

## 25-650: Applied FEA

### Assignment 6

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Due: 4/8/2024

### Overall Objective

The goal was to calculate the factors of safety at the notch of the 4-point bend specimen configuration under a given load for both linear elastic and nonlinear elastic-plastic responses.

### Assumptions

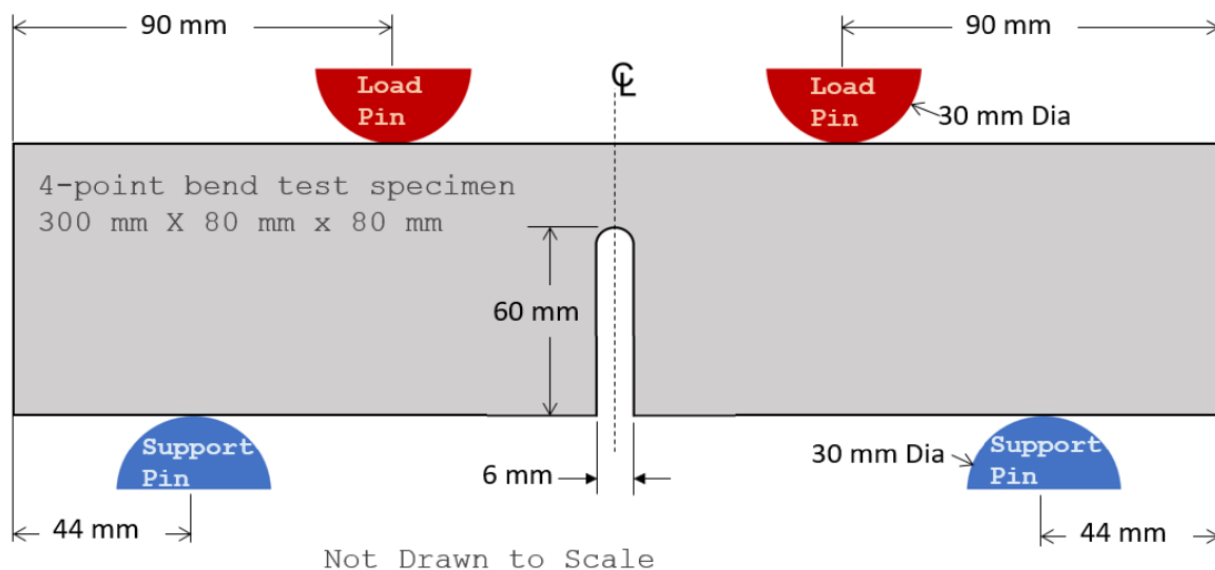
For all situations below, it is assumed that the 2 bottom faces of the support pins are fixed in place and the 2 top faces of the load pins are constrained in the x- and z- direction with an imposed deformation of 1mm in the negative y-direction. Also, it is assumed that there is frictional behavior between all contact surfaces with a coefficient of 0.15.

### Summarized Results

**Part A:** FS1 = 0.13, FS2 = 0.16

**Part B:** FS3 = 1.25, Max equivalent plastic strain = 0.0033 mm/mm

### Geometry



**\*\*Pins are 100mm in length (10mm longer on each side of the specimen)**

## Material Data

The materials used were machine steel for the load and support pins and soft aluminum alloy for the specimen.

**Soft Aluminum Alloy:**  $E = 67 \text{ GPa}$ ,  $\nu = 0.33$ ,  $S_y = 220 \text{ MPa}$ ,  $S_u = 640 \text{ MPa}$

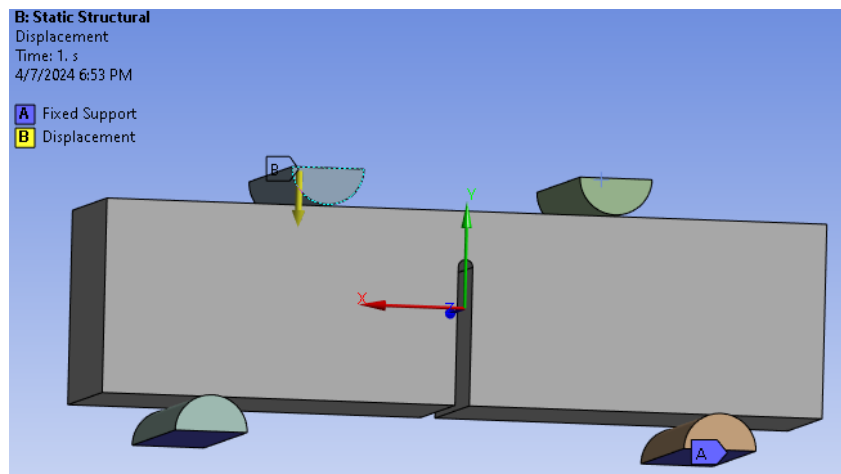
(For elastic-plastic response: Bilinear Kinematic Hardening with  $E_T = 9.0 \text{ GPa}$ )

**Machine Steel:**  $E = 205 \text{ GPa}$ ,  $\nu = 0.29$

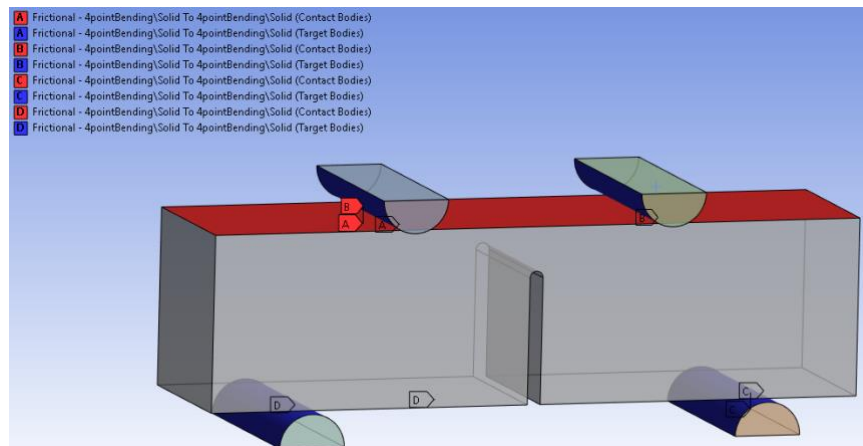
## Boundary Conditions

For this analysis, the following conditions were used:

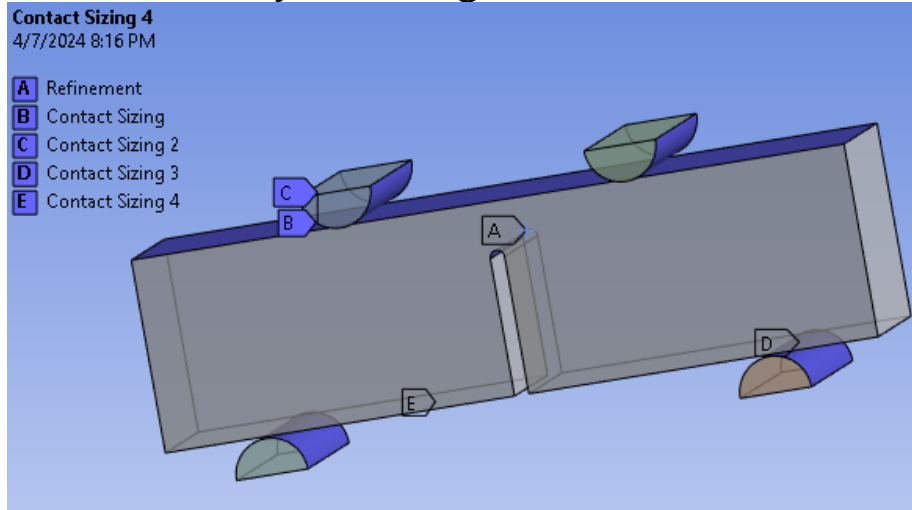
- Fixed support along 2 bottom faces of the support pins
- Constrained in the x- and z- direction with an imposed deformation of 1mm in the negative y-direction along the 2 top faces of the load pins



- Contacts are assumed to be frictional with a constant of 0.15

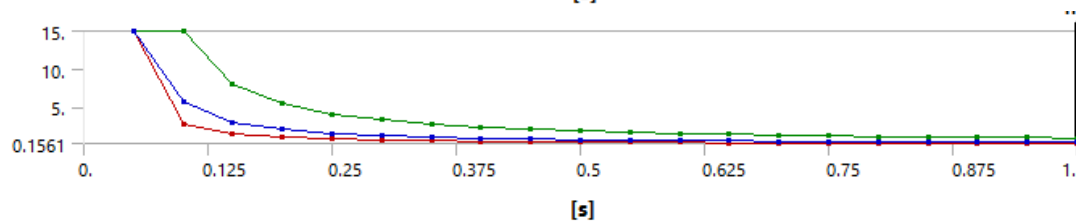
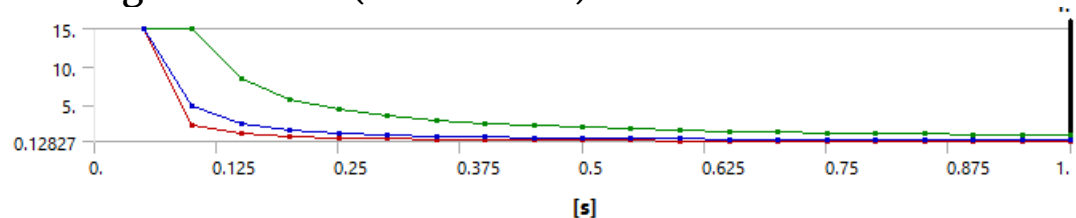


## Mesh and Analysis settings

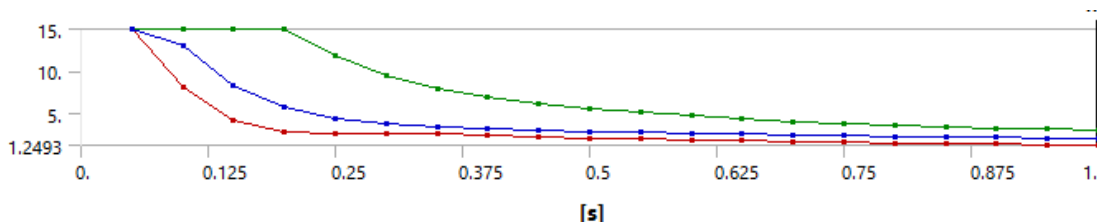


Refinement of level 2 along the face of the curved notch. Convergence studies were not required for this report. To address excessive penetration, mesh contact sizing was added along all the contacts. Also, autotime stepping was turned off and 20 substeps were used to slowly load the specimen and achieve accurate converged results.

### Convergence Part A (FS1 and FS2):

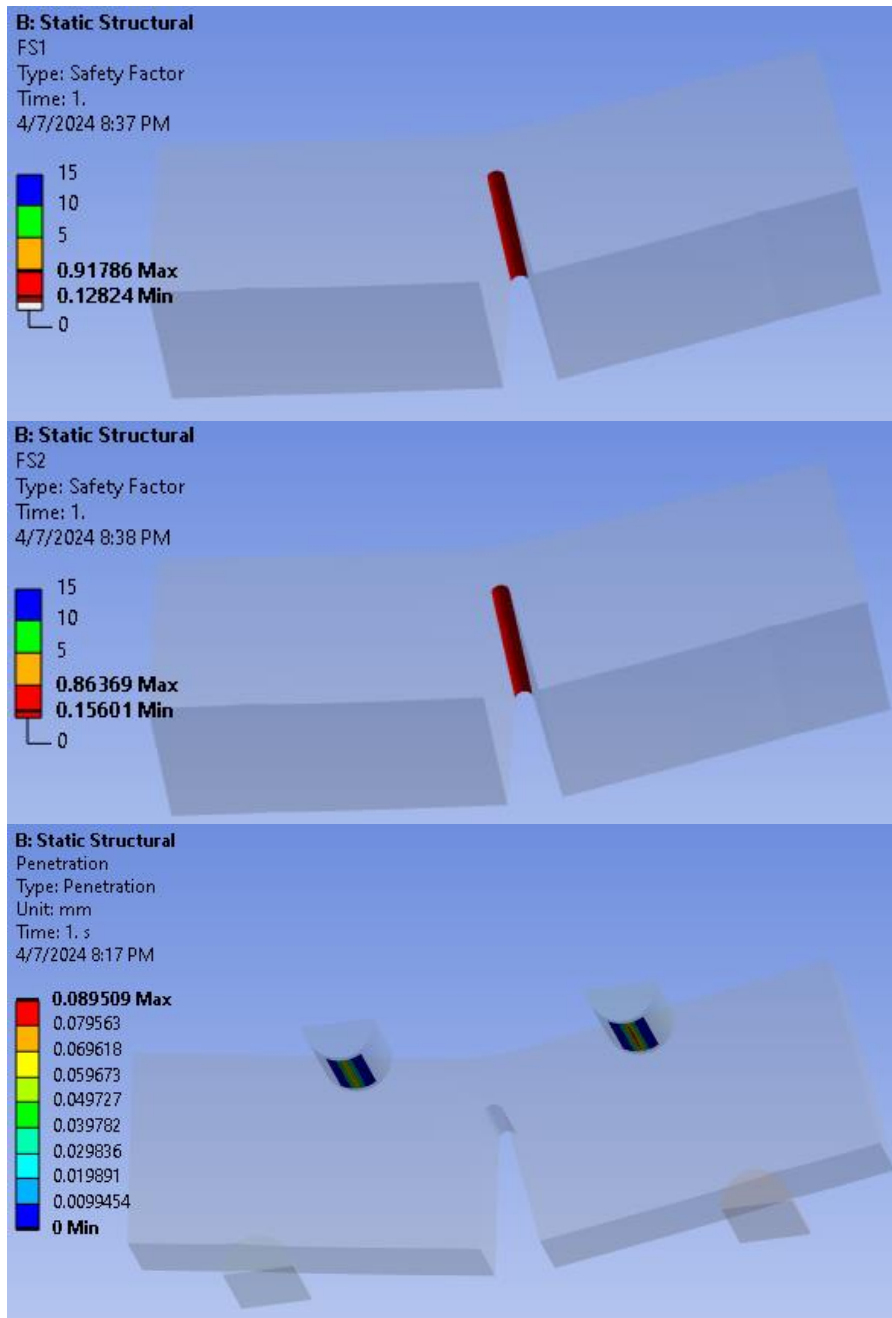


### Convergence Part B (FS3):

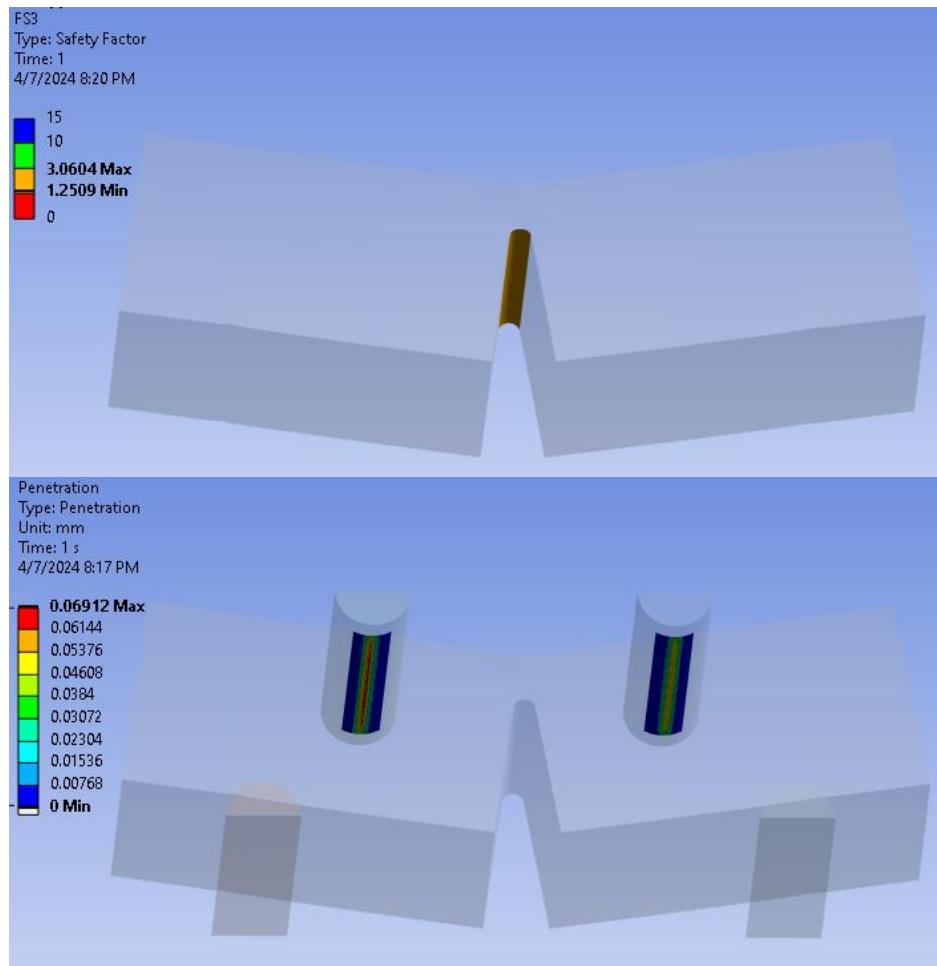


## Full Results

### Part A:



## Part B:



## Conclusion

Overall, the results of the simulations make sense given the conditions used. The goals of the analysis were achieved. Penetration was able to be minimized using contact sizing and numerous sub-steps to achieve slow loading and accurately converged results.