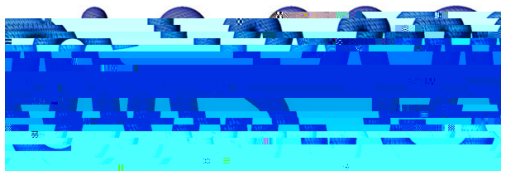
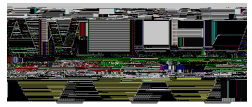
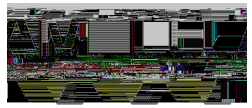


THE UNIVERSITY



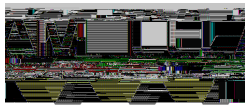
The Joint Advanced Materials and Structures Center of Excellence

FAA Sponsored Project Information



- **Principal Investigator: Dr. Dan Adams**
- **Graduate Student Researchers:**
  - **Brad Kuramoto**
  - **Josh Bluth**
  - **Chris Weaver**
  -

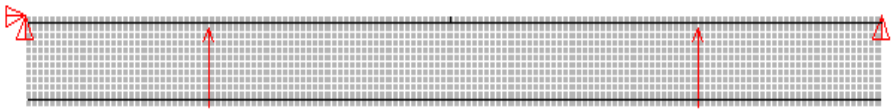
RESEARCH APPROACH:
THREE PHASE PROGRAM



- **PHASE I: Identification and initial assessment of candidate test methodologies**
- **PHASE II: Selection and optimization of best suited Mode I and Mode II test methods**
- **PHASE III: Development of draft ASTM standards**

INITIAL ASSESSMENT OF CANDIDATE TEST METHODOLOGIES

- **Identify candidate Mode I and Mode II test methodologies**
  - **Literature review**
  - **Modifications from adhesive and composite laminate tests**
  - **Original concepts**

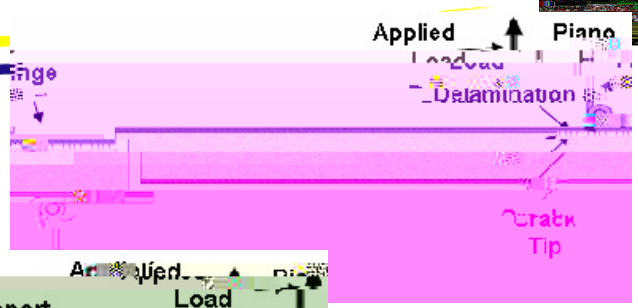


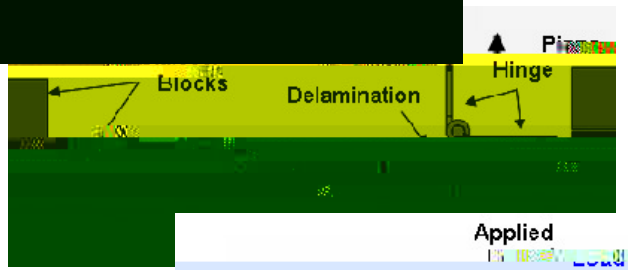
- **Assessment of candidate test configurations using finite element analysis**

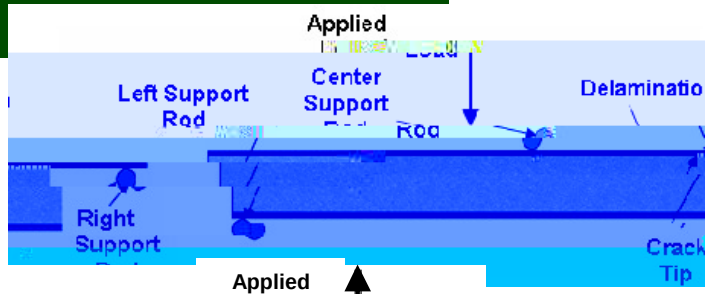
- **Preliminary testing of promising configurations**

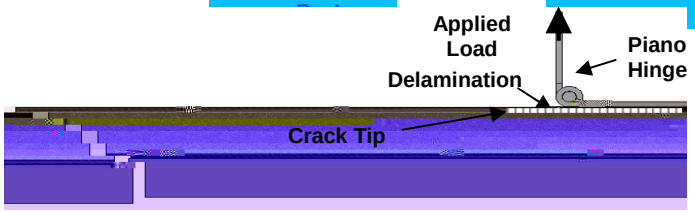
EVALUATION OF CANDIDATE MODE I TEST CONFIGURATIONS

- Double Cantilever Beam (DCB)
- Modified DCB (MDCB)
- Single Cantilever Beam (SCB) with cantilever beam support
- Three Point Flexure (TPF)
- Plate-Supported Single Cantilever Beam SCB



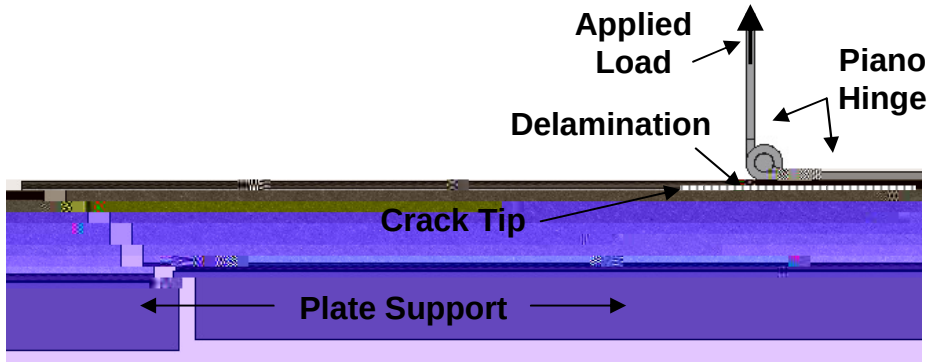




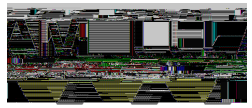


SELECTED MODE I CONFIGURATION: PLATE-SUPPORTED SINGLE CANTILEVER BEAM (SCB)

- **Elimination of bending of sandwich specimen**
  - **Minimal Mode II component (less than 5%)**
  - **No significant bending stresses in core**
- **No crack "kinking" observed**
-



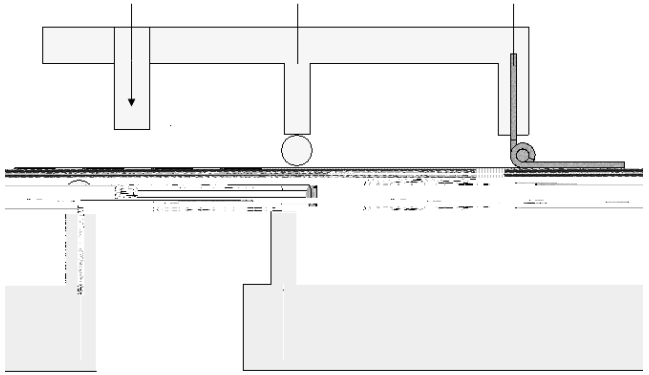
EVALUATION OF MODE II SANDWICH COMPOSITE TEST CONFIGURATIONS



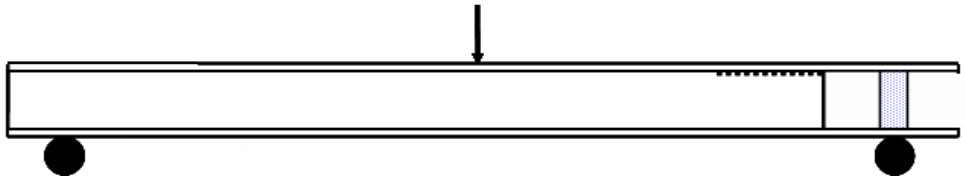
- Three-point End Notch Flexure (3ENF)
- Mixed Mode Bending (MMB)
- End Load Split (ELS)
- Four-point delamination test
- Cracked Sandwich Beam (CSB) with hinge
- Modified CSB with hinge
- Facesheet delamination test
- DCB with uneven bending moments
- Three-point cantilever
- Double sandwich test

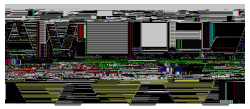
CHALLENGES IN DEVELOPING A SUITABLE MODE II TEST

- **Maintaining Mode II dominated crack growth with increasing crack lengths**
- **Obtaining crack opening during loading**
- **Obtaining stable crack growth along facesheet/core interface**



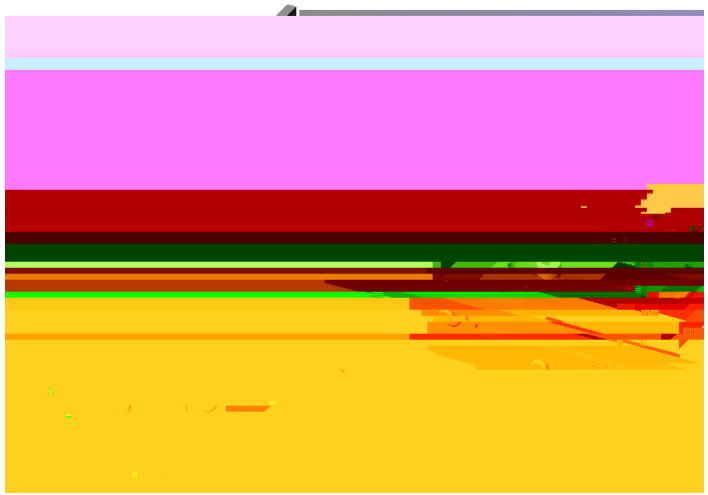
Mixed Mode Bend (MMB) Configuration



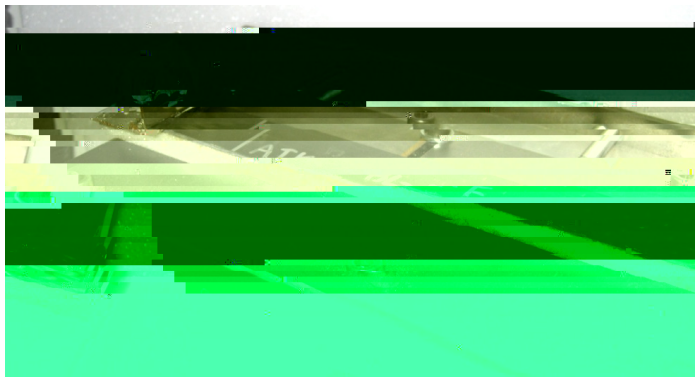


DEVELOPMENT OF TEST FIXTURING:
MODE I TESTING

Plate-Supported Single Cantilever Beam (SCB)



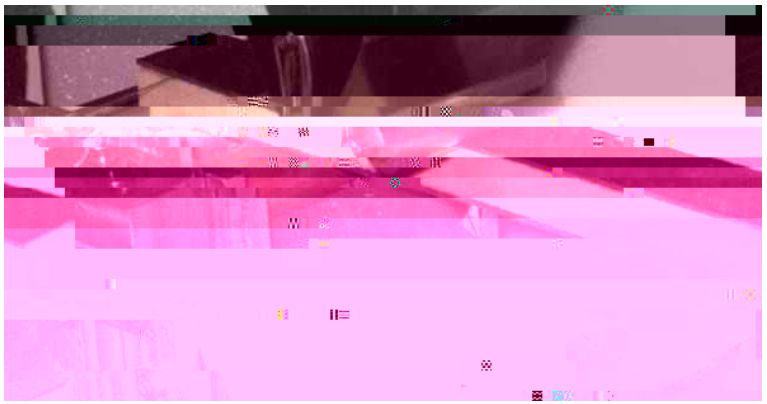
- **Ability to test 1 in. to 3 in. wide sandwich specimens**
- **Edge clamp restraints at base eliminates adhesive bonding**
- **Translating fixture base maintains vertical loading**



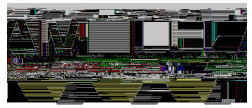
DEVELOPMENT OF TEST FIXTURING:
MODE II TESTING

Cracked Sandwich Beam (CSB)

- Modified three-point flexure fixture
- Support top facesheet without need of core removal
- Elimination of bonded aluminum block



CURRECT FOCUS:
TEST METHOD ASSESSMENT

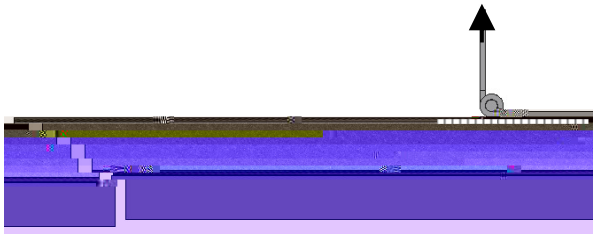


- **Determination of Acceptable Ranges of Specimen Parameters**
  - **Facesheet parameters**
    - **Thickness, flexural stiffness, flexural strength**
  - **Core parameters**
    - **Thickness, density, stiffness, strength**
  - **Specimen and delamination geometry**
- **Use of three different core materials (12-14 mm thickness)**
  -

Mode I dominant over range of facesheet thicknesses and crack lengths considered

MODE I SENSITIVITY STUDY: CORE MATERIAL EFFECTS

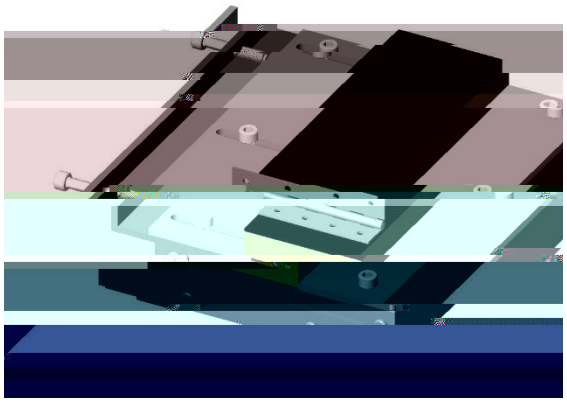
- Mode I dominant over range of cores considered
- Minimal variability among materials and crack lengths
- Test appears suitable for a wide range of common core materials



MODE II SENSITIVITY STUDY: CORE MATERIAL EFFECTS

CURRENT ACTIVITIES:
Further Development of Mode I and Mode II Test Methods

- Evaluation of Improved Mode I and Mode II Test and Analysis Methodologies
- Selection of Test and Analysis Methodologies for Standardization
- Validation of Selected Mode I and Mode II Test and Analysis Methodologies
- Preparation of Draft ASTM Standards



A LOOK FORWARD