Correlation of ROMs of a Threaded Fastener

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Introduction
Motivation: How many fasteners?

- 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
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
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

\[ \frac{F}{A} = E \frac{\Delta x}{L} \quad \Rightarrow \quad E_2 = \frac{A_1}{A_2} E_1 \]

**Spot Weld Tension and Shear Functions**

**Spot Weld Failure Envelope**

\[ (\frac{u_n}{u_{n\text{crit}}})^p + (\frac{u_t}{u_{t\text{crit}}})^p \geq 1.0 \]
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

Results with 0° Load Angle

- Test
- Spring-Element Model
- Single-Property Model
- Dual-Property Model
Initial Prediction - Shear
Calibrated Results: Tensile and Shear

Results with 0° Load Angle

Results with 90° Load Angle
Intermediate Angles: Results
Intermediate Angles after Calibration
Intermediate Angles after Calibration
Intermediate Angles after Calibration

![Graph showing results with 75° Load Angle]
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

This research was conducted at the 2020 Nonlinear Mechanics and Dynamics Research Institute hosted by Sandia National Laboratories and the University of New Mexico.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-NA-0003525.
Thank you!
Questions?