Failure of Notched Laminates Under Out-of-plane Bending

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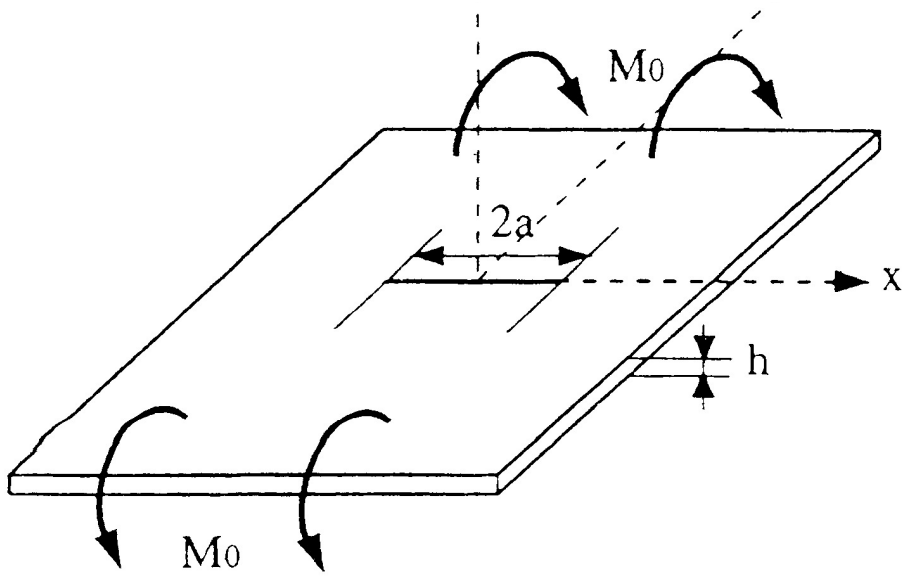
Objective: For out-of-plane bending of notched laminates, determine the modes of failure and evaluate the capability of current models to predict failure

Experiments: Four-point bending

Modeling: Progressive Damage Development

Experiments: Four-point Bending Tests



Notch Lengths: 2a = 1 inch & 2a = 4 inches

BMS 8-276 Carbon Fiber Tape

Laminate Types

- 10% 0° Plies
- 30% 0° Plies
- 50% 0° Plies

Laminate Thicknesses

- 20 plies Thick
- 40 plies Thick

Notch Lengths

- 1 inch
- 4 inches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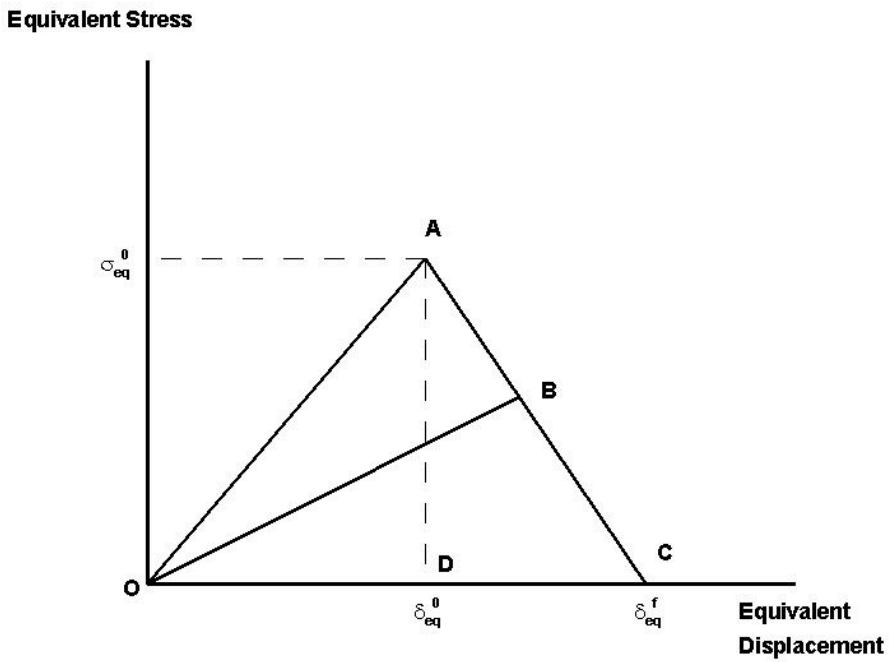
ABAQUS Progressive Damage Model

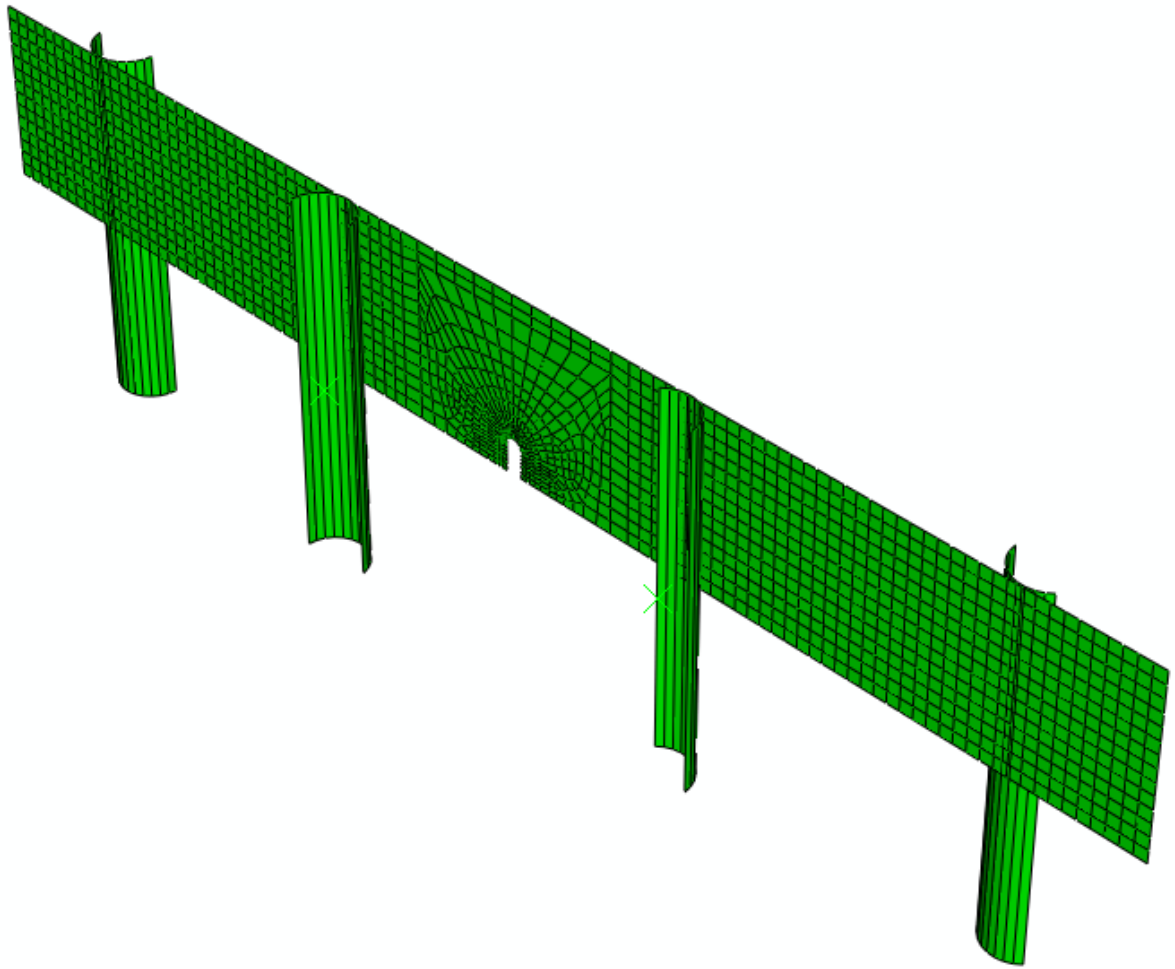
- Damage Initiation – Hashin Theory
  - Fiber Tension
  - Fiber Compression
  - Matrix Tension
  - Matrix Compression

Damage Evolution

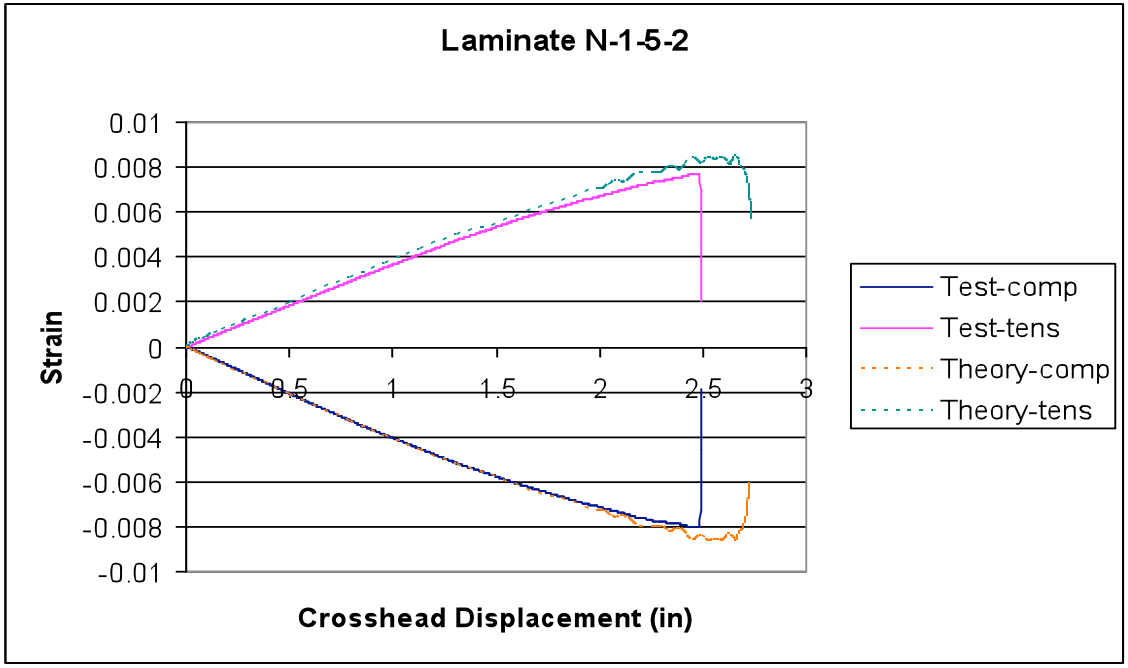
Strain Softening



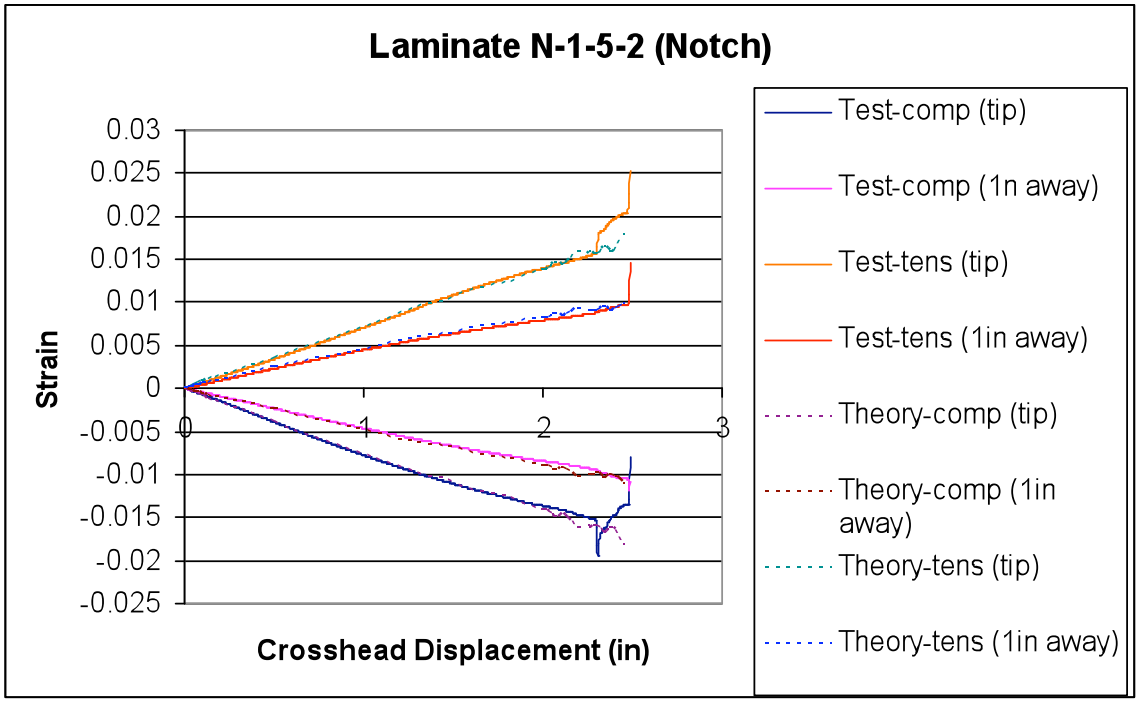
Simulation of the 4-point Bend Test



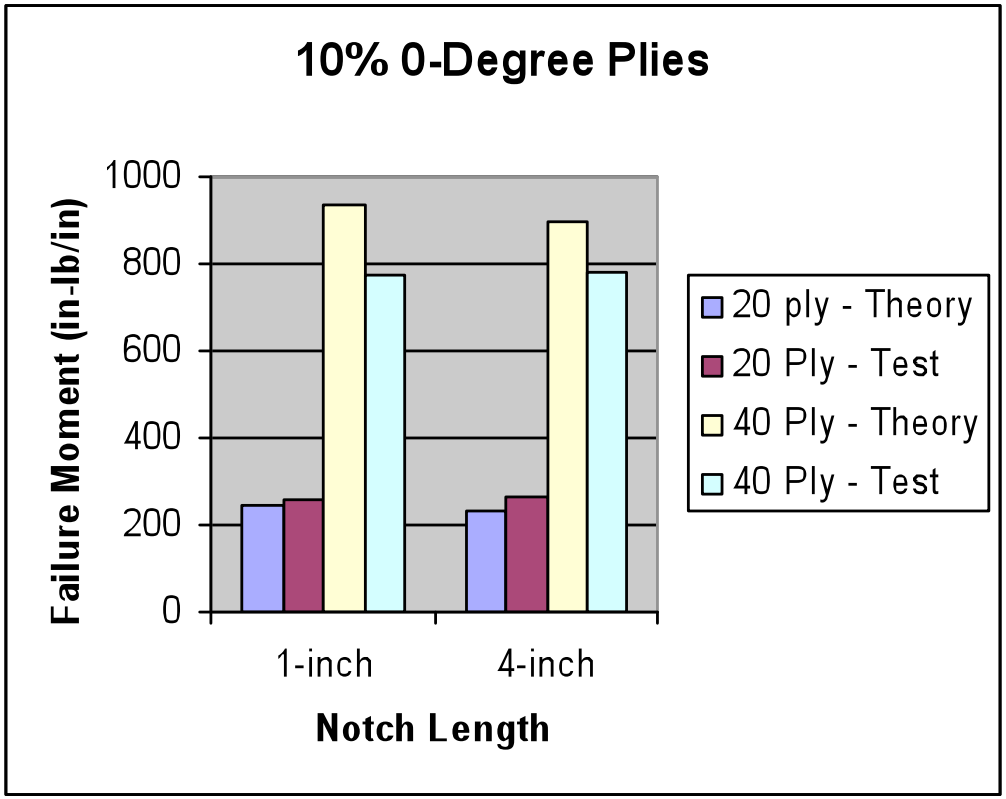
Far Field Strains



Notch Tip Strains



FAILURE LOADS



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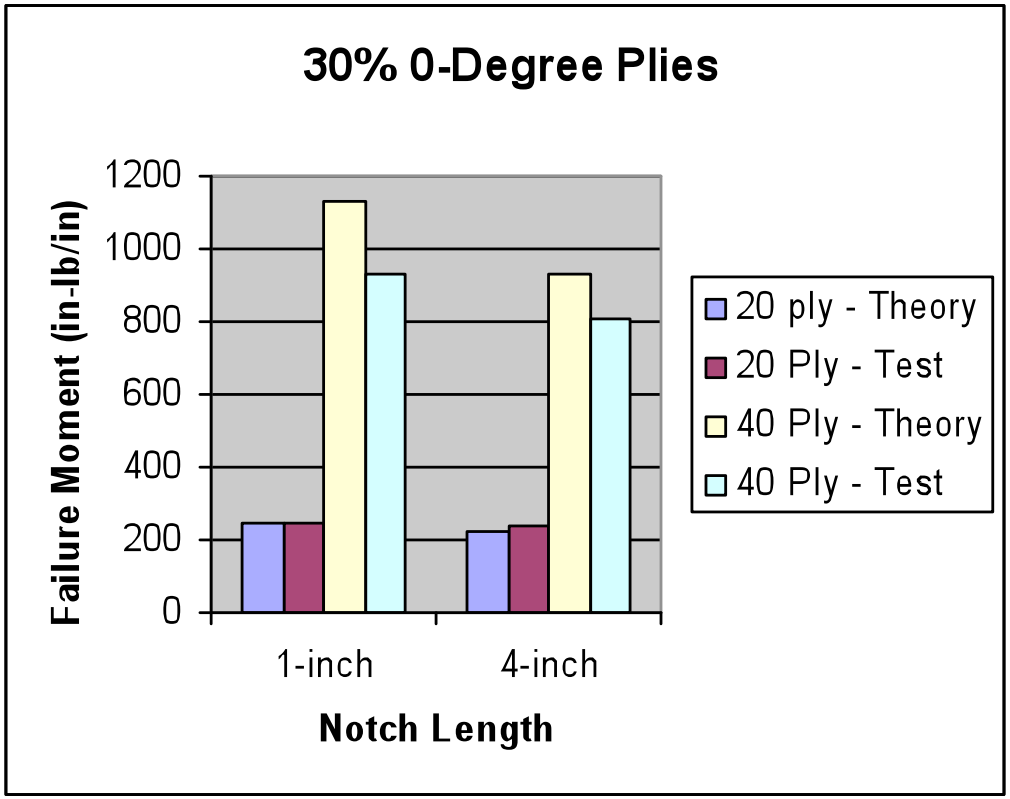

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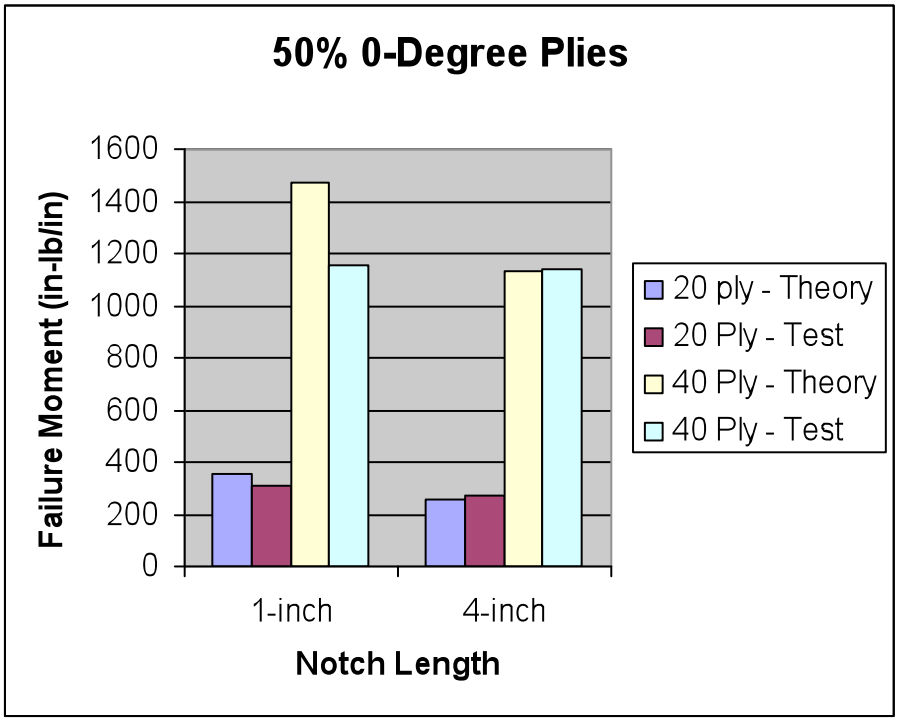
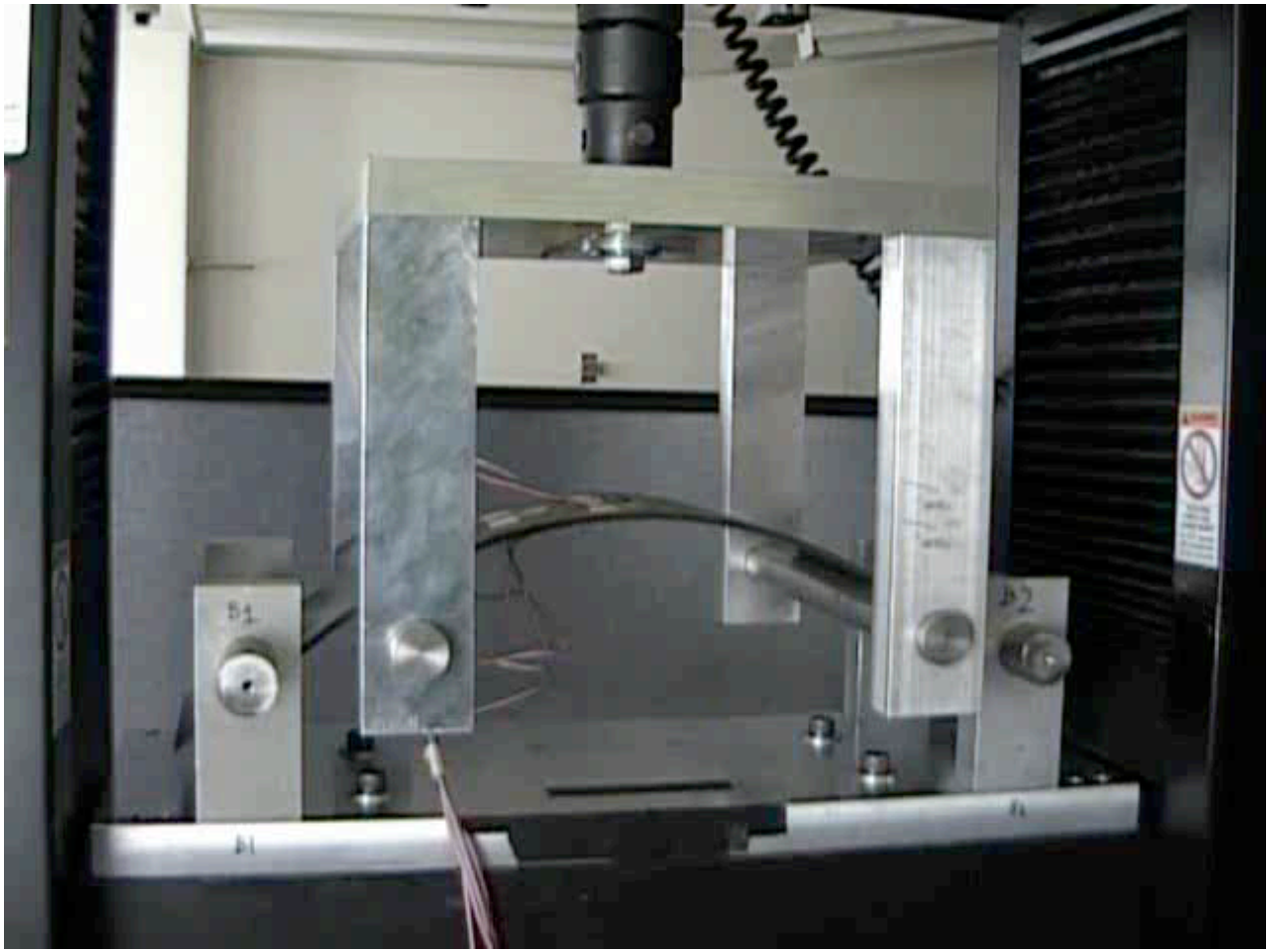
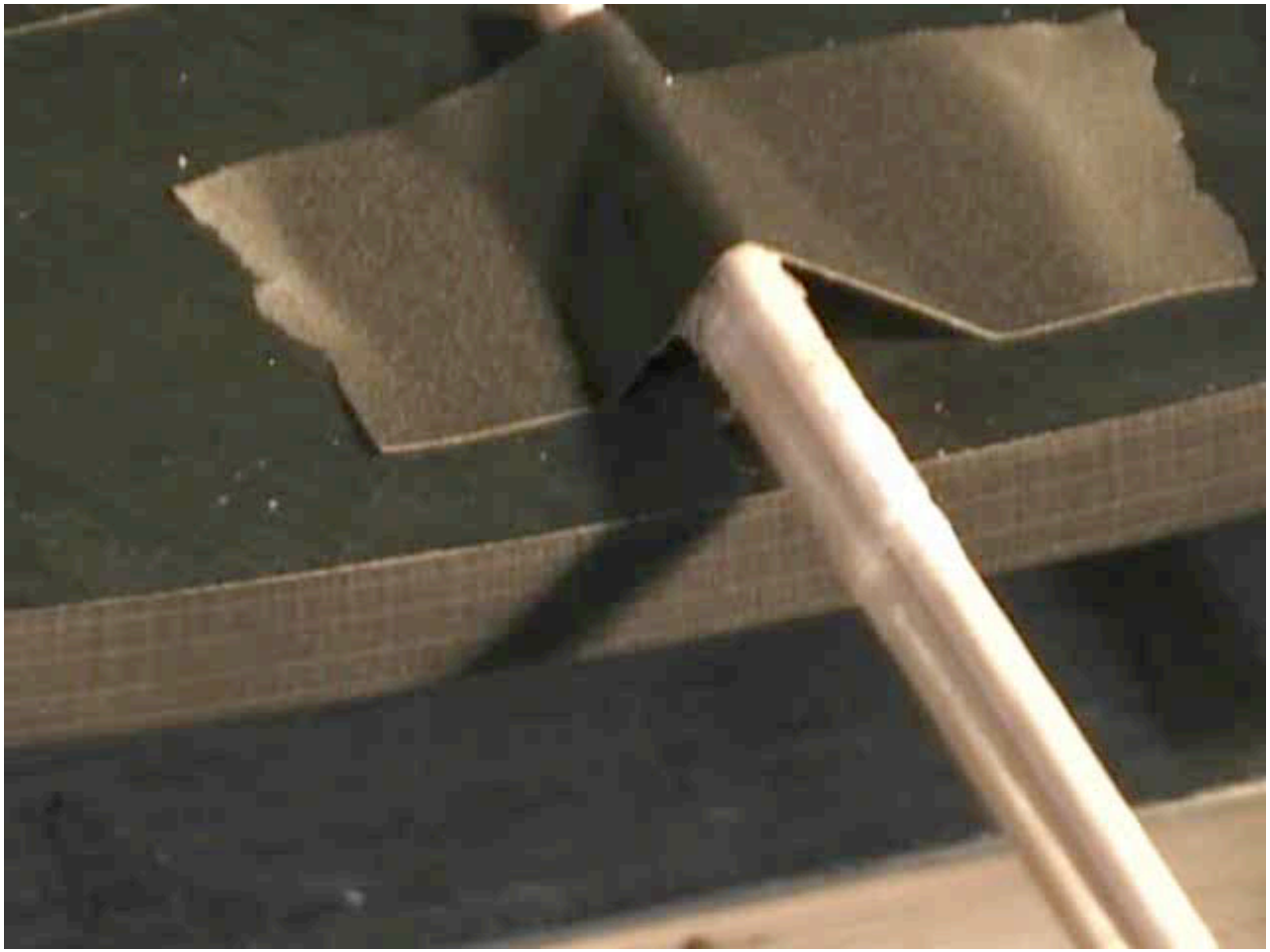
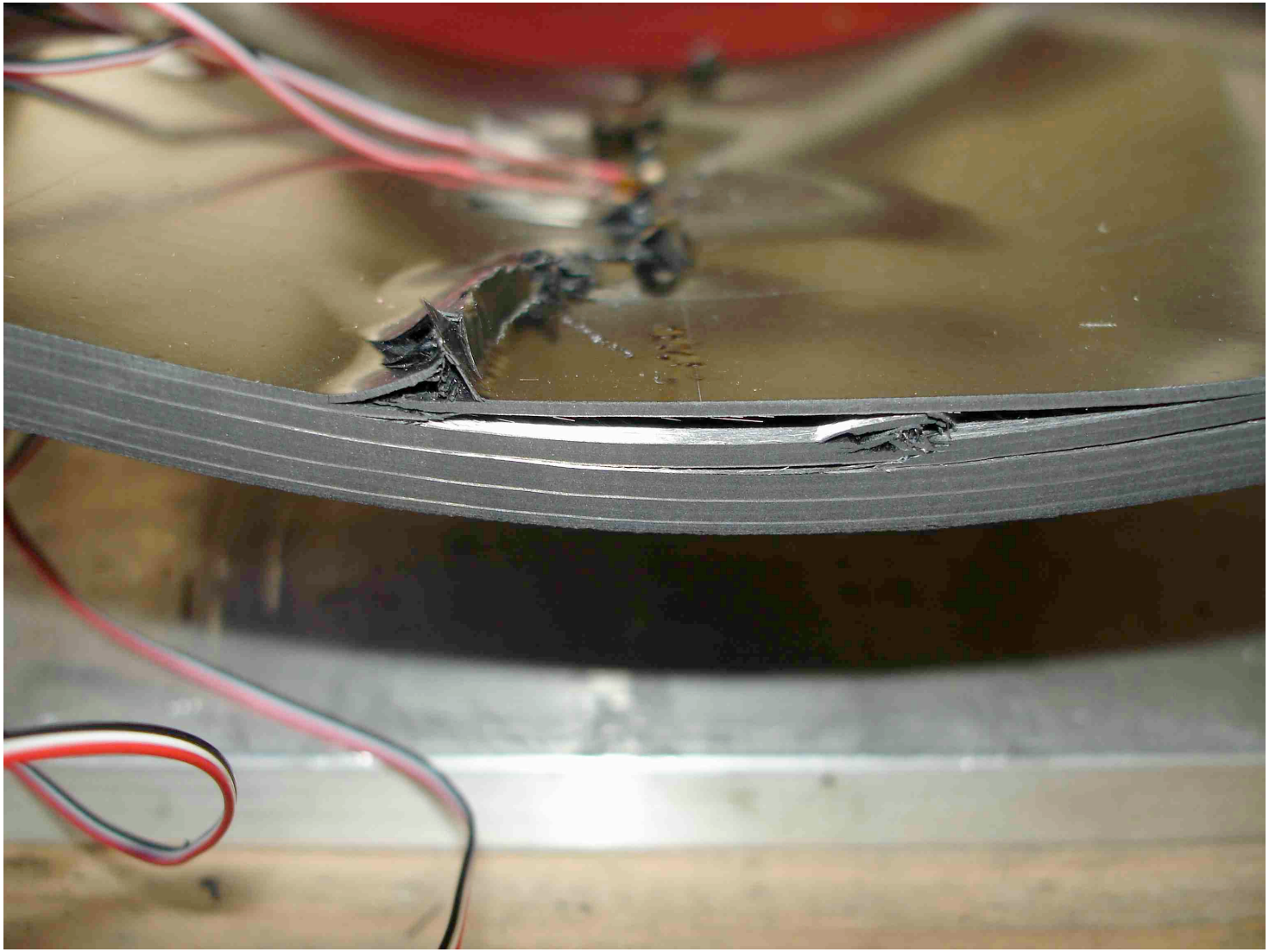


Damage Model Performance

- Thin Laminates – average error=7%
- Thick Laminate – average error=16%







FUTURE WORK

- Delamination Modeling
- Mesh Dependence Effects
- Damage Parameter Sensitivity Study
- Evaluation of Semi-Empirical Models