SHEAR CHARACTERIZATION OF COMPOSITE LAMINATES AND ADHESIVES

Jeff Kessler

Dan Adams

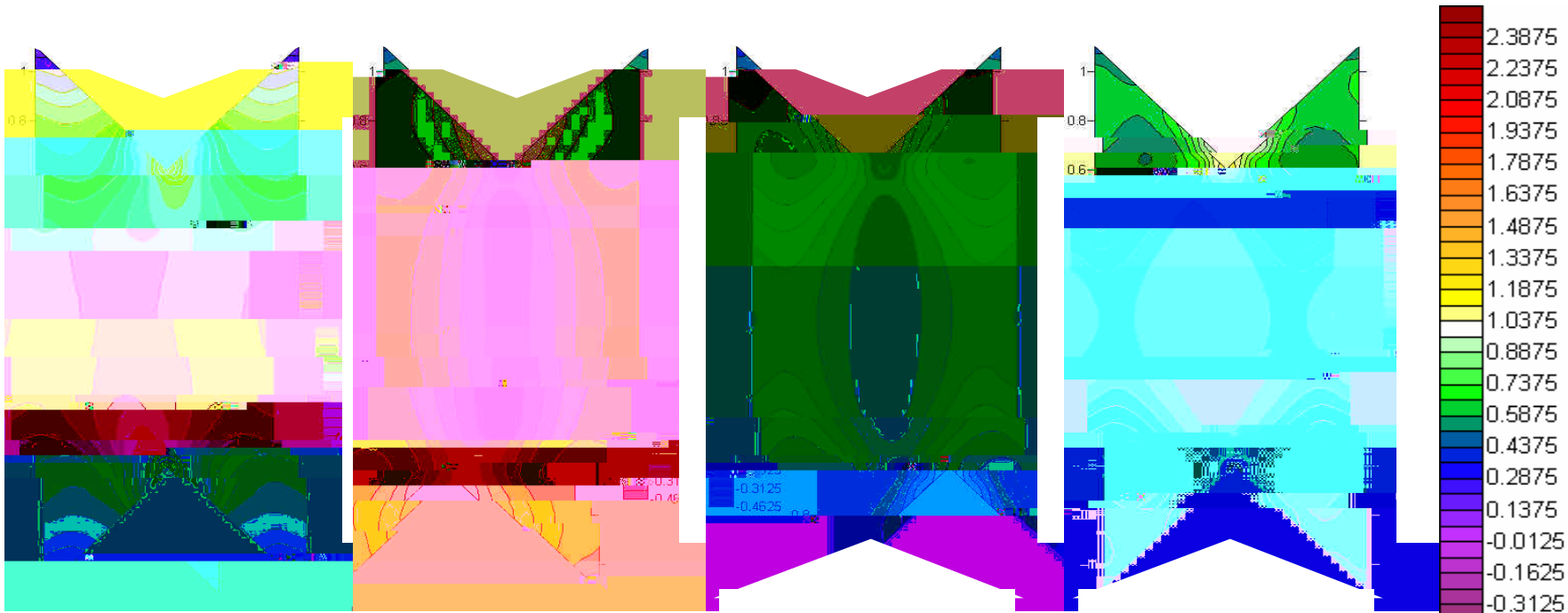
Department of Mechanical Engineering
University of Utah
Salt Lake City, UT

The Joint Advanced Materials and Structures Center of Excellence

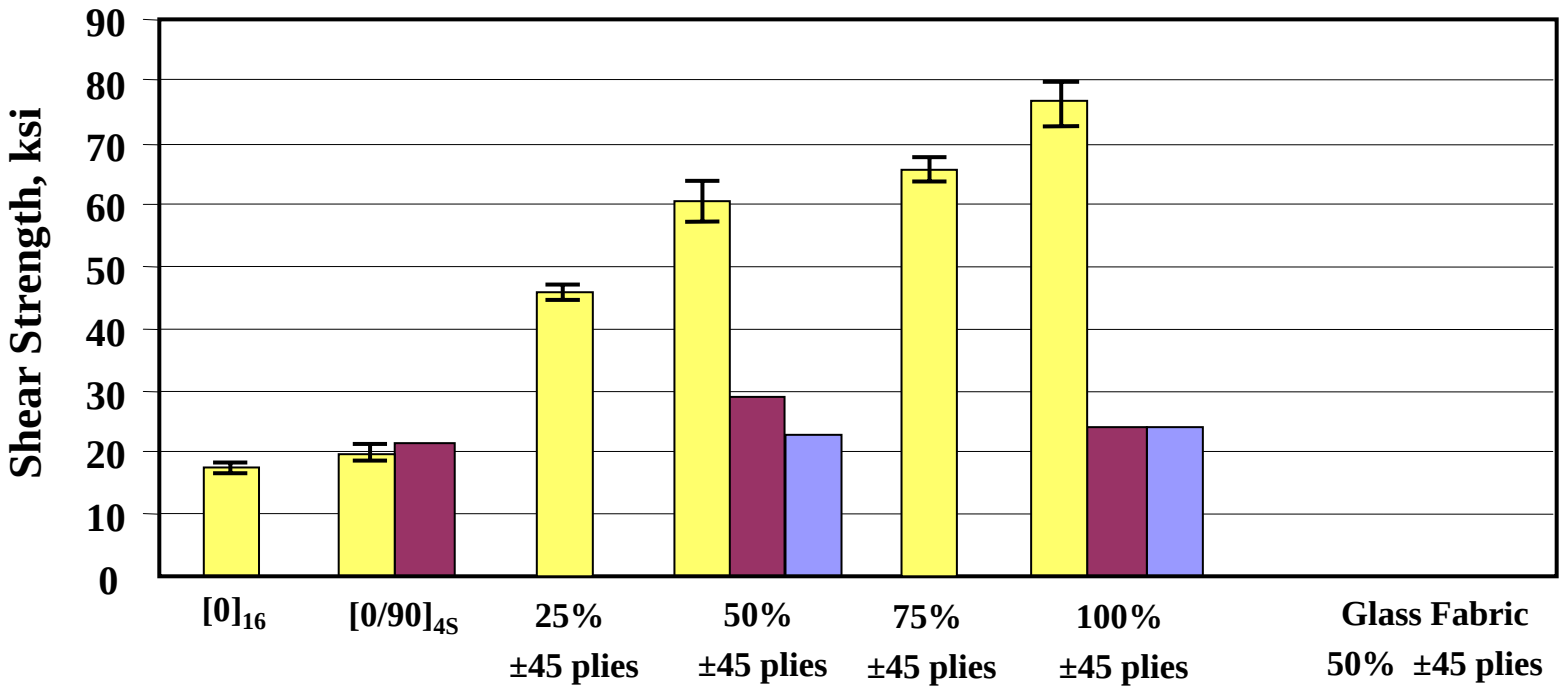
FAA Sponsored Project Information

- P.I. - Dr. Dan Adams
- Graduate Student Researchers:
  - Mike Moriarty
  - Adam Gallegos
  - Matt Nielson
  - Nick Burst
- FAA Technical Monitors
  - Peter Shyprykevich
  - Curt Davies
- Industry Participation
  - Vishay MicroMeasurements, Inc.

Uniformity of Shear Stress in V-Notched Rail Shear Specimen



$[0]_{16}$ $[0/90]_{4S}$ $[0/\pm45/90]_{2S}$ $[\pm45]_{4S}$



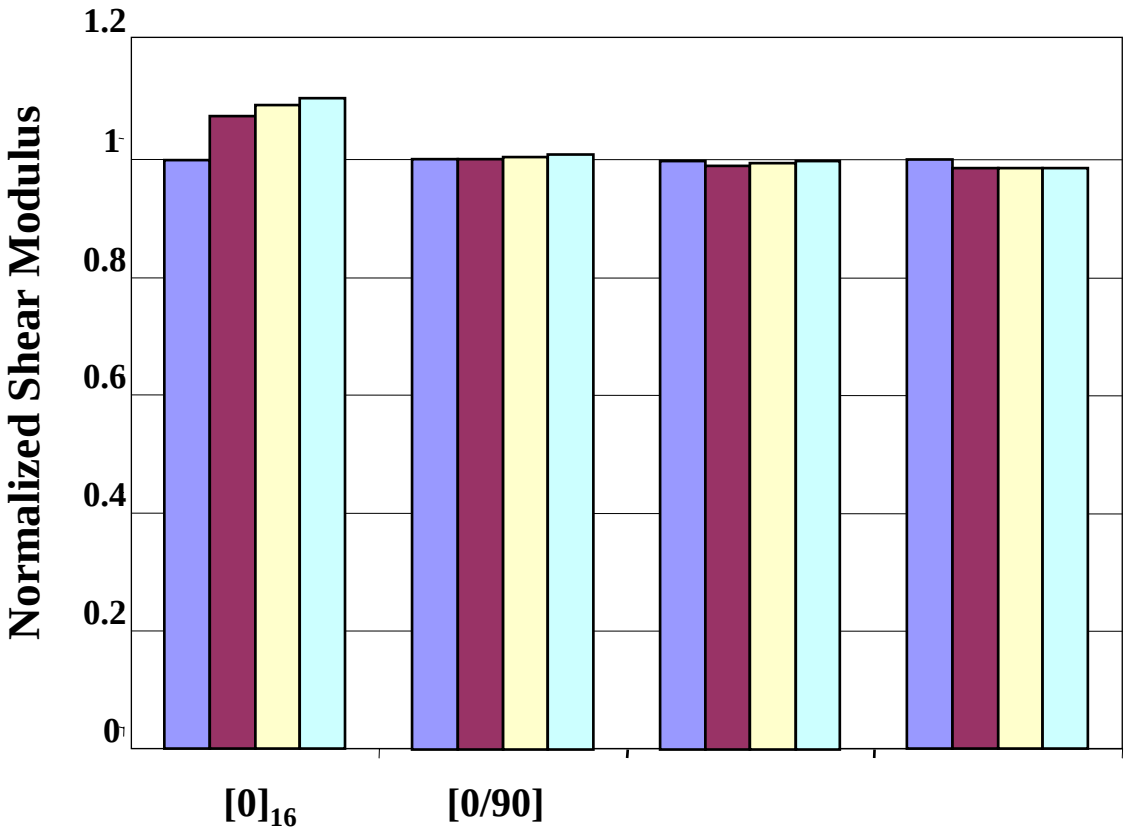
Carbon/Epoxy Laminates, t = 0.08 in.

Comparison of Specimen Sizes: Woven Composites

Iosipescu Shear
ASTM D 5379

V-Notched Rail Shear
ASTM D 7078

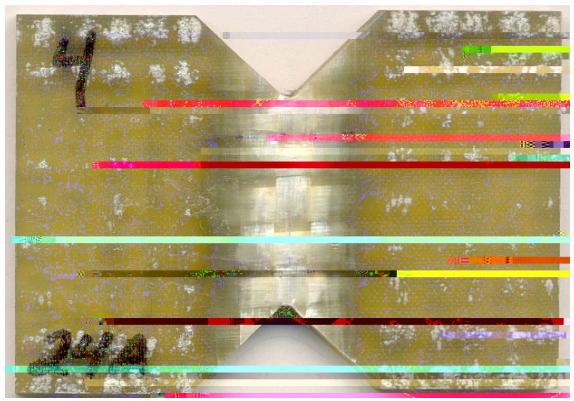
2-Rail Shear
ASTM D 4255



Notch-to-Notch Gage (1.2 in.)
“Compact Gage” (0.75 in.)
“Iosipescu” Gage (0.45 in.)

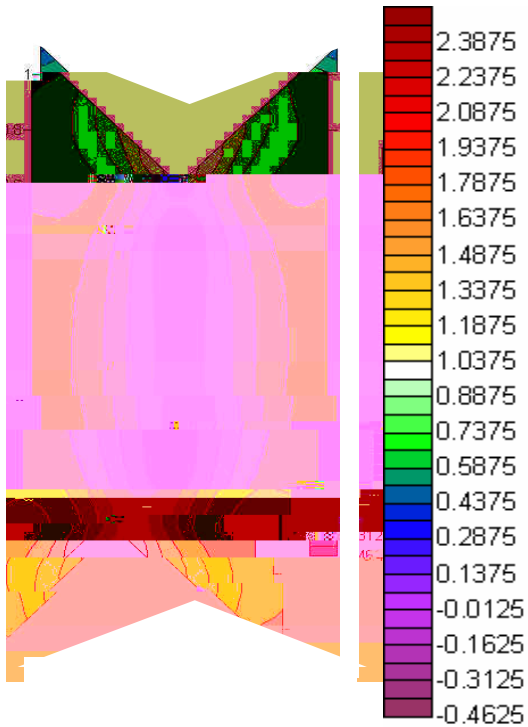
Optimal Shear Gage for Textile Composites

1.4 x 0.9 tows/cm



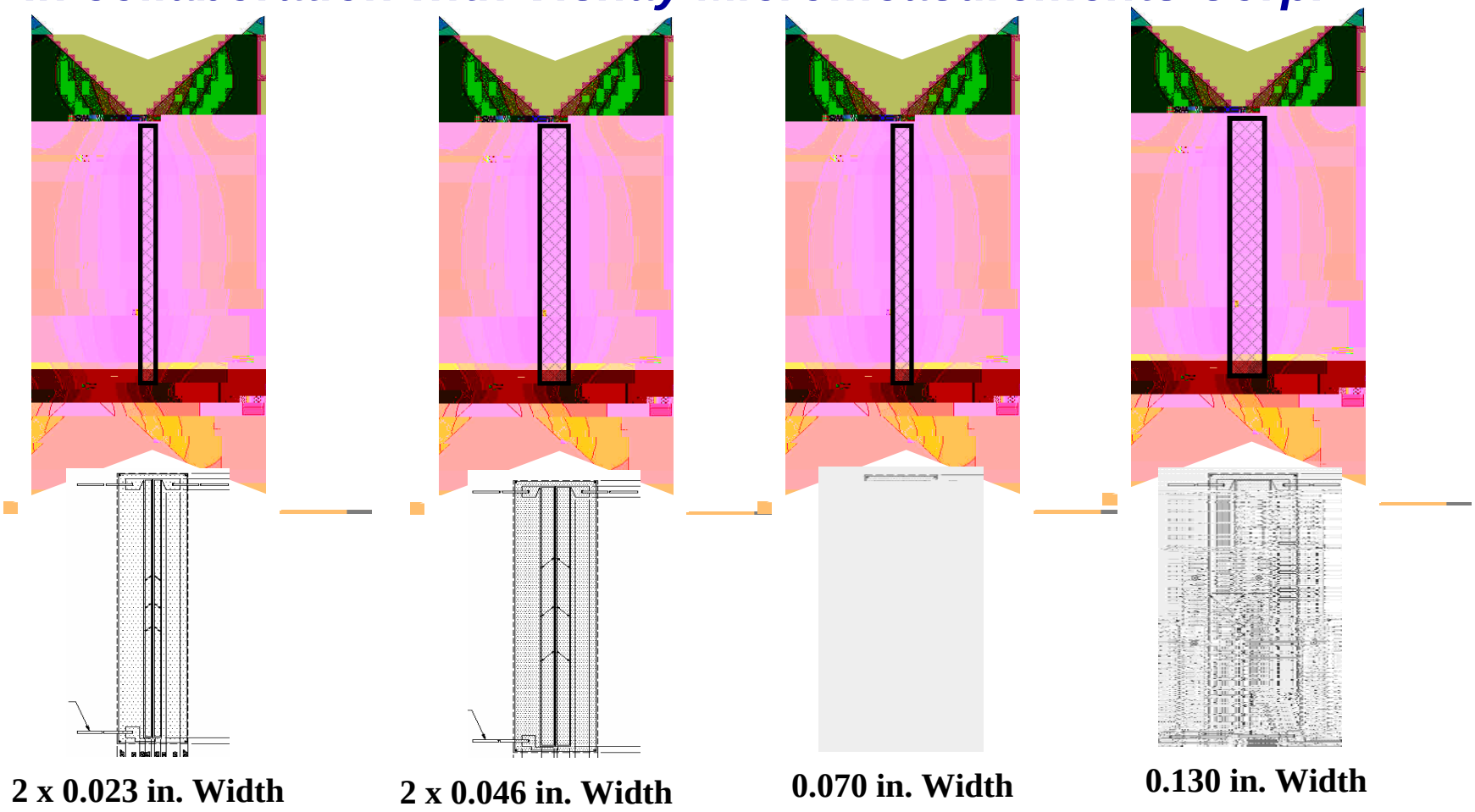
2 x 1.6 tows/cm

- Adequate gage width desired for coarse textiles
- Narrow region of uniform shear strain



Candidate Shear Gages for V-Notched Rail Shear Test

In collaboration with Vishay Micromeasurements Corp.



2 x 0.023 in. Width **2 x 0.046 in. Width** **0.070 in. Width** **0.130 in. Width**

Shear Characterization of Adhesives

Motivation:

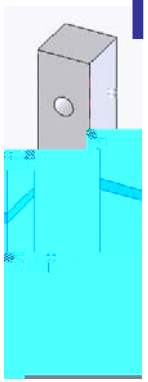
- Lack of consensus on whether mechanical properties of an adhesive are affected by bondline thickness
- Need for shear response of adhesives for use in the design and analysis of adhesive joints

Objectives:

- Determine the influence of bondline thickness on the shear properties of aerospace adhesives
- Develop test methodology for shear characterization of adhesives.

Determination of Adhesive Properties

In-Situ Properties

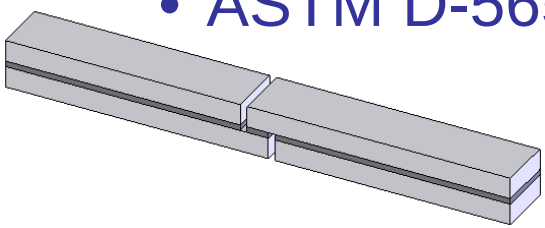


Tensile: Butt-Joints

- ASTM D-2094 and D-2095

Shear: Lap Joints

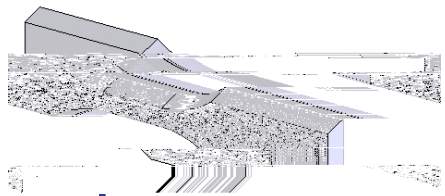
- ASTM D-1002
- ASTM D-3165
- ASTM D-5656



Bulk Properties

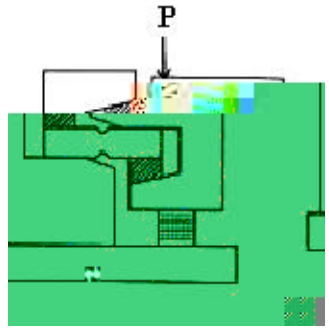
Tensile: Dog-Bone

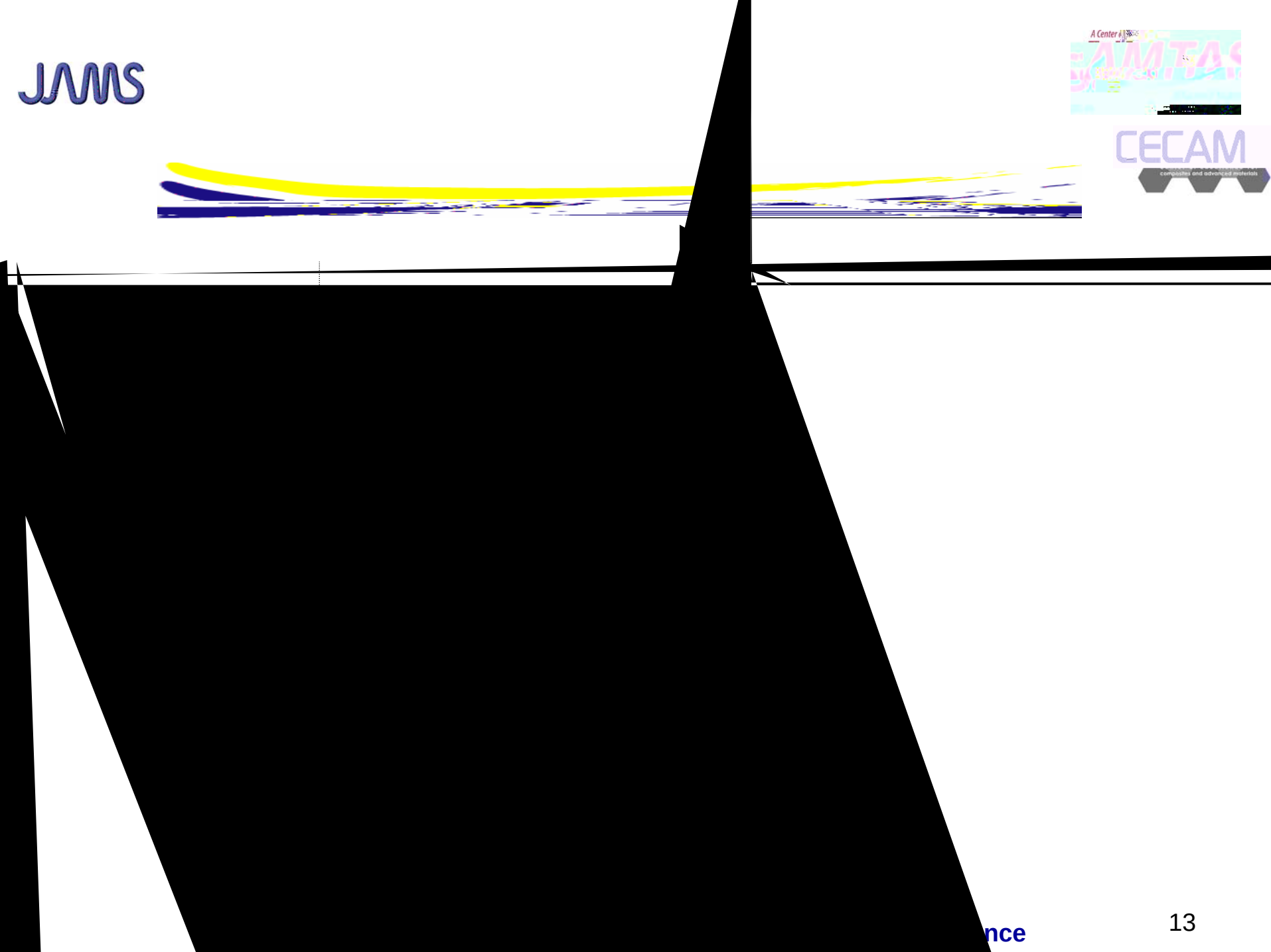
- ASTM D-638



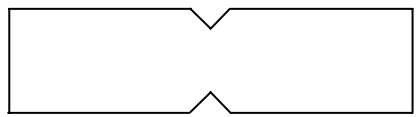
Shear: Iosipescu

- ASTM D-5379





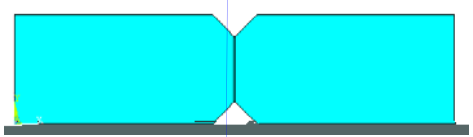
Shear Testing of Adhesives:
Use of the Iosipescu Shear Test



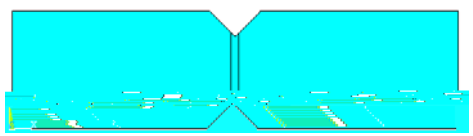
3.0 in.

Use of Iosipescu Shear Test for "In-Situ" Adhesive Testing

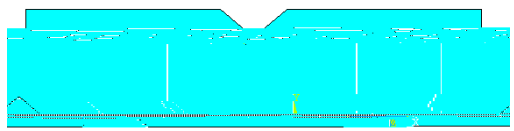
Loctite EA 9394 adhesive with aluminum adherends



0.010"



0.050"



0.100"

90° **120°**

0.010 in. **0.050 in.** **0.100 in.**

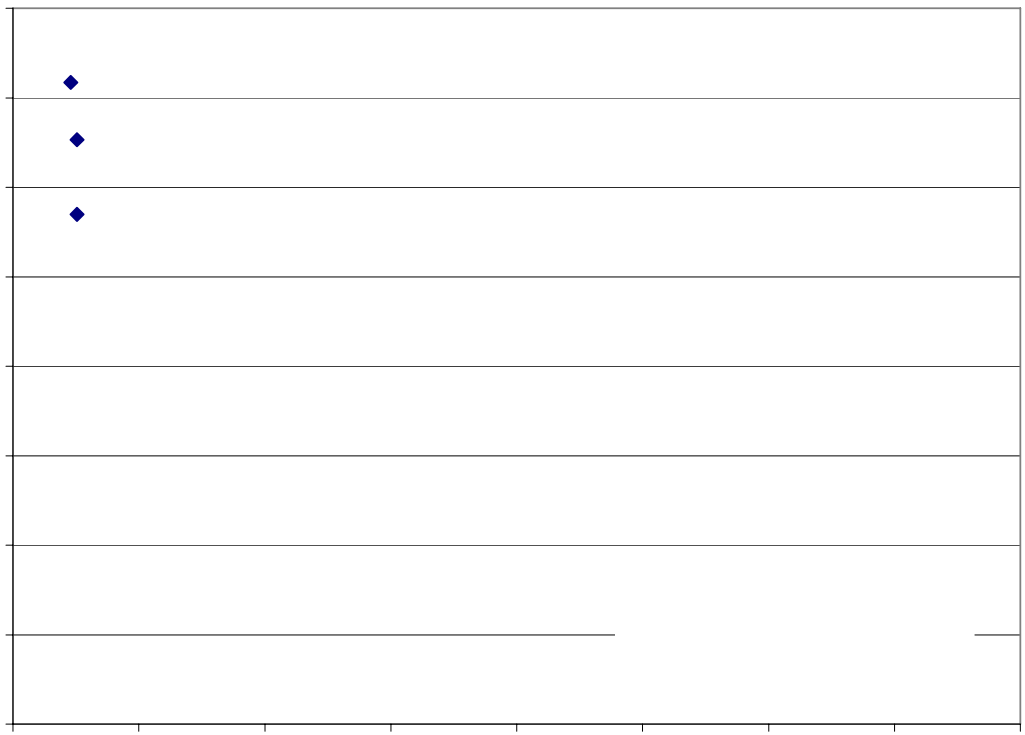
Mechanical Testing:
Bulk Adhesive and "In-Situ" Shear Specimens

Loctite EA 9394 adhesive

Loctite EA 9360 adhesive

Loctite EA 9394 adhesive with aluminum adherends

In-Situ Tensile Testing
Butt-Tensile Results



Conclusions: Adhesive Testing

- Iosipescu shear test appears to be well suited for both bulk and in-situ shear testing
  - 90° notch angle for bulk adhesive testing
  - 120° notch angle for in-situ adhesive testing
- Shear properties (modulus, strength) do not appear to be dependent on adhesive thickness
- Apparent adhesive thickness effect in tensile strength is produced by differences in stress state within adhesive layer
- Bulk adhesive properties may be applied to thin adhesive bondlines