DAMAGE TOLERANCE TEST METHOD DEVELOPMENT FOR SANDWICH COMPOSITES

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FAA Sponsored Project Information

- **Principal Investigator: Dr. Dan Adams**
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  - **Brad Kuramoto**
- **FAA Technical Monitor**
  - **David Westlund**
- **Collaborators:**

  Boeing

  Materials Sciences Corporation

BACKGROUND:

Damage Tolerance Test Methods for Sandwich Composites

- **Damage tolerance test methods for monolithic composites have reached a relatively high level of maturity**
  - Damage Resistance: ASTM D 7136 – Drop-Weight Impacting
  - Damage Tolerance: ASTM D 7137 – Compression After Impact
- **Less attention to sandwich composites…until recently**
  - **SAMPE/ASTM D30 Panel at Joint Meeting October 2009**

    "*Damage Resistance and Damage Tolerance of Sandwich Structures*"

    Dan Adams, organizer, panelist Carl Rousseau, moderator
  - **ASTM D30 publishes standard for sandwich damage resistance**
    - ASTM D7766 (2011) "*Standard Practice for Damage Resistance* Testing of *Sandwich* Constructions"
  - **SAMPE/ASTM D30 Panel at Joint Meeting October 2011**

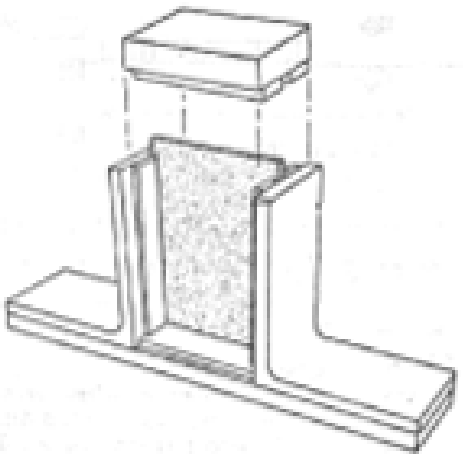
    "*Damage Resistance of Composite Sandwich Structures*"

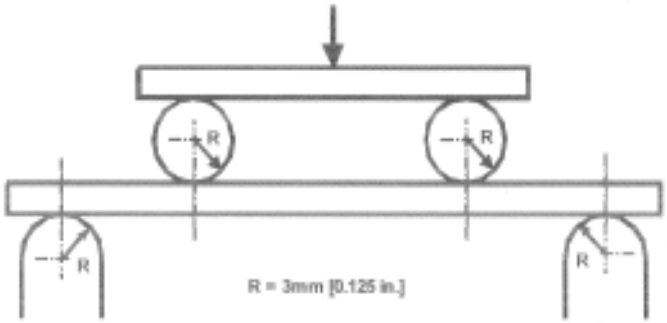
    Dan Adams, organizer Carl Rousseau, moderator

RESEARCH OBJECTIVES:

Damage Tolerance Test Methods for Sandwich Composites

- **Evaluate candidate test methodologies**
- **Develop a standardized ASTM test method**
- **Compare residual strength results of sandwich panels using proposed test methods**
- **Investigate scaling of test results**





Where Do We Start?

What is the intended usage of a damage tolerance test method for sandwich composites?

- **Quality Assurance**
- **Material ranking/selection/specification**
- **Establishing design properties/allowables**
- **Research and development activities**
- **Product development**
- **Other?**

Intended Usage Likely to Affect Type of Test Method

Intended Usage Likely to Affect Test Method

- ***Material ranking/selection/specification***
  Specify a sandwich panel configuration

  Example: D 7137: Specified lay-up and target laminate thickness for CAI testing

- ***Establishing design properties/allowables***
  - **Allow a wide range of sandwich panel configurations**

    Example: C 364: Edgewise compression strength of sandwich panels

Development of an ASTM Standard:

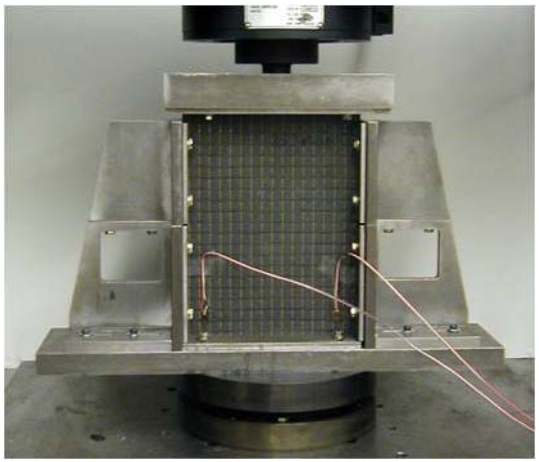
Damage Tolerance of Sandwich Composites

Process Includes:

- Review of Similar/Relevant Standards
- Establish intended usage(s)
- Develop suitable test fixturing
- Establish suitable range of sandwich configurations
  - Facesheet parameters
  - Core parameters
- Specify suitable specimen geometries
- Develop proper test procedures

CANDIDATE TEST CONFIGURATIONS:

Damage Tolerance of Sandwich Composites



Edgewise Compression

- Preferred DT test method for monolithic laminates
- High interest level for sandwich composites

Four-Point Flexure

- Constant bending moment and zero shear in damaged section of panel
- Damaged facesheet can be placed under compression or tension

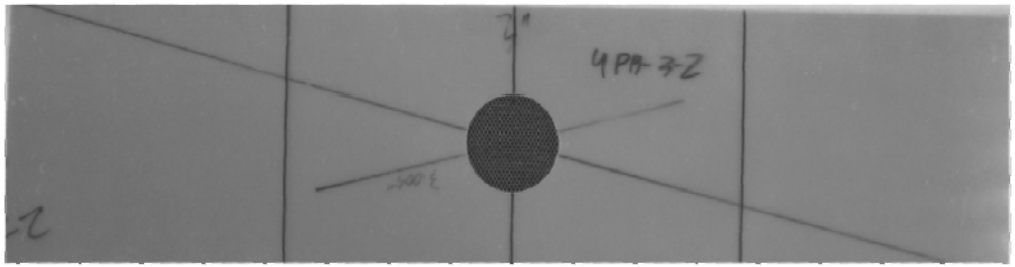
Pressure Loading

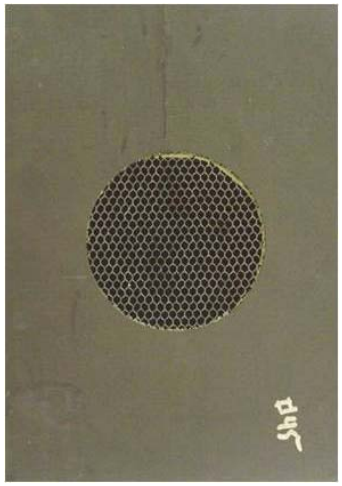
- Simply supported sandwich panel
- Distributed load
- Of interest for pressure loaded applications

INITIAL EXPERIMENTAL EVALUATION:

Use of Idealized Impact Damage

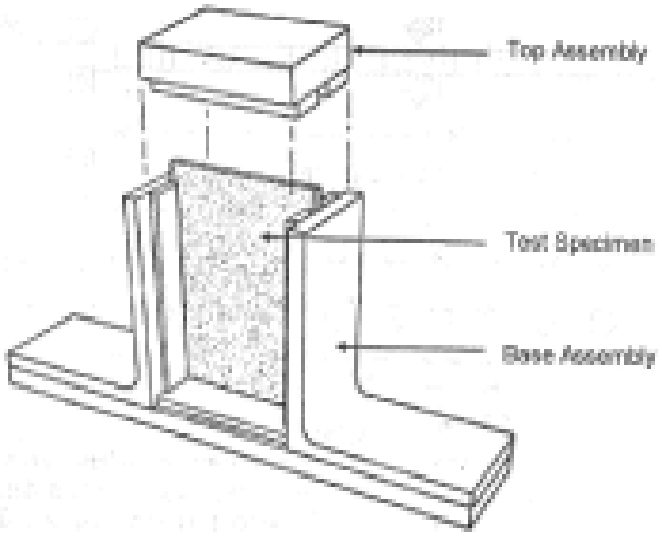
- G11 glass/epoxy facesheets & Nomex honeycomb core
- "Idealized" damage: 1 in. and 3 in. hole in facesheet
- Develop a recommended procedure for each method
- Initial assessment of damage tolerance
  - Develop familiarity with each test method
  - Identify additional issues requiring investigation
  - Initial assessment of each test method
  - Identification of test method limitations

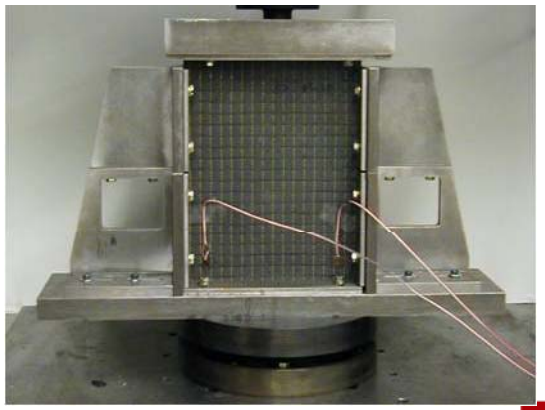




Edgewise Compression Testing For Damage Tolerance: Testing Considerations

- **Specimen size – Scaling**
- **Test fixture**
  - **End supports**
    - **Clamping of top and bottom**
    - **Potting of core**
  - **Side edge supports**
    - **Knife edge (pinned)**
    - **Clamped (reduce rotation)**
- **Method of specimen alignment**
- **Strain measurement**
  - **Alignment**
  - **Determination of load paths**

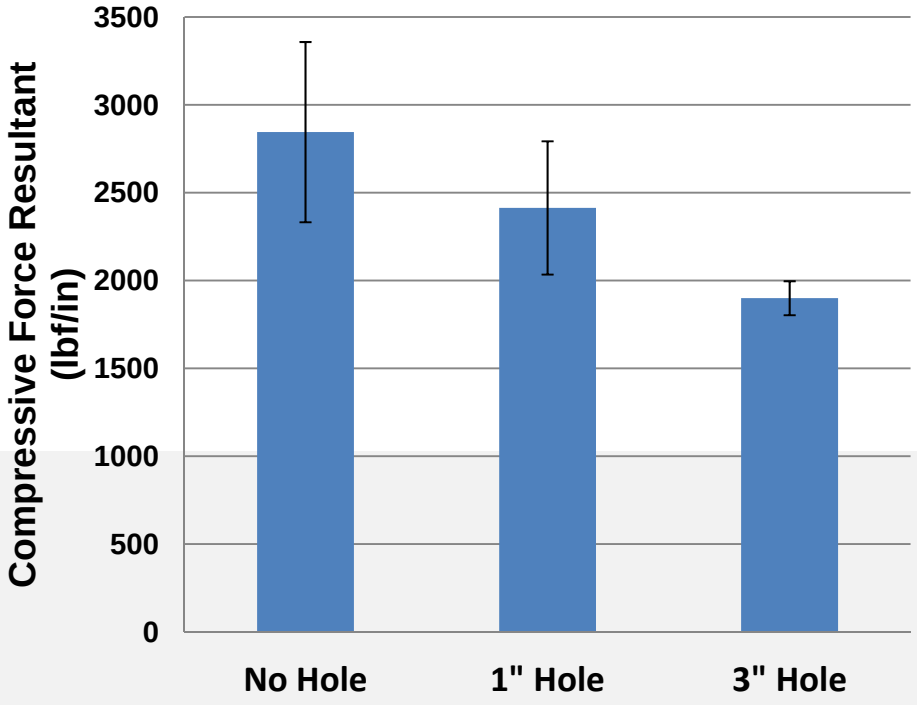


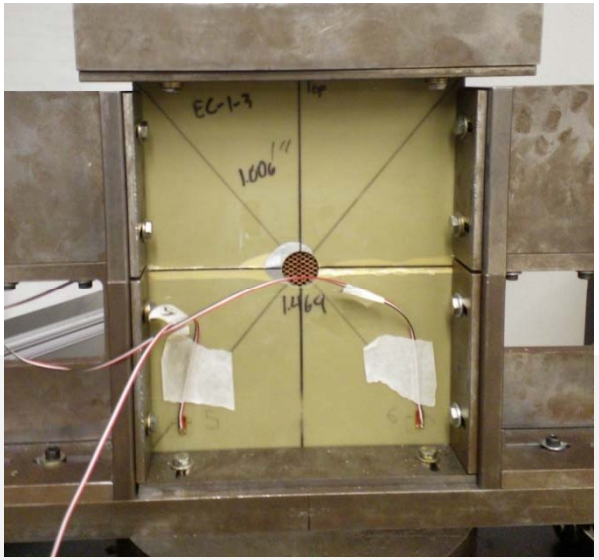


Edgewise Compression Testing For Damage Tolerance: Initial Evaluations

- **G11 glass/epoxy facesheets & Nomex honeycomb core**
- **"Idealized" damage – 1 in. & 3 in. hole in one facesheet**

Failure of specimen with no damage

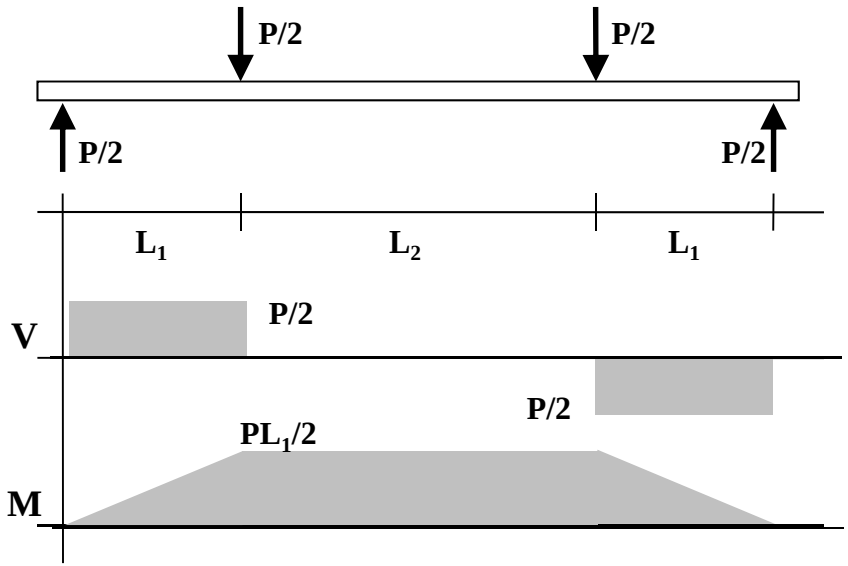


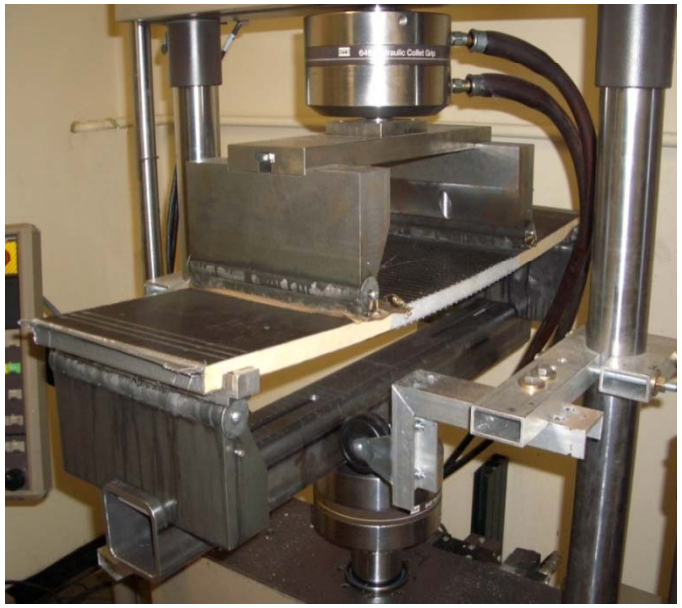


Failure of specimen with 1 in. hole

Four-Point Flexure Testing For Damage Tolerance: Testing Considerations

- **Location of damage: tension or compression loading?**
- **Sandwich panel dimensions (length & width)**
- **Required length of central test section (damage region) of panel**
- **Required length of outer regions to develop bending moment**
- **Core requirements for shear stress - outer panel sections**
- **Facesheet /core requirements at loading points**

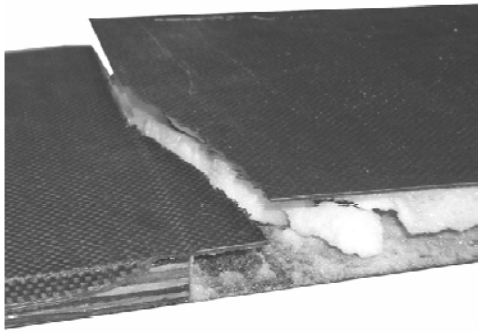


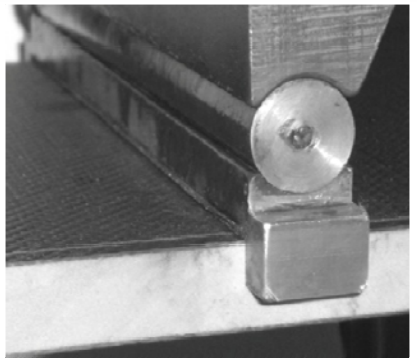


Four-Point Flexure Testing For Damage Tolerance: Initial Evaluation

Undesirable failures in no-damage specimens

- Shear failure of honeycomb core in outer regions
  - Fill honeycomb cells
  - Substitute higher strength core
- Localized failure at loading points
  - Distribute load over larger area
  - Fill honeycomb cells

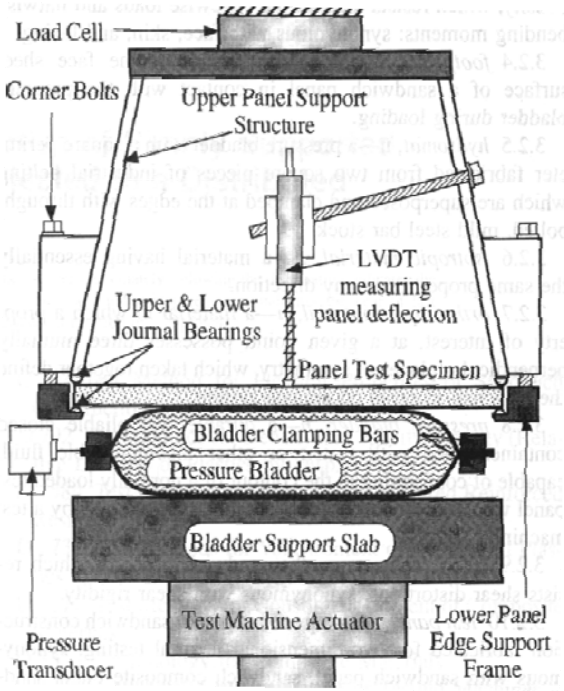




Uniform Pressure "Hydromat" Test

Based on Existing Standard: ASTM D 6146

- Simulates hydrostatic pressure loading
- Pressure loading of sandwich panel using pressure bladder
- Test machine used to press bladder against test panel
- Quasi-static or cyclic fatigue loading
- Size of sandwich panel dependent on sandwich properties
- Current usage primarily in marine industry



Hydromat Testing For Damage Tolerance: INITIAL EVALUATION

Testing currently underway

- Idealized damage located on tension-loaded facesheet
- Sandwich specimen simply supported by the upper and lower panel support
- Specimen loaded by lowering assembly onto the pressure bladder

SUMMARY
Benefits to Aviation

- Standardized damage tolerance test method for sandwich composites
- Test results used to predict damage tolerance of sandwich composites
- Scaling of test results for application on composite sandwich structures