24-650 Applied Finite Element Analysis

Assignment 6

submitted by

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Objective

The goal of this assignment is to perform an analysis of nonlinear contact and plasticity of a 4-point bend specimen. The results are:

Part A: FS_1 = **0.168**, FS_2 = **0.202**

Part B: FS_3 = **1.61**, Max equivalent plastic strain = **0.0201** mm/mm

Assumptions and Loading Conditions

1) The specimen is notched and made of a **soft aluminum alloy**: E = 67 GPa, v = 0.33.Wind load 9000N at the top.
2) Its yield strength, Sy, and ultimate strength, Su, are 220 MPa and 640 MPa.
3) The support and load pins are made of **machine steel:** E = 205 GPa, v = 0.29.
4) The load pins are constrained against in-plane motion and each load by an imposed deformation: delta = 1mm.

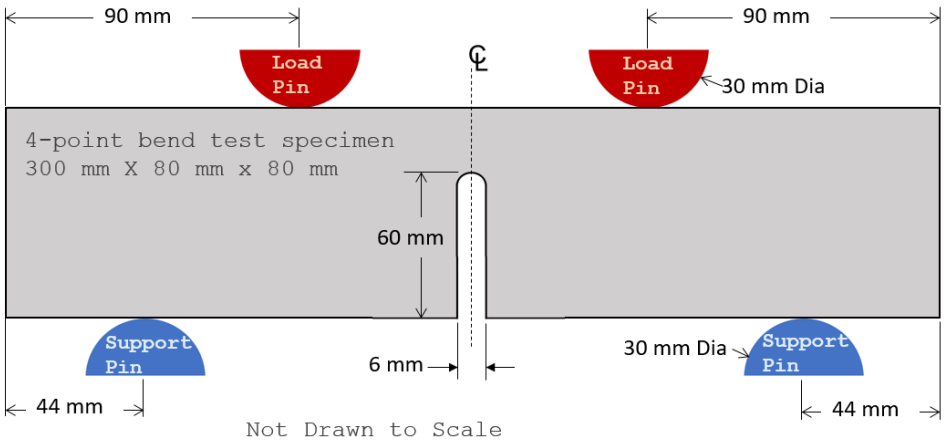


Figure 1

Model

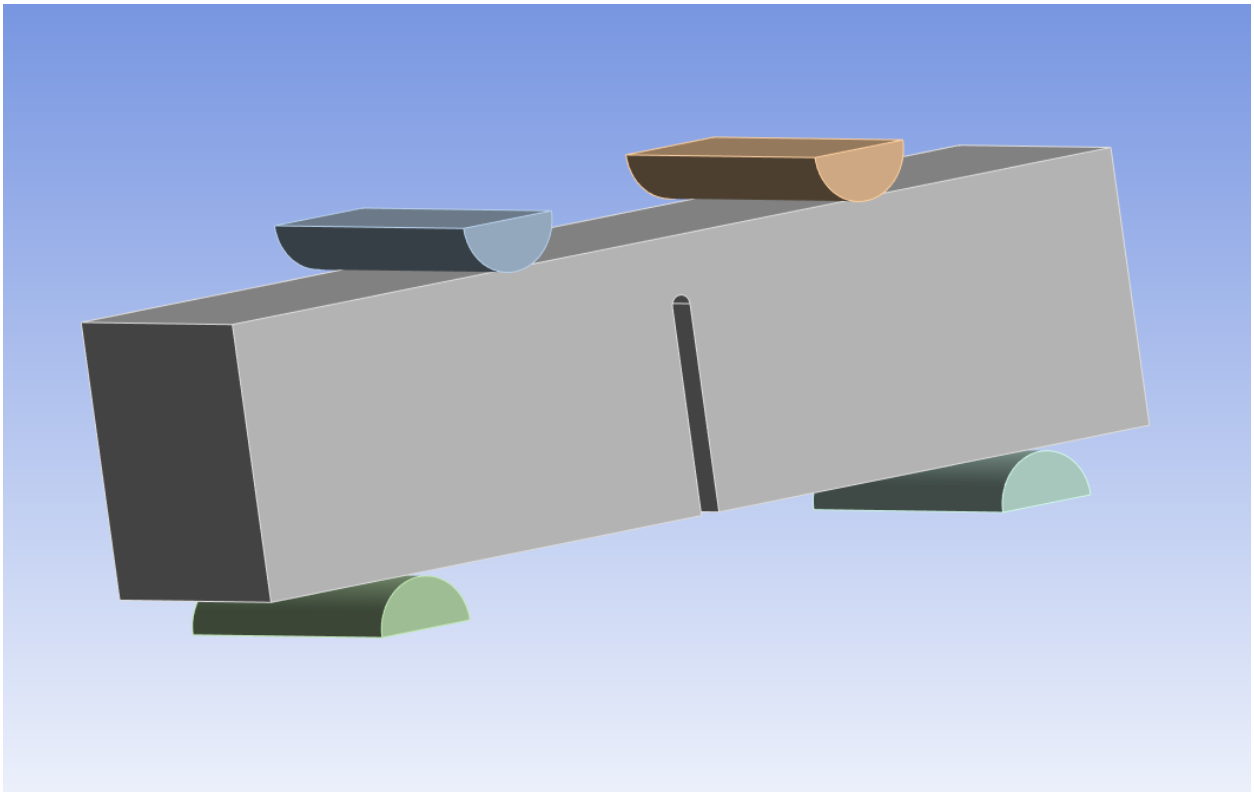


Figure 2. The geometry of the specimen.

Boundary Conditions (Part A&B)

The boundary conditions of support on bottom of the pin is indicated below.

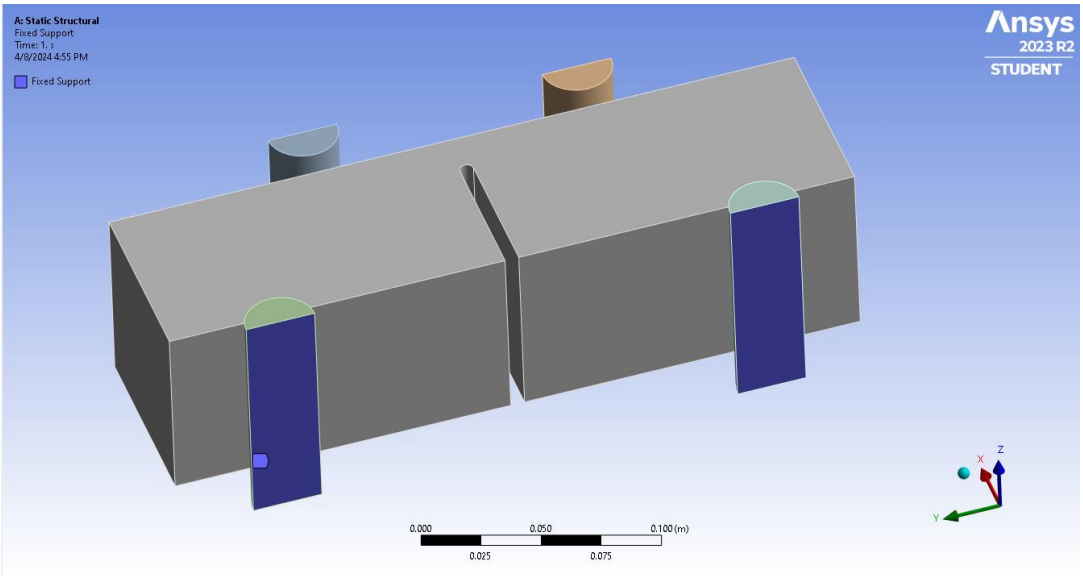
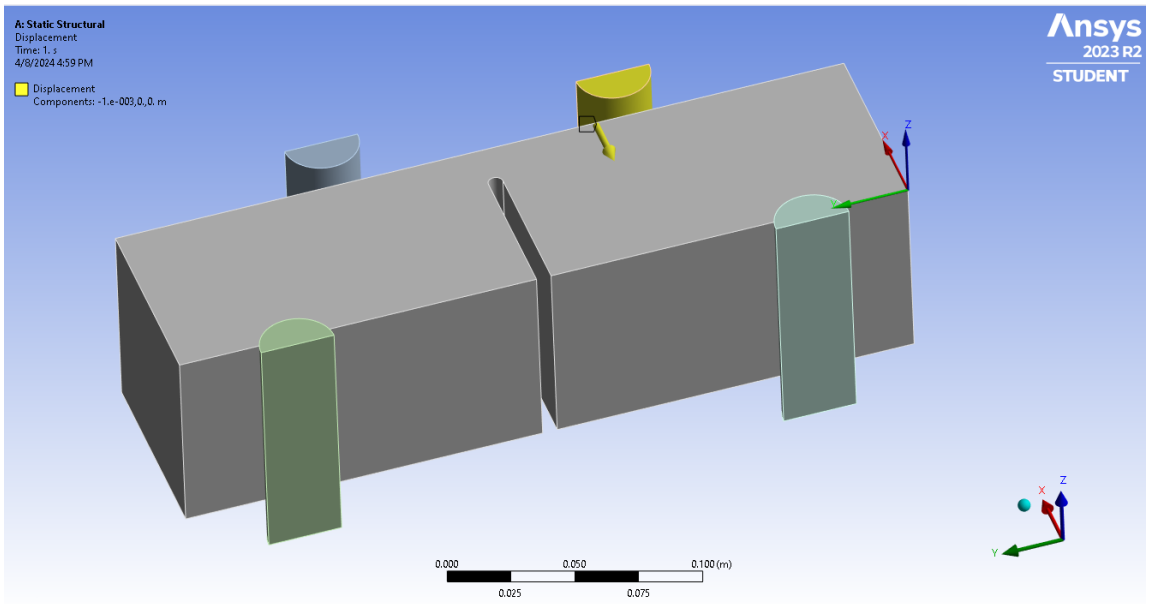
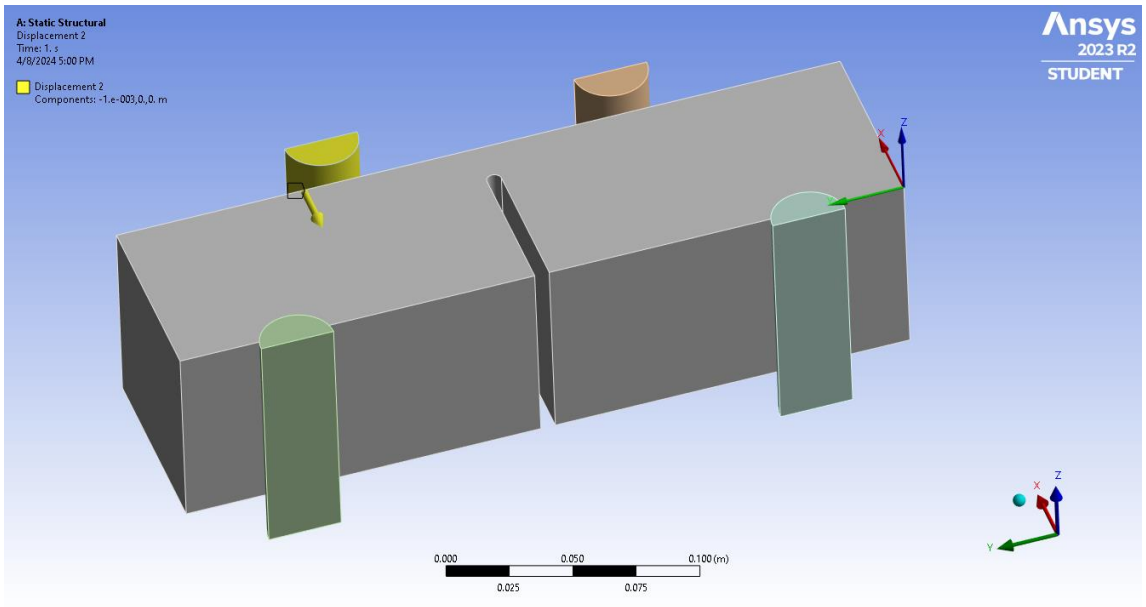


Figure 3. Support BC

Two displacement BCs are indicated below:





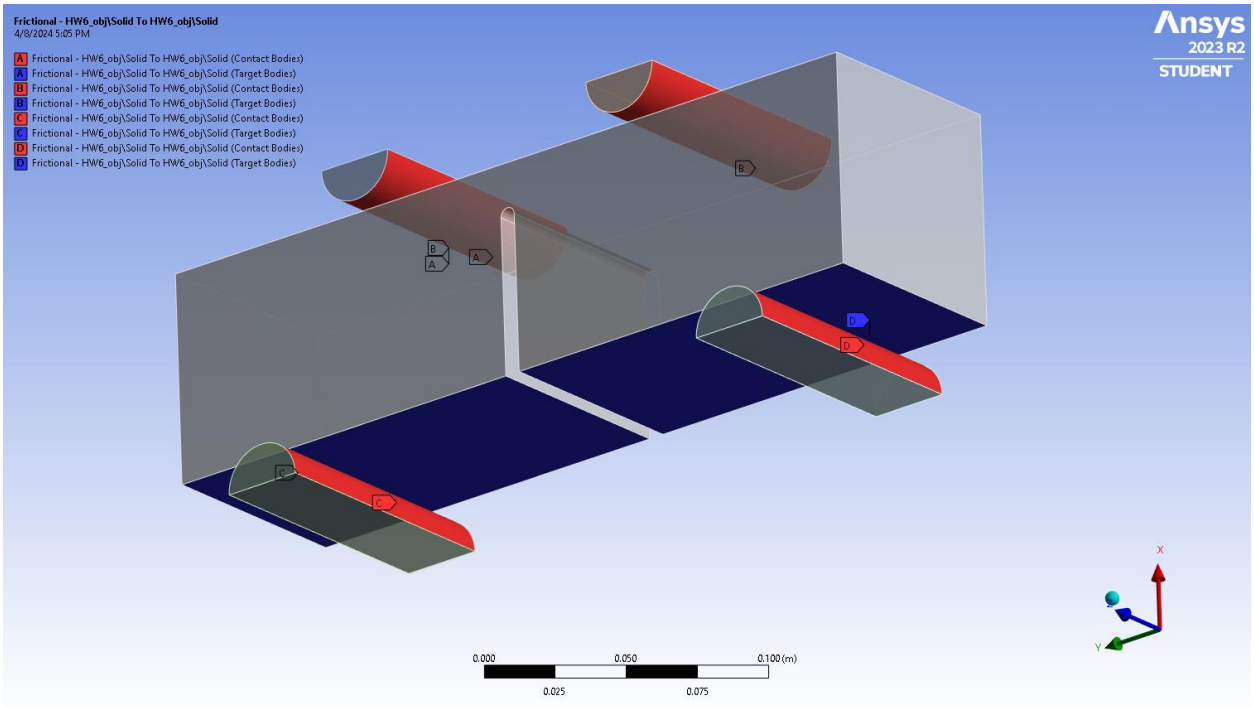
Details of "Displacement 2"

Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Type	Displacement
Define By	Components
Coordinate System	Global Coordinate System
X Component	-1.e-003 m (ramped)
Y Component	0. m (ramped)
Z Component	0. m (ramped)
Suppressed	No

Figure 4. Displacement BCs.

Contacts

The four contacts with a **friction coefficient of 0.15** is indicated below:



Details of "Multiple Selection"

Scope	
Scoping Method	Geometry Selection
Contact	1 Face
Target	1 Face
Contact Bodies	HW6_obj\Solid
Target Bodies	HW6_obj\Solid
Protected	No
Definition	
Type	Frictional
Friction Coefficient	0.15
Scope Mode	Manual
Behavior	Program Controlled
Trim Contact	Program Controlled
Contact APDL Name	
Target APDL Name	
Suppressed	No
Display	
Element Normals	No

Analysis Settings

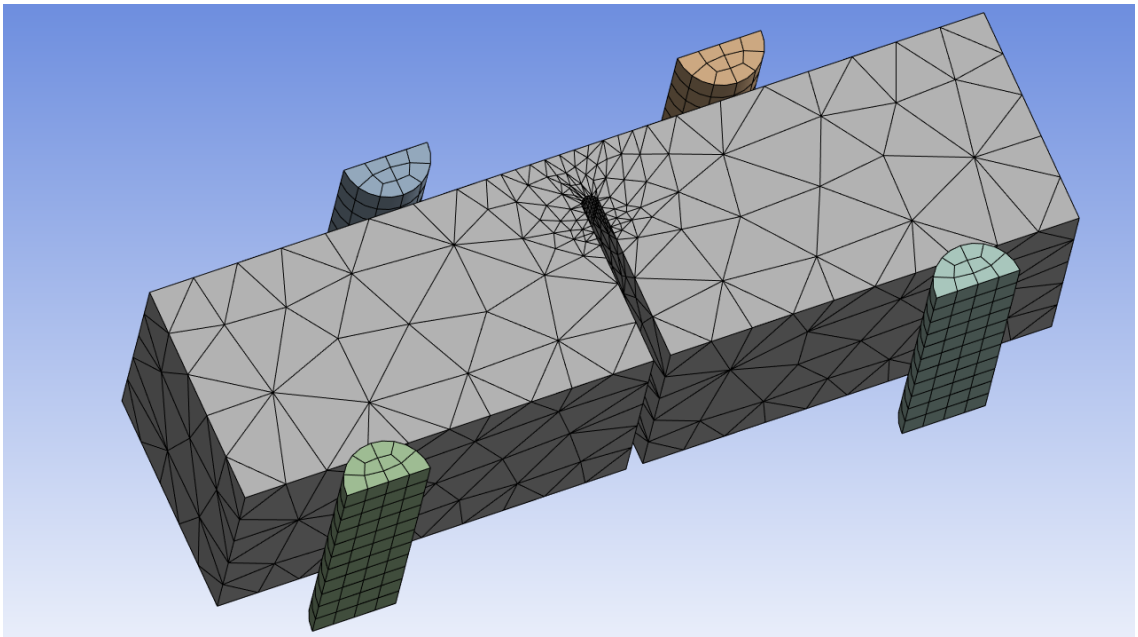
In this case, for the step settings, the sub-step has been settled with slow and careful loads, as indicated below:

Details of "Analysis Settings"

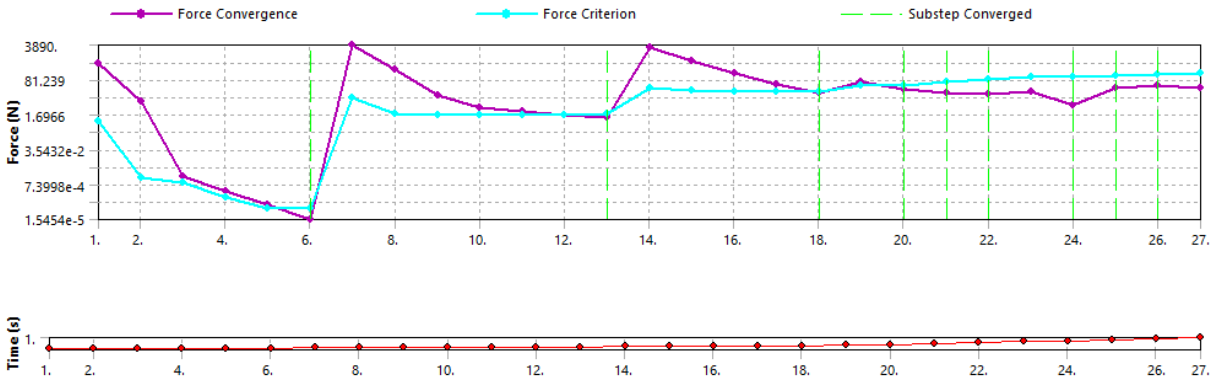
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	On
Define By	Substeps
Initial Substeps	10.
Minimum Substeps	10.
Maximum Substeps	1000.

Mech Settings

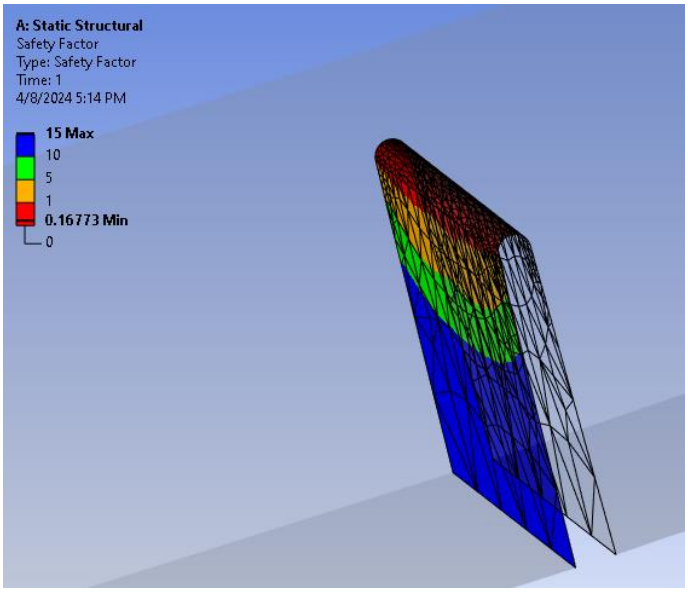
The mesh setting stays at default except for the **refinement factor of 2** around the notch area.



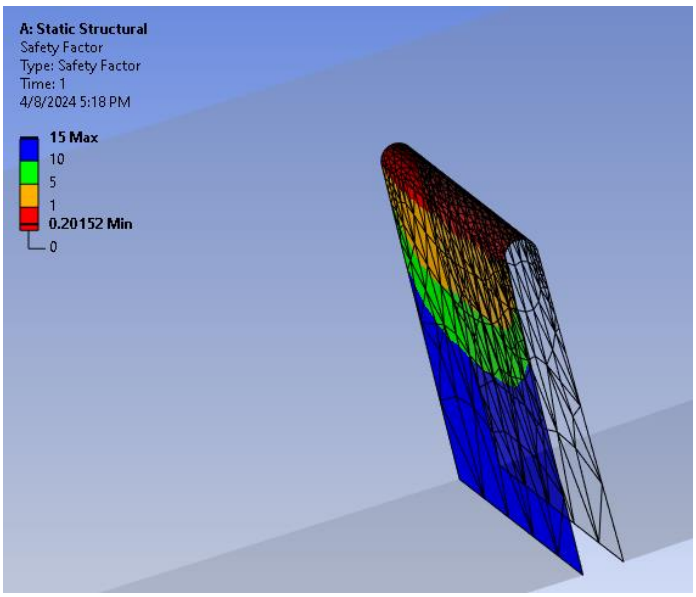
Results (Part A)



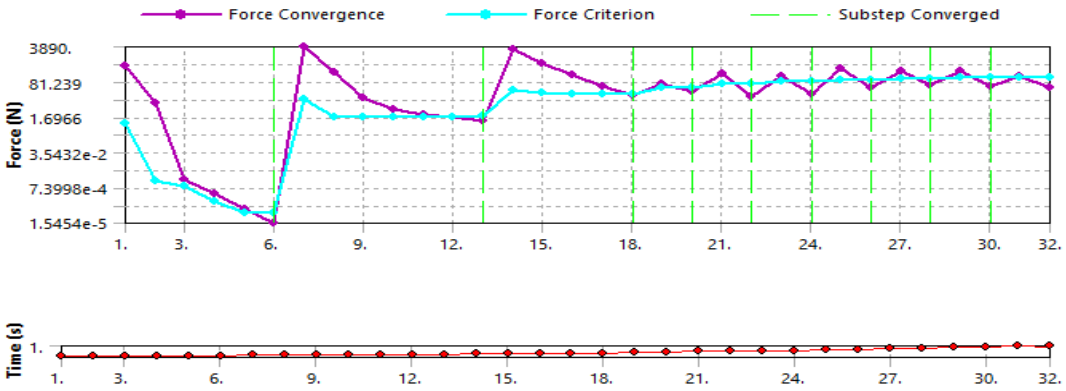
Definition	
Theory	Max Tensile Stress
Stress Limit Type	Tensile Yield Per Material



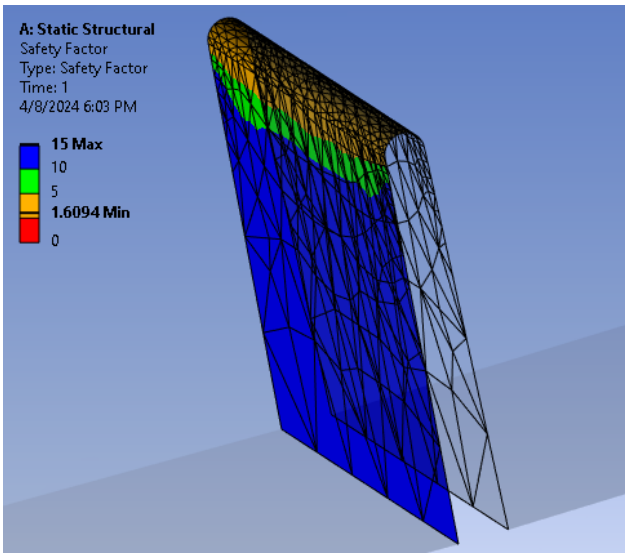
Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Yield Per Material



Results (Part B)

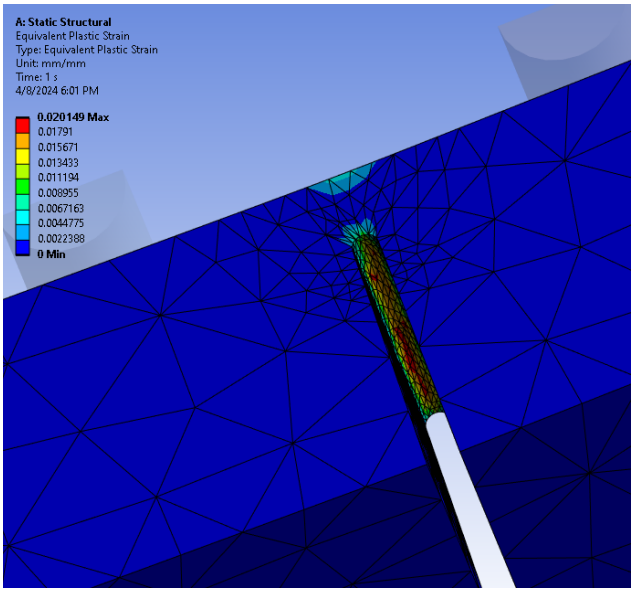


Definition	
Theory	Max Equivalent Stress
Stress Limit Type	Tensile Ultimate Per Material



Details of "Equivalent Plastic Strain"

Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	0. mm/mm
Maximum	2.0149e-002 mm/mm
Average	1.3152e-003 mm/mm
Minimum Occurs On	HW6_obj\Solid
Maximum Occurs On	HW6_obj\Solid



Conclusion

In this assignment, we performed an analysis of nonlinear contact and plasticity of a 4-point bend specimen.

For model contact, implementing robust contact algorithms within the simulation software to accurately capture the interactions between different components during the forming process, and define contact interfaces between the contact and target material helped to correct the model contact.

Over-penetration occurs when the explosive force penetrates the target material excessively, leading to undesirable deformation or damage. To minimize over-penetration, optimize the explosive charge design, including its shape, size, and placement relative to the target material such as the steel pin is slightly wider than the notched alloy.

Based on the result, the strain-rate is not relatively high, so in this case a large deformation is not necessary.

During this assignment, we also explored the difference between elastic and plastic material, as their performance could be completely different under same boundary conditions.