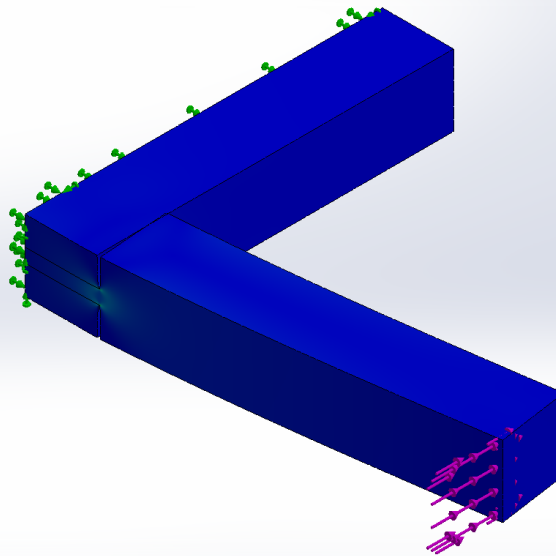


Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 21,8508



Force end x Bridle

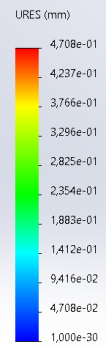
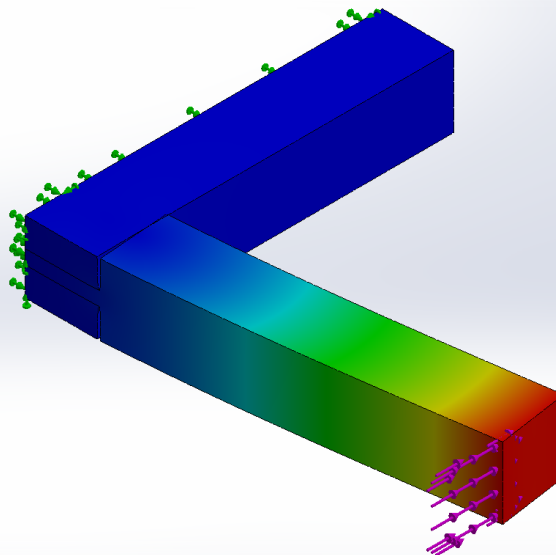
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 128,677



Isometric

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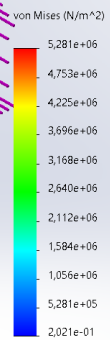
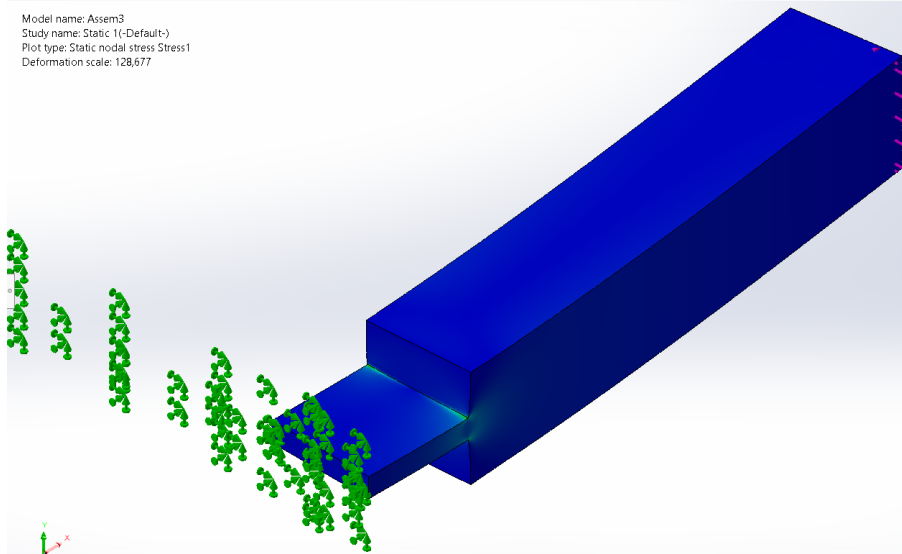
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 128,677



Isometric

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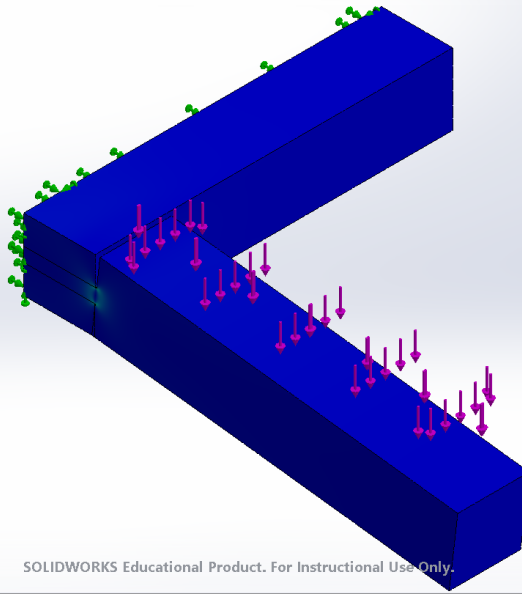
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 128,677



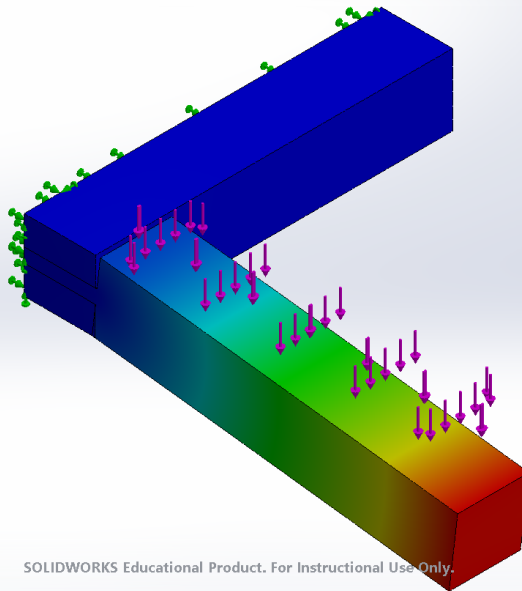
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Shared force y Bridle

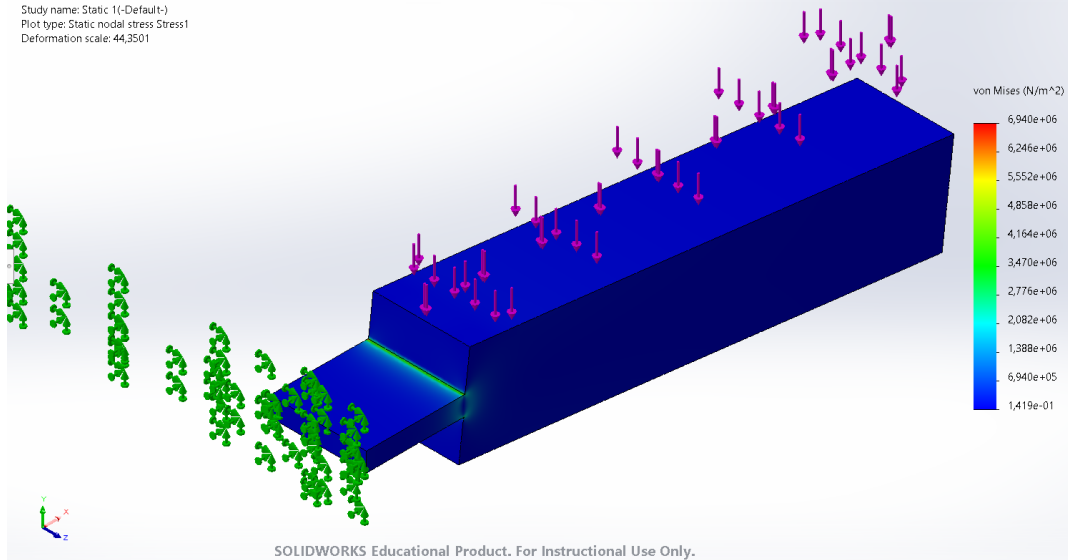
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 44,3501



Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 44,3501

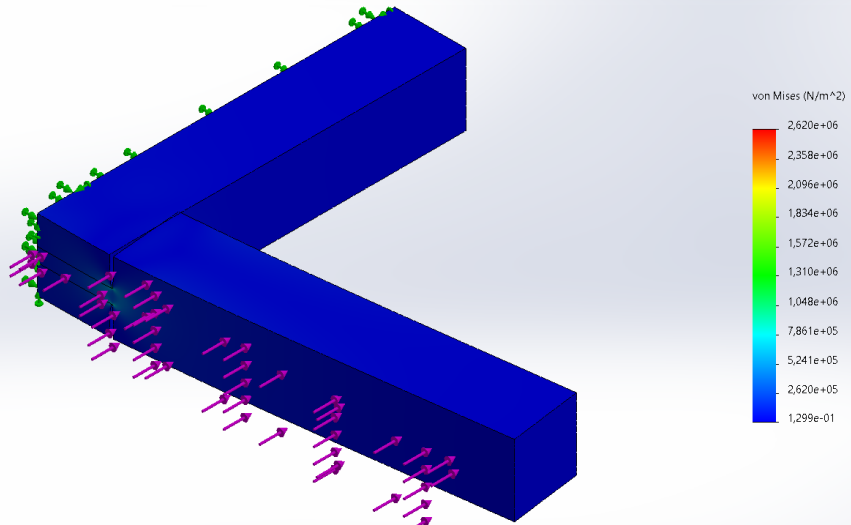


Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 44,3501



Shared force x Bridle

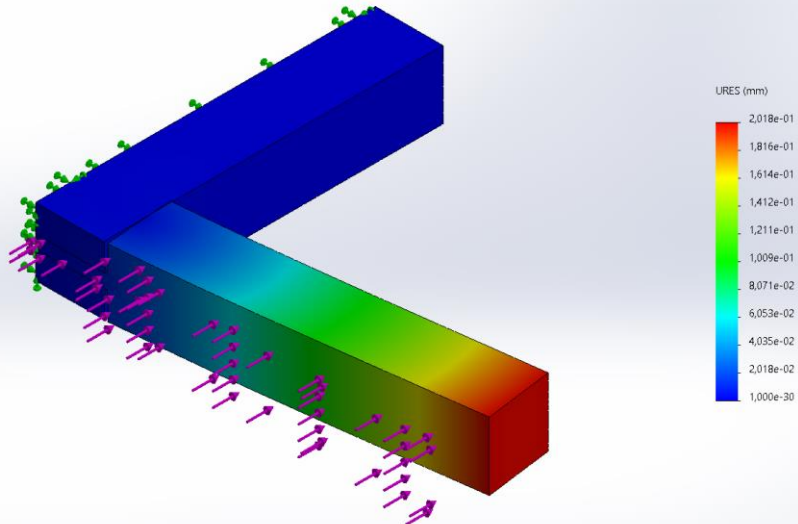
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 299,903



*Isometric

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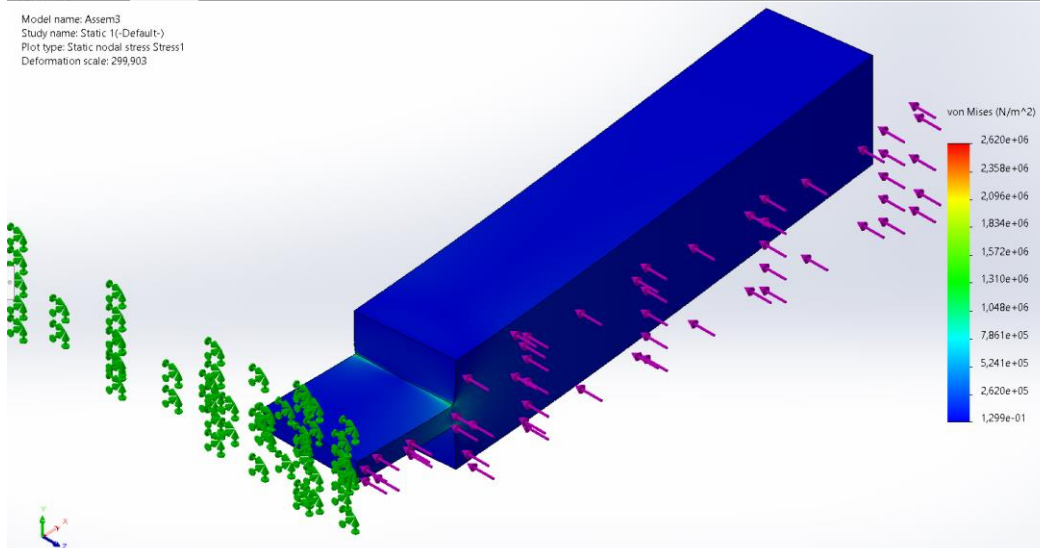
Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 299,903



*Isometric

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Model name: Assem3
Study name: Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 299,903



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