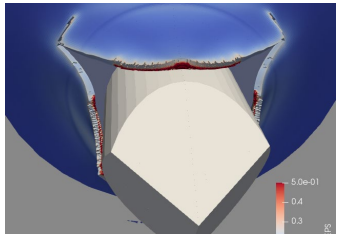
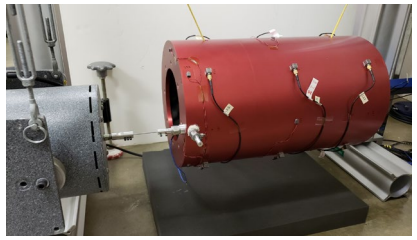
Correlation of ROMs of a Threaded Fastener





Students:

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Mentors:

Neal Hubbard, John Mersch, Jonel Ortiz, Emily Miller, Jeff Smith, and Tariq Kharishi

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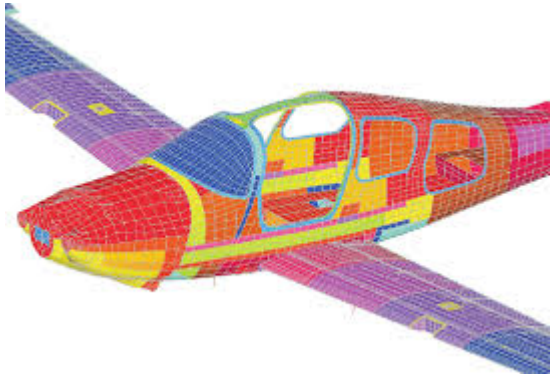
SAND2020-7662 PE

Presentation Contents

- Introduction
- Model Set-up
- Initial Predictions
- Calibrated Models
- Intermediate Angles Results
- Conclusion

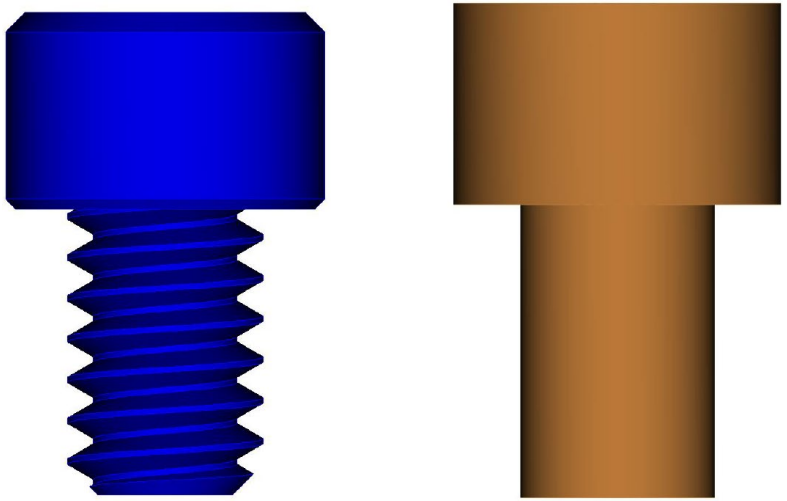
Introduction

Motivation: How many fasteners?



HURLEY, T. AND VANDEMBURG, J., "SMALL AIRPLANE CRASHWORTHINESS DESIGN GUIDE" 2002.

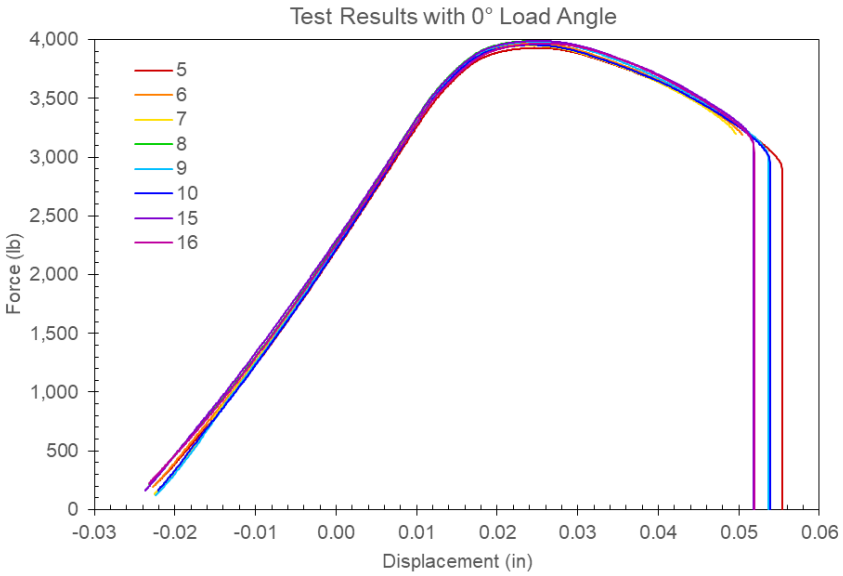
- Fasteners are everywhere: from phones to cars to planes
- Failure can lead to minor inconveniences to major catastrophes
- High-fidelity models of threaded fasteners computationally expensive
- Reduced-order models (ROMs) can be an effective method to replicate the response

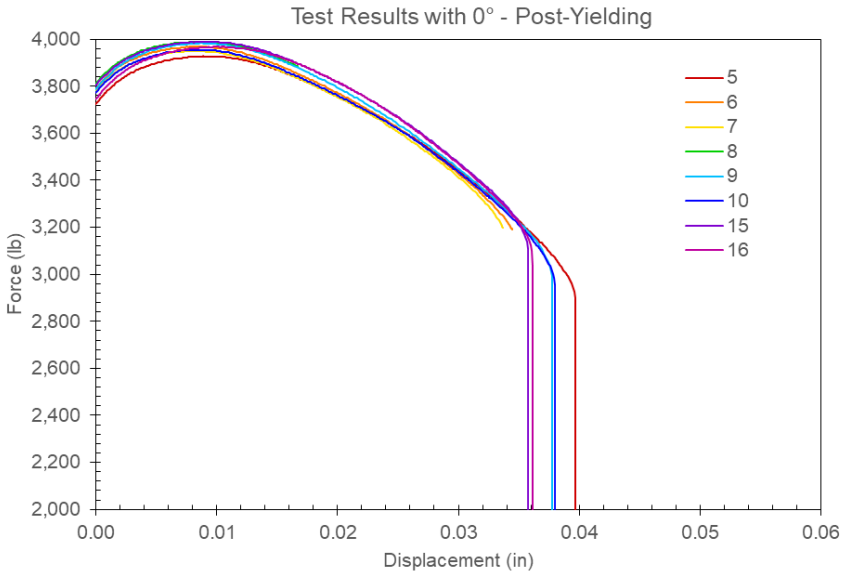


ORTIZ, J., "COMMONLY USED PRELOADING METHODS," 2019.

Project Goals

- Generate **blind predictions** for ROMs based on **nominal parameters**
- Calibrate **plastic response** of the ROMs to **experimental data** from collaboration with UNM
- Evaluate the **plastic response** of **intermediate angles** using calibrated model

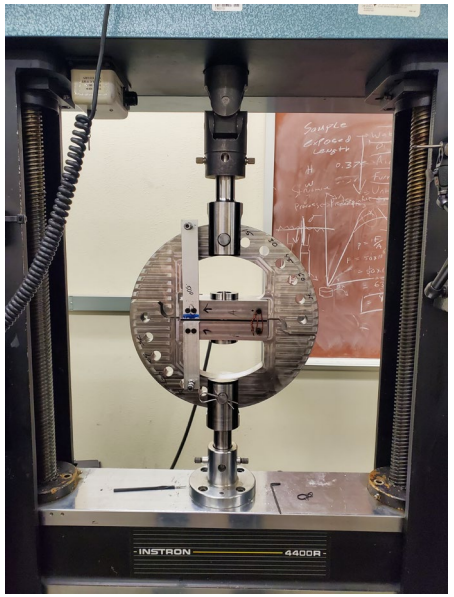


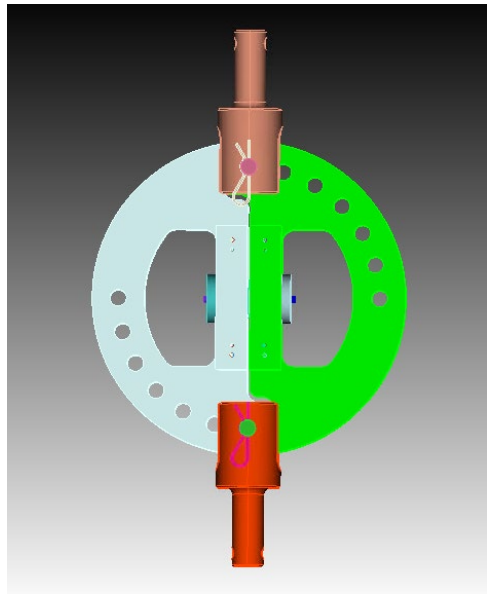


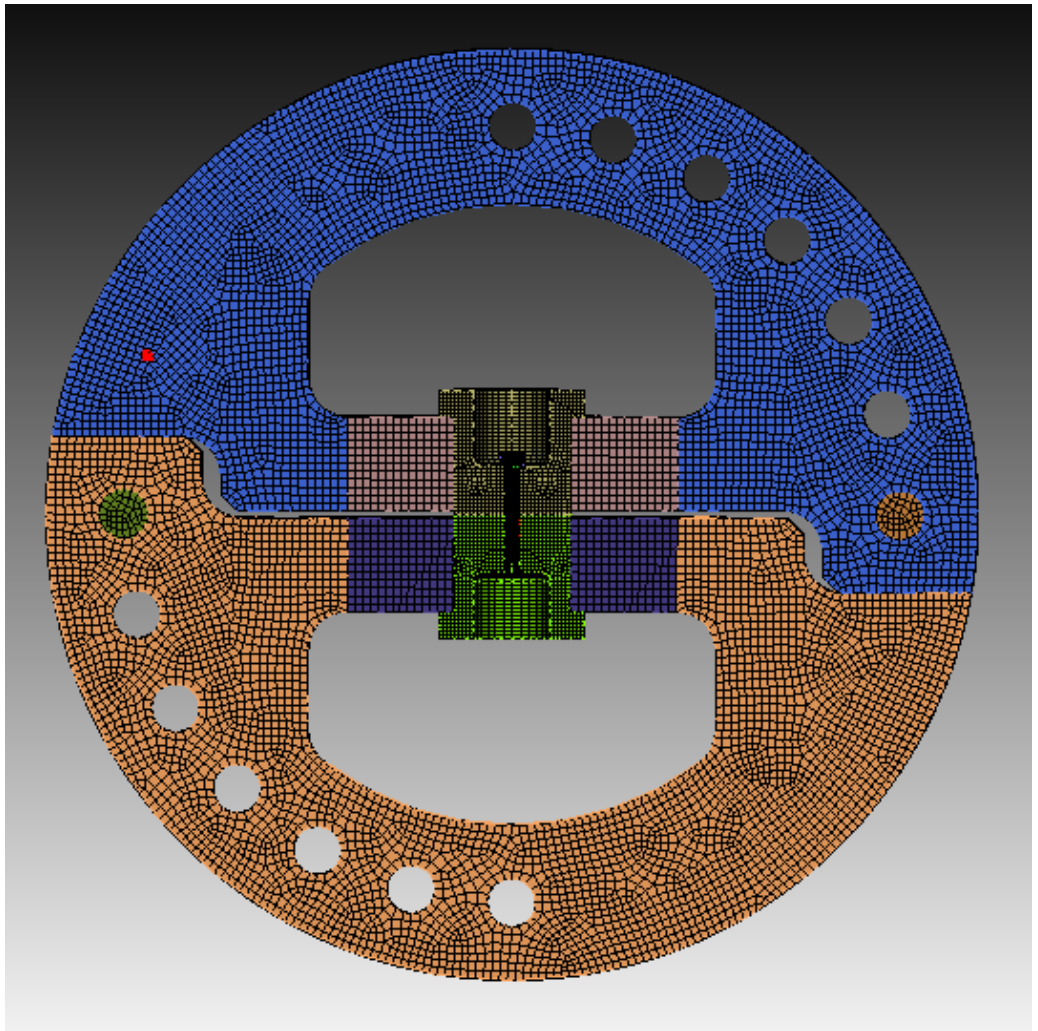
Model Set-up

Fixture Model

- D-rings with holes from 0° – 90° spaced 15° apart
- Fastener held in by bushings
- Model must be defeatured for meshing
  - Removed clevis assembly and detailed features
  - Webcut half of the fixture geometry on the symmetric plane
  - Placed clevis rods at each load angle
  - Used a fine mesh for the bushings and fastener if one was included

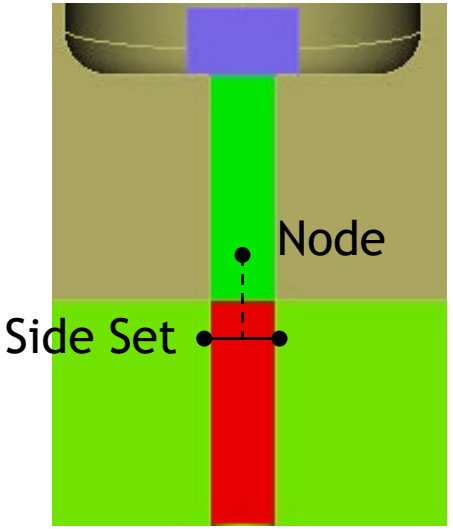




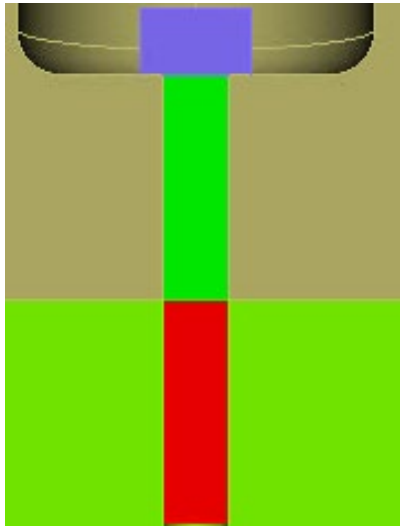


Reduced Ordered Models

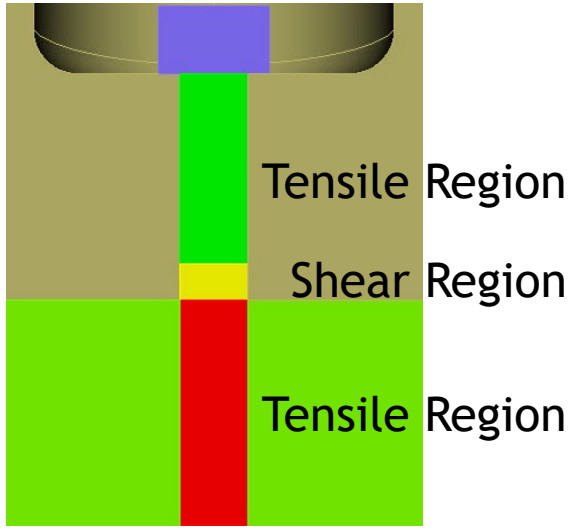
- Spot Weld
  - Applies a force-displacement relationship in tension and shear to a node-side set pair
- One-Block Plug
  - Single set of material properties
  - Calibrated to tensile data
- Two-Block Plug
  - Two sets of material properties
  - Tensile region calibrated to tensile data
  - Shear region calibrated to shear data



Spot Weld



One Block Plug



Two Block Plug

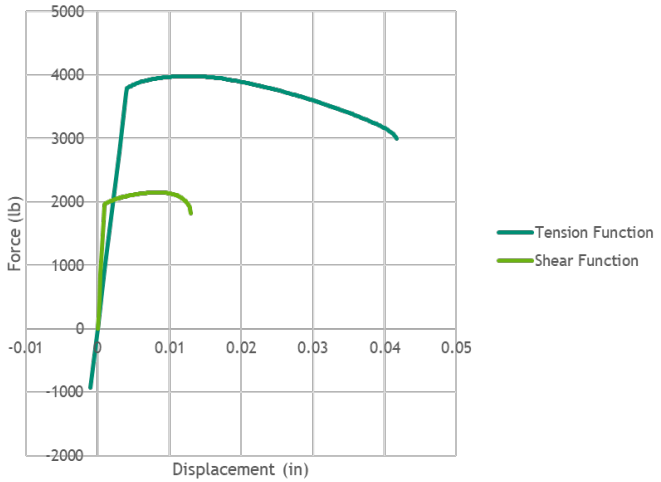
Material

- **Fixture 4340 Steel**
  - Young's Modulus: 30.4e6 psi
  - Density: 7.33 g/cc
  - Poisson's Ratio: 0.32
  - Yield Stress: 142.7 ksi
- **Fastener (A574) Tensile Region**
  - Effective Young's Modulus*: 21.1e6 psi
  - Yield Stress: 155 ksi
  - Poisson's Ratio: 0.3
- **Fastener (A574) Shear Region**
  - Effective Yield Stress: 90 ksi (~60% of tensile region)
  - Rest as Tensile Region

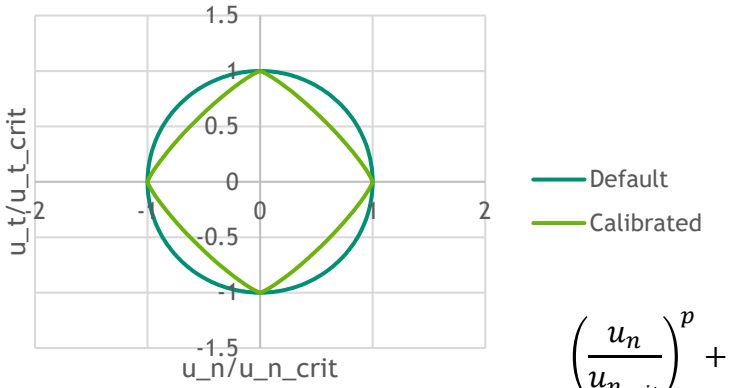
*Effective Young's Modulus

$$\frac{F}{A} = E\frac{\Delta x}{L} \longrightarrow E_2 = \frac{A_1}{A_2}E_1$$

- **Spot Weld Tension and Shear Functions**



- **Spot Weld Failure Envelope**



$$\left(\frac{u_n}{u_{n_{crit}}}\right)^p + \left(\frac{u_t}{u_{t_{crit}}}\right)^p \geq 1.0$$

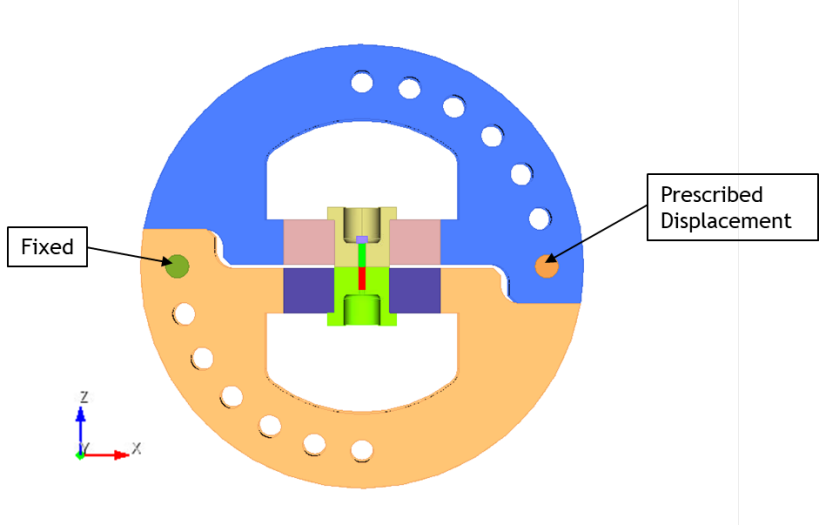
Loading and BC

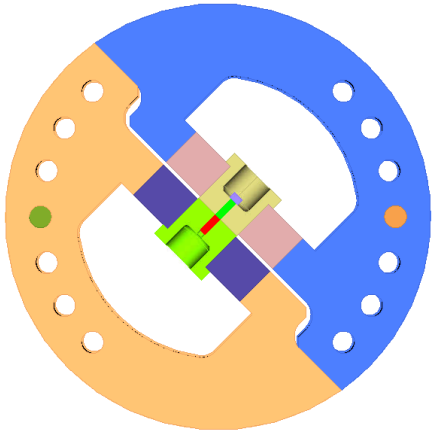
General

- Experimental loading condition
  - Fixed Constraint
  - Prescribed Displacement in x
- Symmetry in Y to account for half model
- Surface contacts

Spot Weld

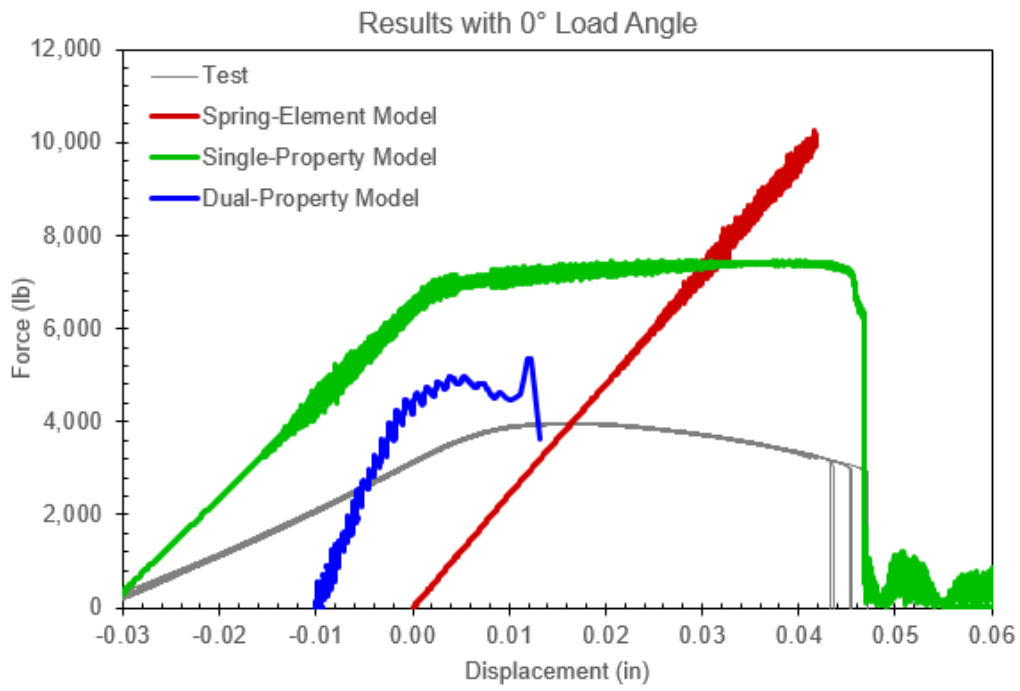
- Rigid surfaces for spot weld

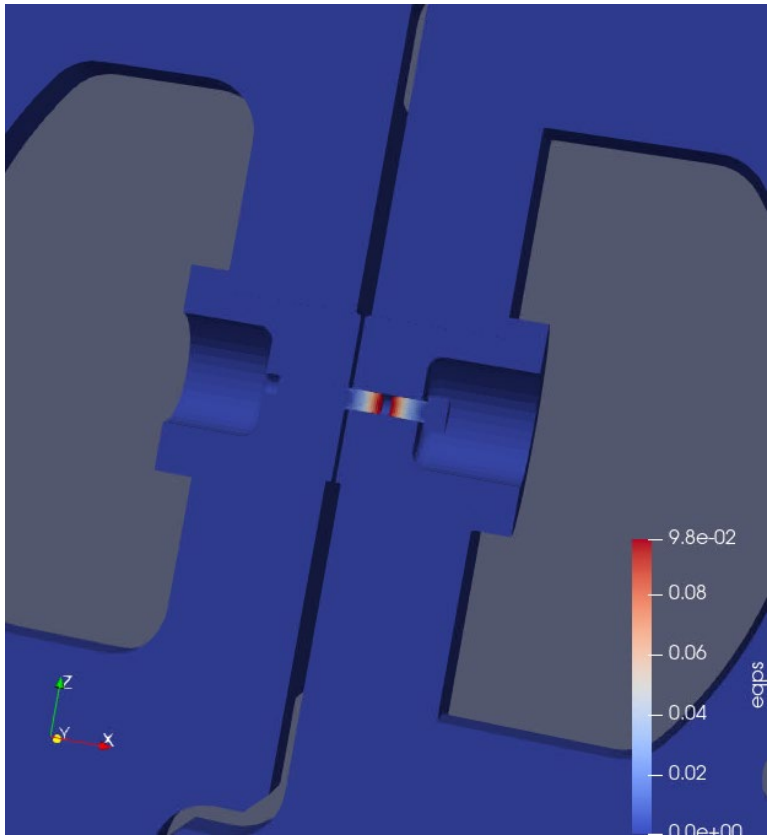




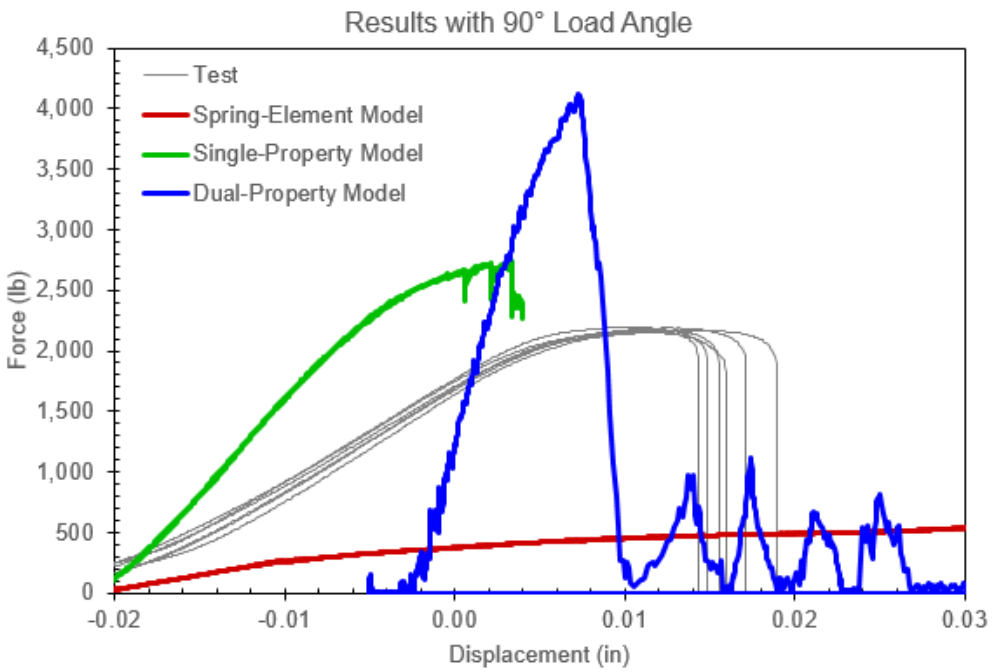
Initial Results

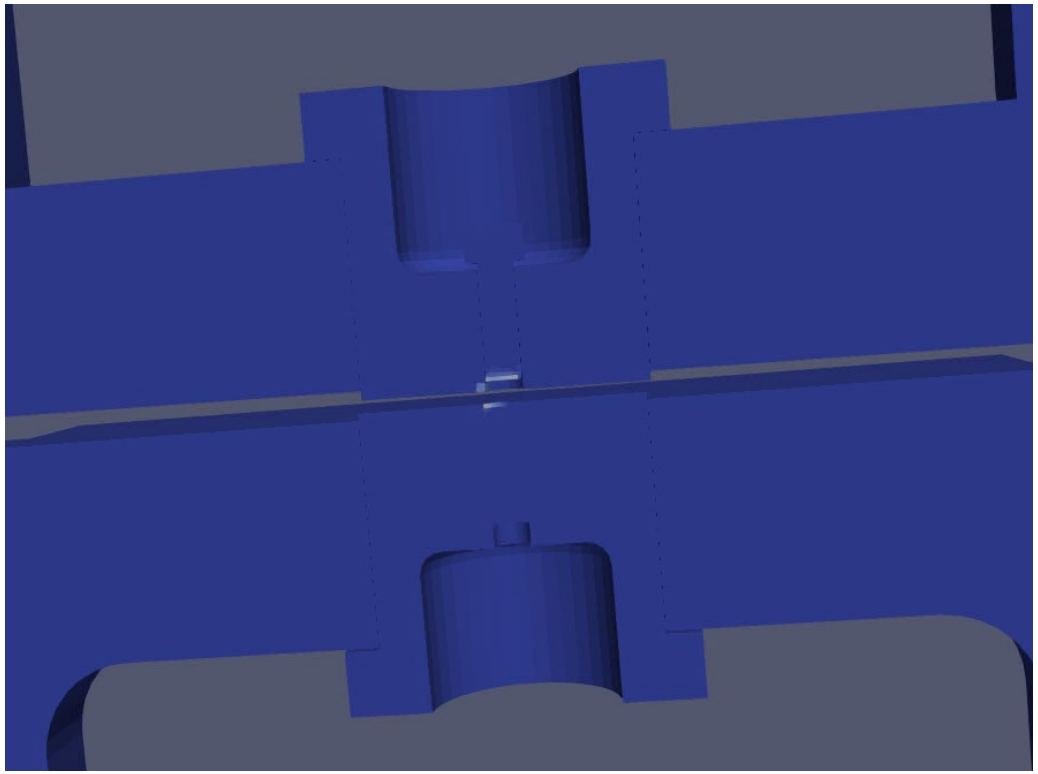
Initial Prediction - Tension





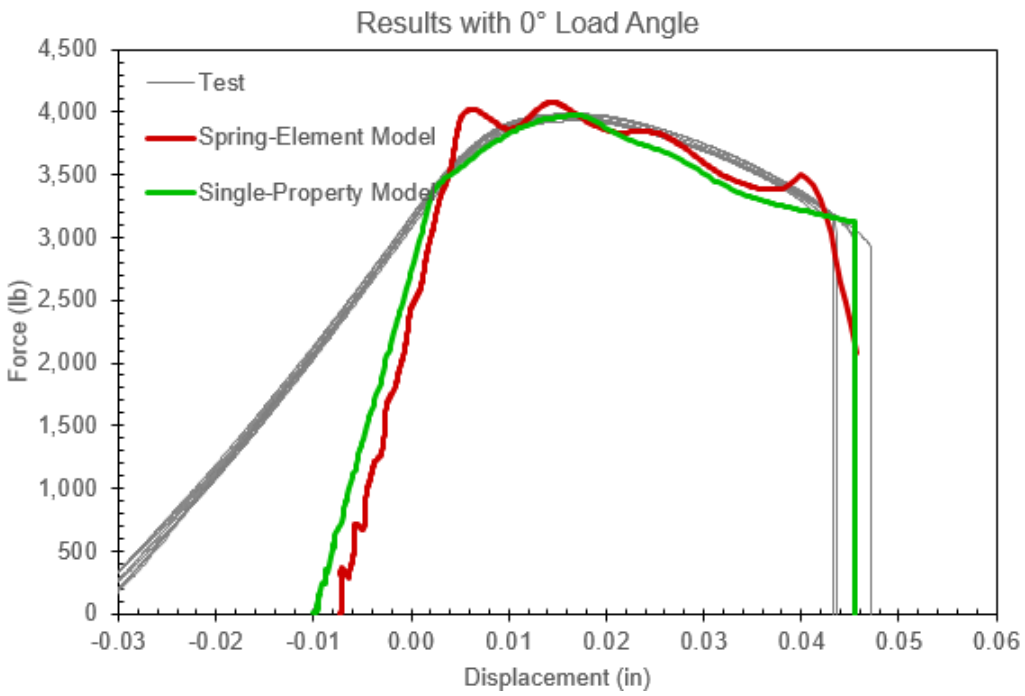
Initial Prediction - Shear

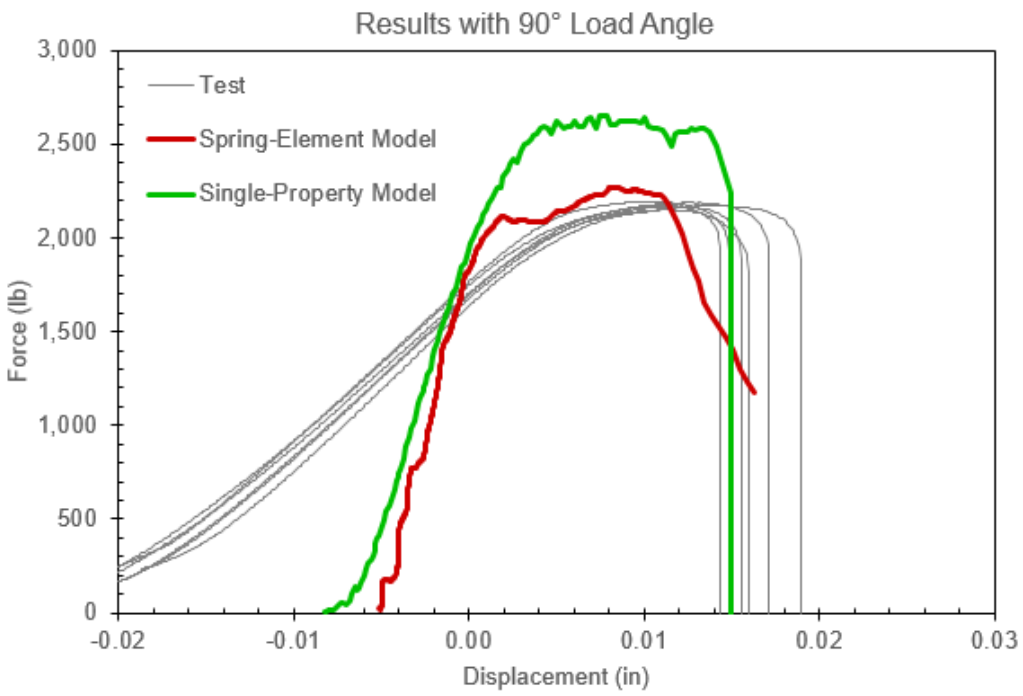




Calibrated Models: Results

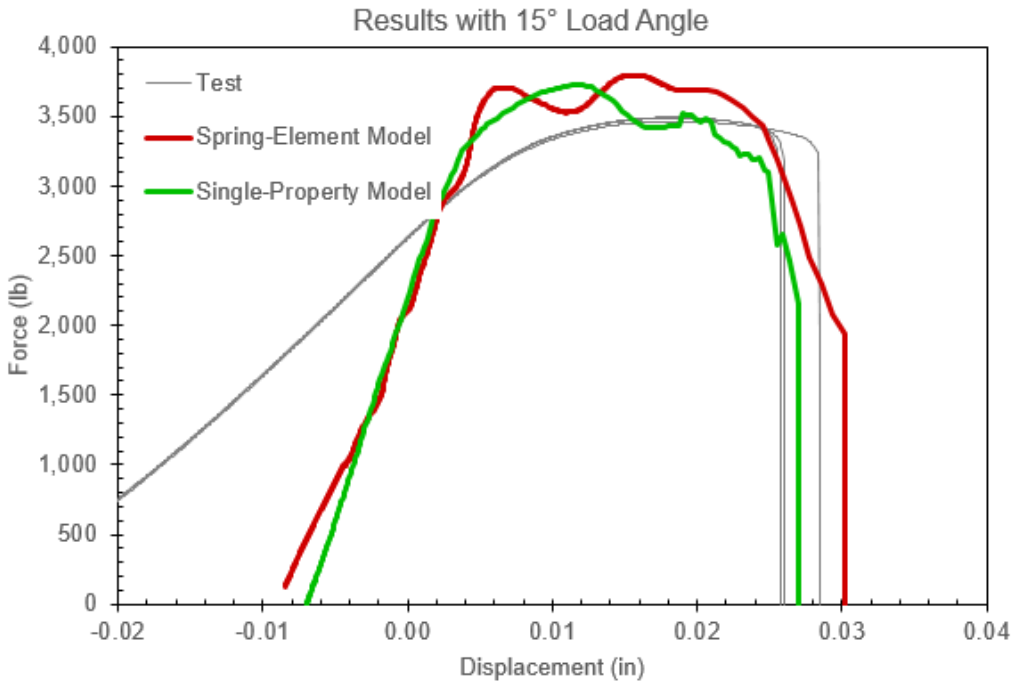
Calibrated Results: Tensile and Shear

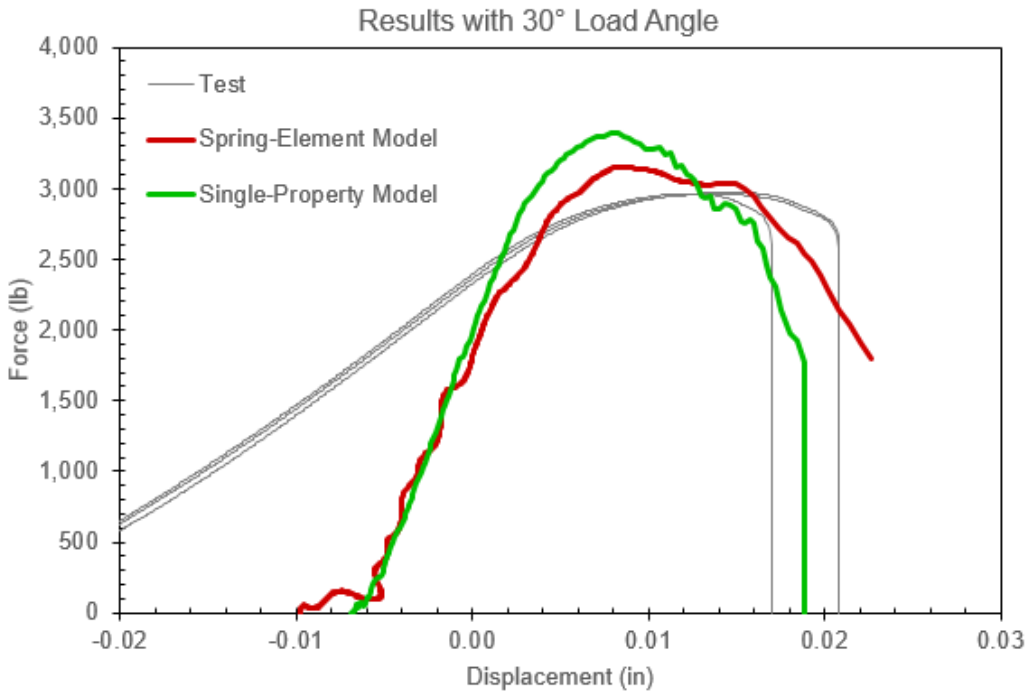




Intermediate Angles: Results

Intermediate Angles after Calibration





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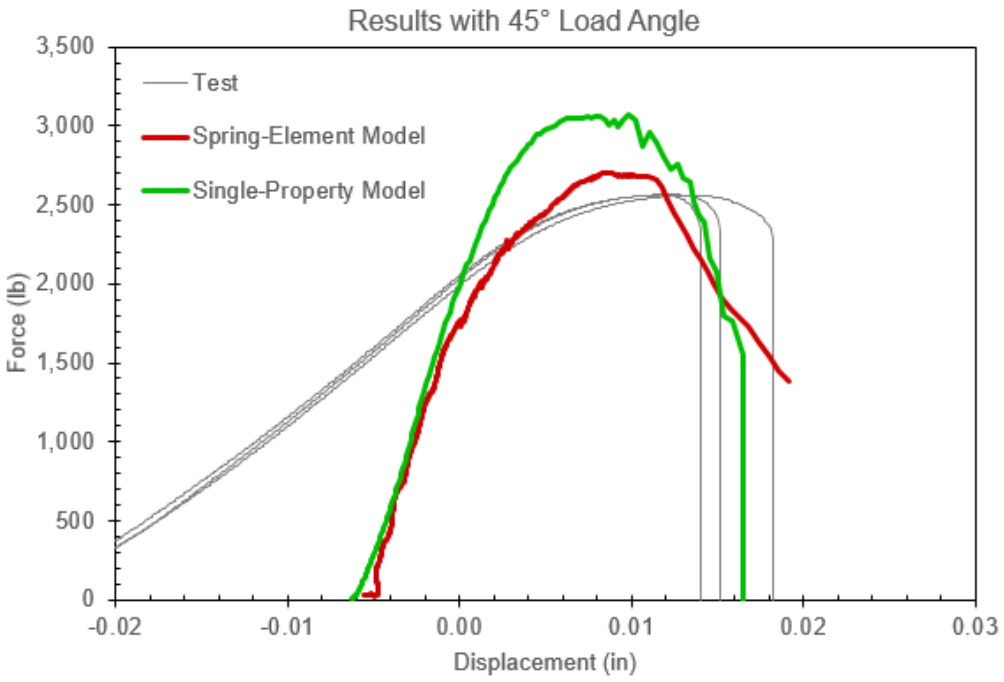
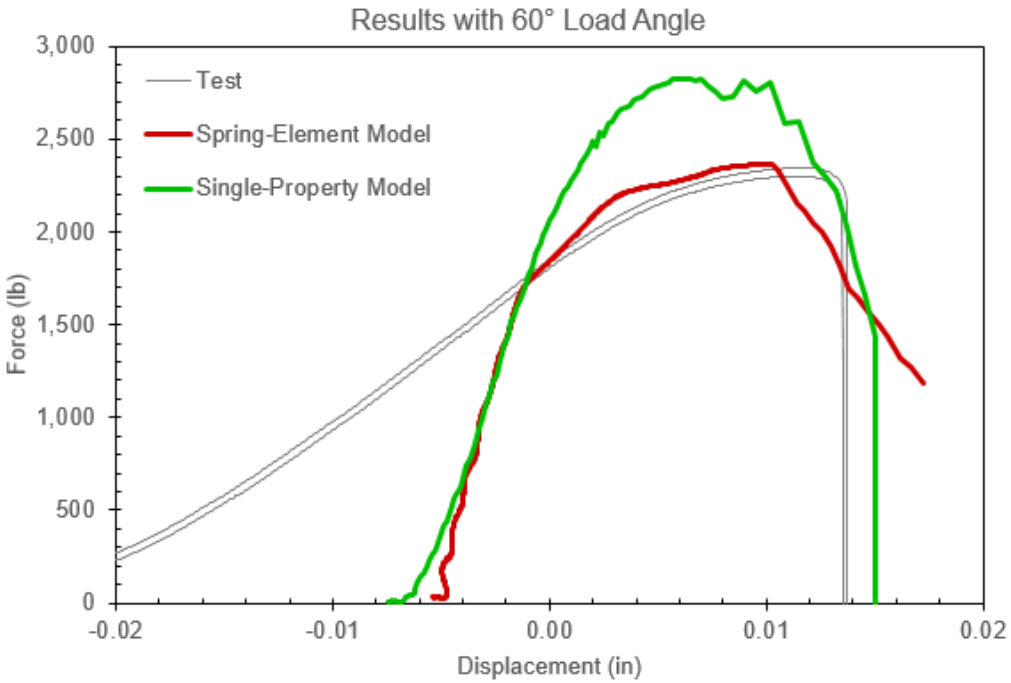
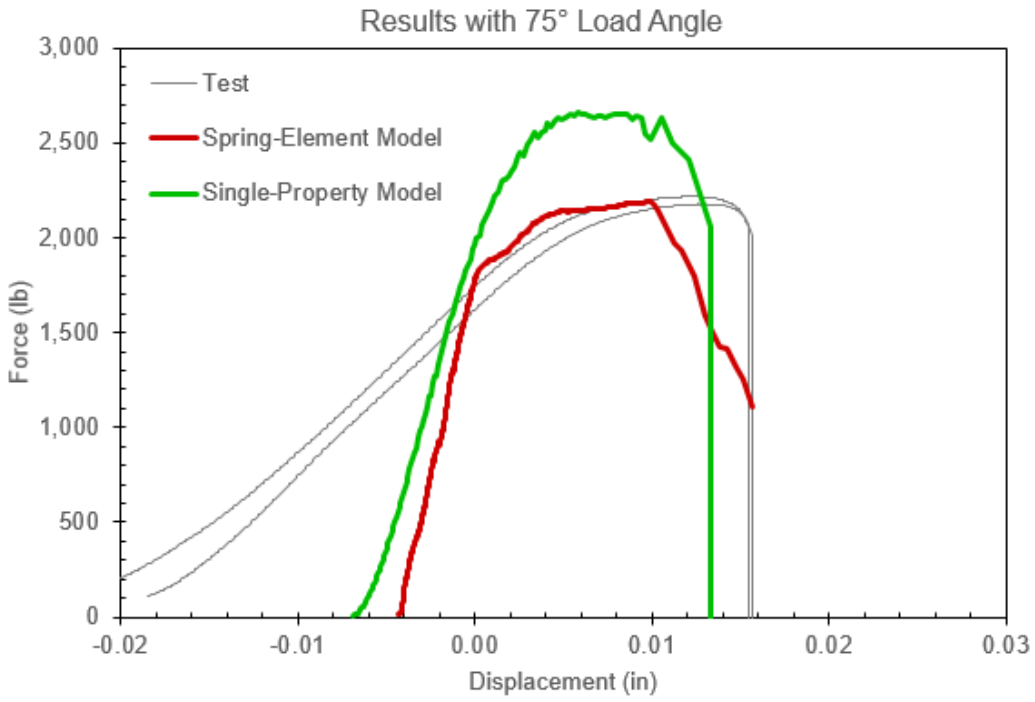




Intermediate Angles after Calibration

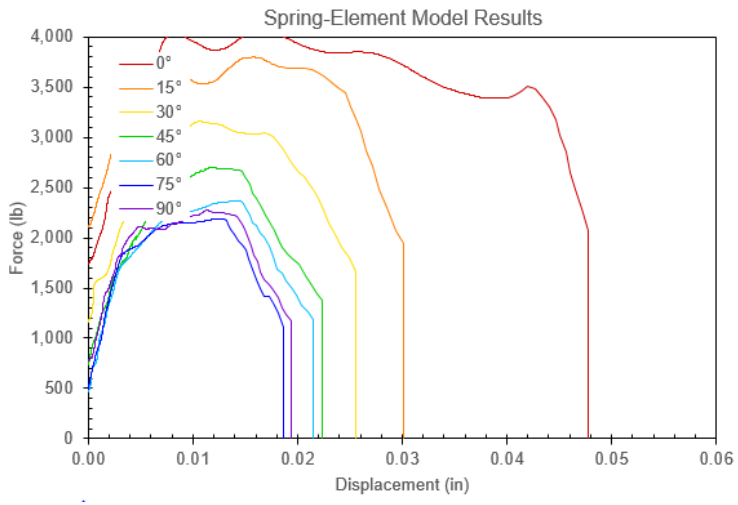


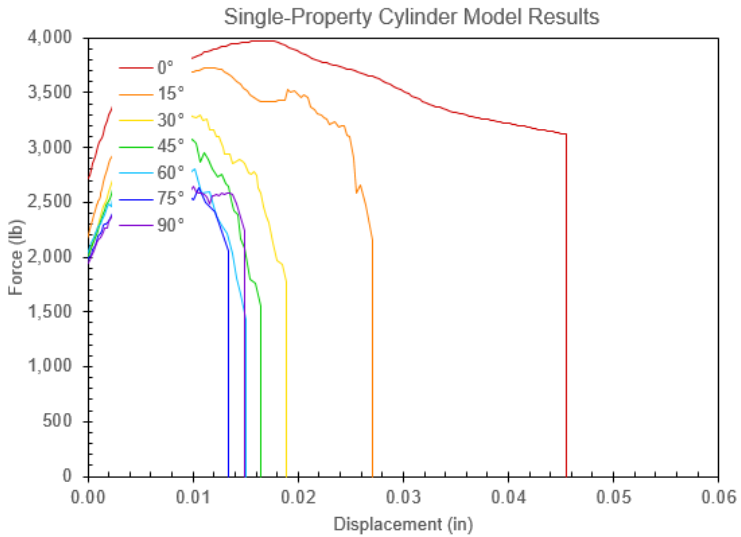
Conclusion

Concluding Remarks

Spring Model Hardening follows the magnitude of the curve and failure point quite effectively

One Block Plug takes longer to tune but can follow the Load/Displacement of a particular angle





Acknowledgements

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Thank you!

Questions?