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Analysis of Defective Socket Head Bolts at High Strain Rates

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ME 6203 Final Project

Preliminary Report

Sandia National Laboratories

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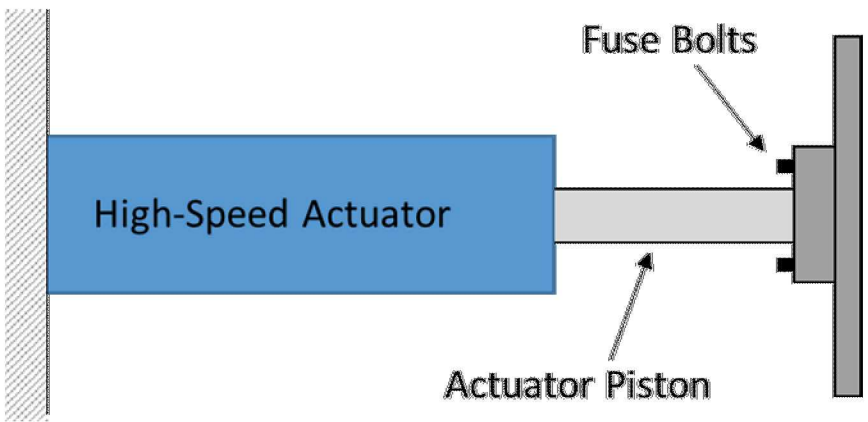
Introduction and Motivation

- Fuse bolts are used to protect high-speed actuator piston from bending during dynamic experiments
- A 3/8” fuse bolt fractured unexpectedly due to a manufacturing defect in the connection between the bolt head and shank
- Need to better understand how the defect caused fracture and the overall behavior of socket head fuse bolts at high strain rates



Top view: normal socket head bolt

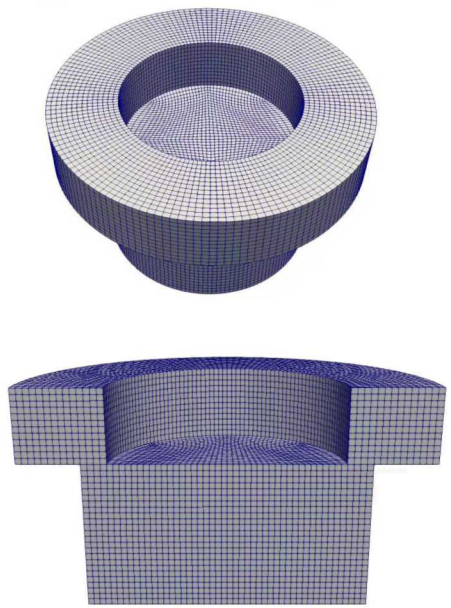
Top view: defective socket head bolt

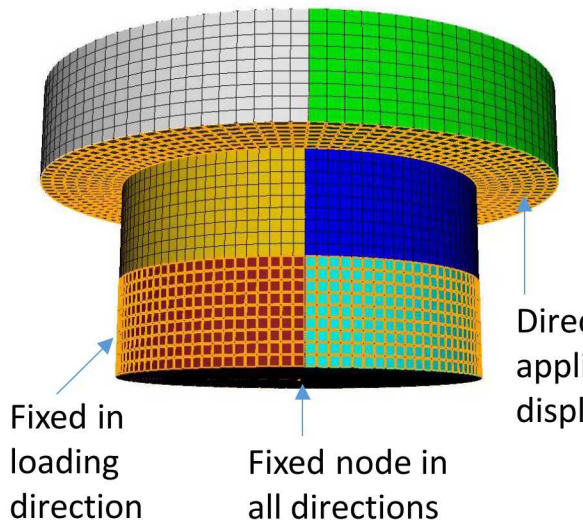
Bottom view: fractured defective socket head bolt

Material Model and Modeling Inputs

- SIERRA SM explicit dynamics FEM software
- Johnson-cook plasticity model
  - High strain rates and finite strains
  - Rate and temperature-dependent hardening function
  - Damage is defined as cumulative effective plastic strain
- Hexagonal solid elements
- Boundary conditions for simplified geometry:
  - 200 in/sec displacement applied to bearing surface of bolt head
  - Threaded section fixed in loading direction
  - Center node at bottom of bolt shaft is fixed in all directions to prevent rigid body motion

Material properties for Johnson-Cook	
Youngs Modulus, psi	2.80E+07
Poisson's Ratio	0.33
Yield Stress, psi	130000
Shear Modulus, psi	2.49E+05
Hardening Constant	5.00E+09
Hardening Exponent	2.28E-01

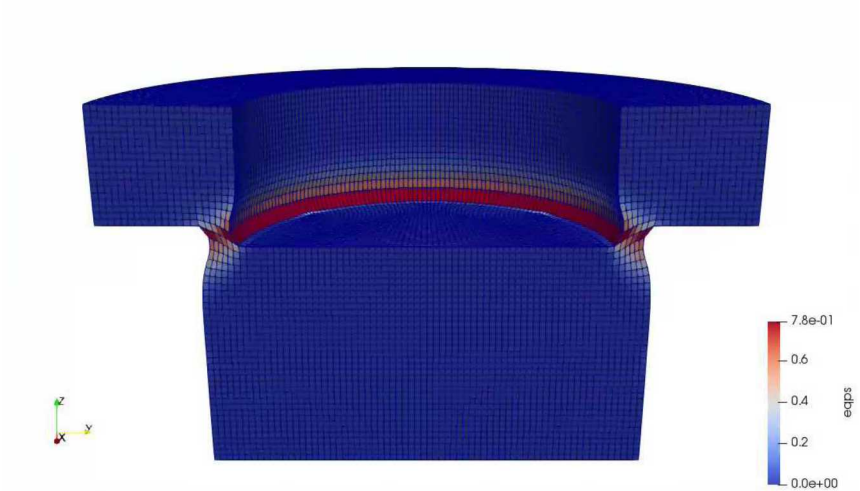


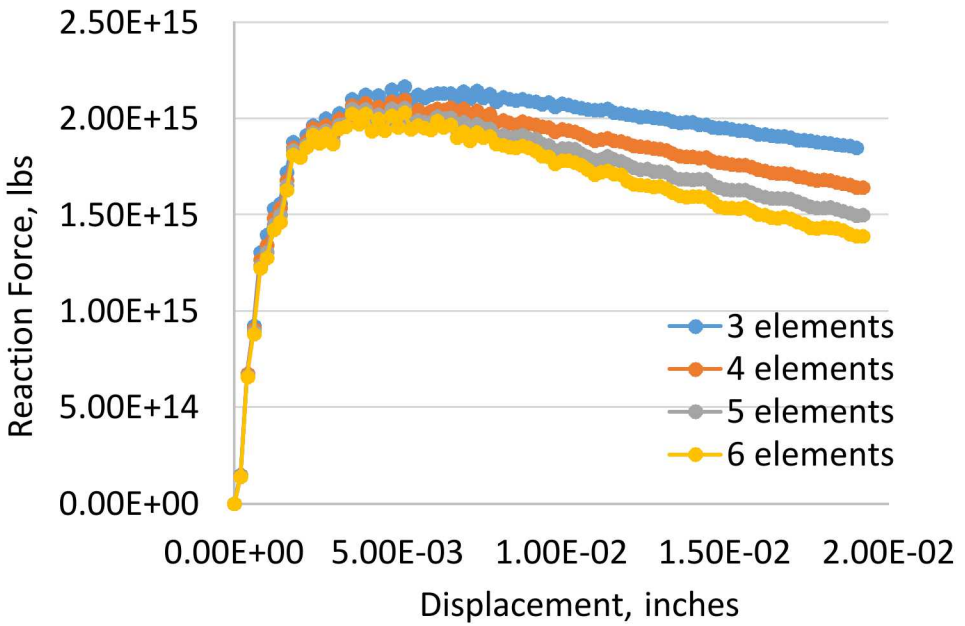


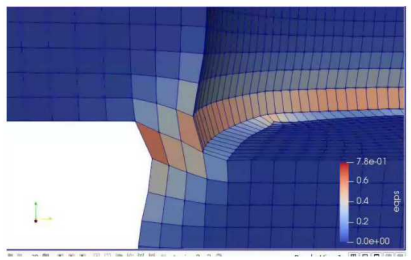
Preliminary Results

- Vary the number of elements through the thickness of affected region

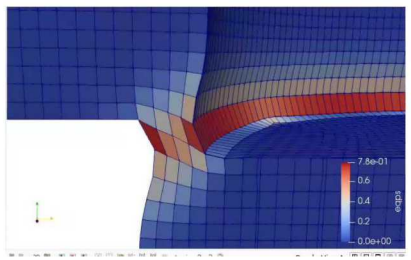
Equivalent plastic strain



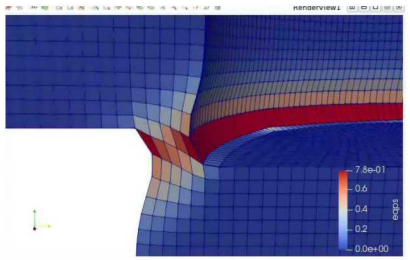




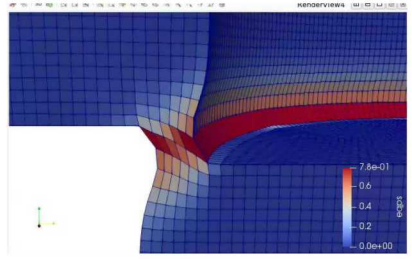
3 elements



4 elements



5 elements



6 elements

Work in Progress

- Model full geometry of bolt
  - Examine when failure occurs in reduced cross-section
  - Determine the required socket head drive depth and fuse diameter to guarantee failure in reduced cross-section
- Examine the effect of changing plasticity parameters on final bolt geometry
- Locally refine mesh in region of interest