Certification of Discontinuous Composite Material Forms for Aircraft Structures

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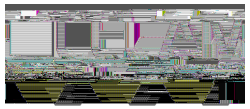
The Joint Advanced Materials and Structures Center of Excellence

Cert of Discontinuous Composite Material Forms for Aircraft Structures



- Motivation
  - Discontinuous fiber composites (DFC) are being used in aircraft and automotive structures because

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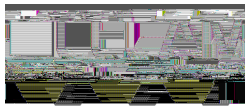

Hexcel HexMC is one type of DFC:

- AS4/8551UD prepreg is slit-chopped-randomly distributed in “new” preg roll:

  chips: ~9 x 50mm

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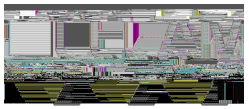

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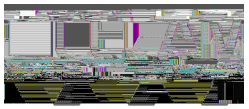

- Key Issues
  - Rigorous structural analyses currently very difficult (“impossible”):
    - rel high variability in all mechanical properties
    - lack of material allowables
    - lack of standard design or analysis methods
  - Consequently certification of DFC parts currently require testing large numbers of parts (“point design”)…issues:


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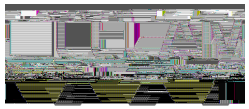
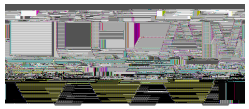


Project Information



- Personnel Involved:

  University of Washington:
  Paolo Feraboli, Tyler Cleveland, Marissa Morgan (A&A Dept)
  Mark Tuttle, Paul Labossiere, *Tory hif n* (ME Dept)
  Hexcel (principally):
  Bruno Boursier (Dublin, CA)
  Dave Barr (Kent, WA)
  Boeing (principally):
  Bill Avery (Seattle, WA)
  FAA (principally):
  Larry Ilcewicz (Renton, WA)

- FAA Technical Monitor:

  Curt Davies (Atlantic City, NJ)

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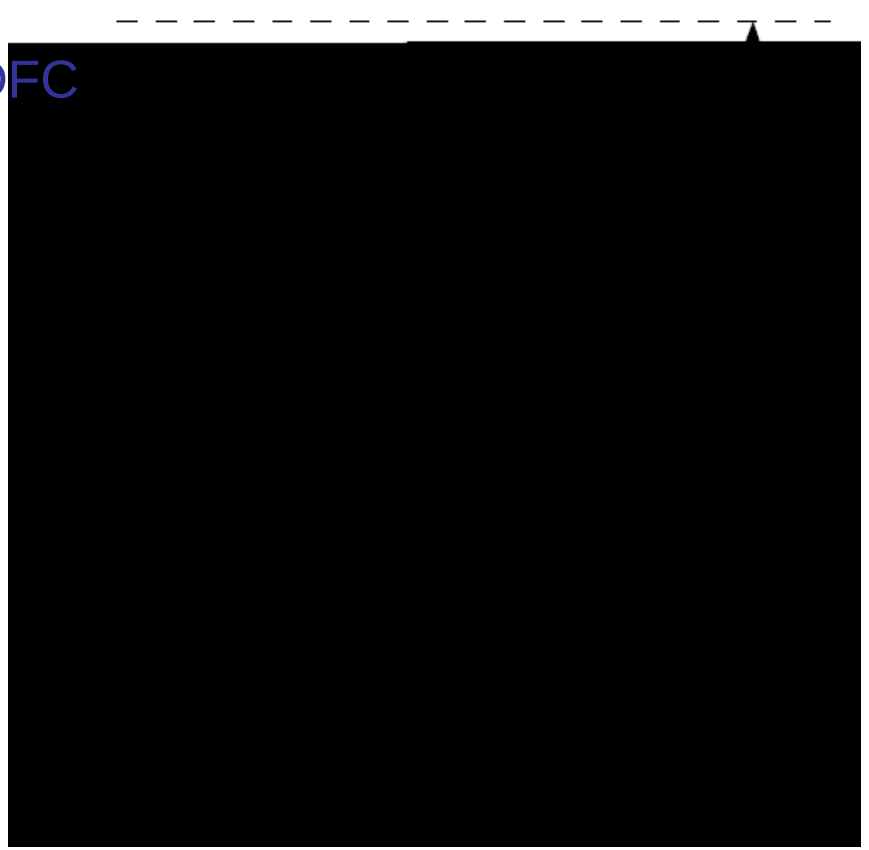
- Objective:
  - Simplify certification of DFC structures
- Technical Approach:
  - Use HexMC as model material



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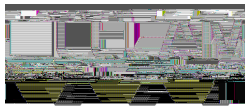

- Technical Tasks (4-year):
  - Blocks 1,2,3 :

    Hexcel: Generate allowables database: UNT, UNC, OHT, OHC, FHT, FHC, bearing, bearing/ by-pass, etc. Fabricate panels/etc needed for coupon-level UW studies

    UW-Tuttle:

    - Evaluate and develop understanding of effects of ply drops/adds (ply drop rate, part thickness, and molding-related issues such as high- vs low-flow areas)
    - Evaluate and develop understanding of load redistribution and failure at or near part fastener locations
    - Evaluate and understand the effect of NDI indications on properties/performance


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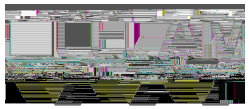

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Intercostal selected for study:

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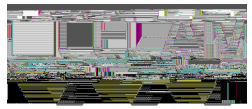
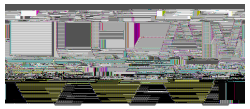


(A sampling of current activities & preliminary results):

- Characterizing structure in high-flow vs low-flow regions
- Modulus measurements:
  - Strain gages
  - Digital Image Correlation
- UNT & OHT versus UNC & OHC tests
- Beam flexural testing

High-and Low-Flow Panels



Hexcel fabricated delivered multiple panels:

High-and Low-Flow Panels

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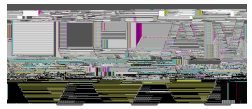
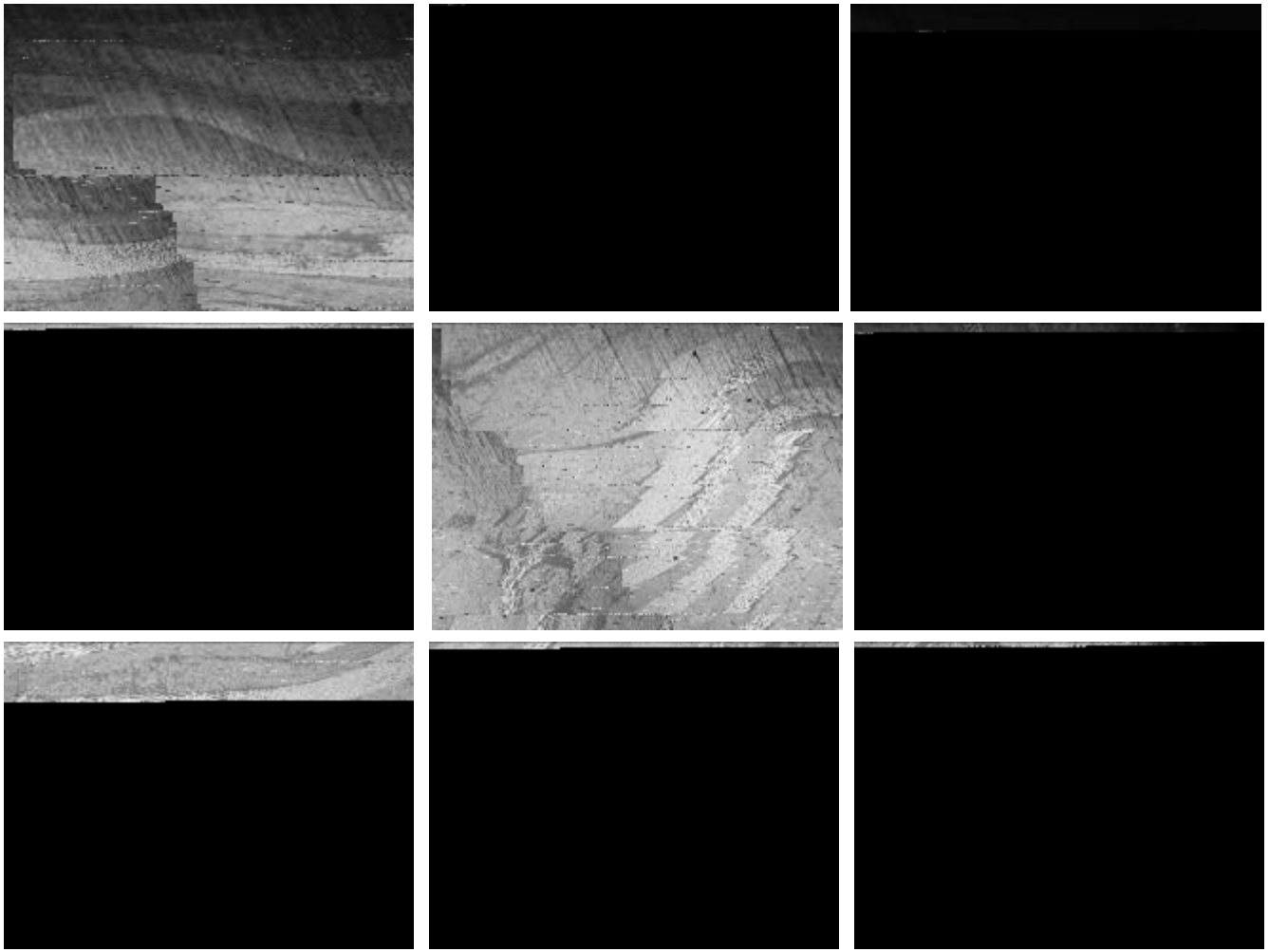


High-and Low-Flow Panels

Optic icroscopic i ges ne r edge



Modulus Measurements

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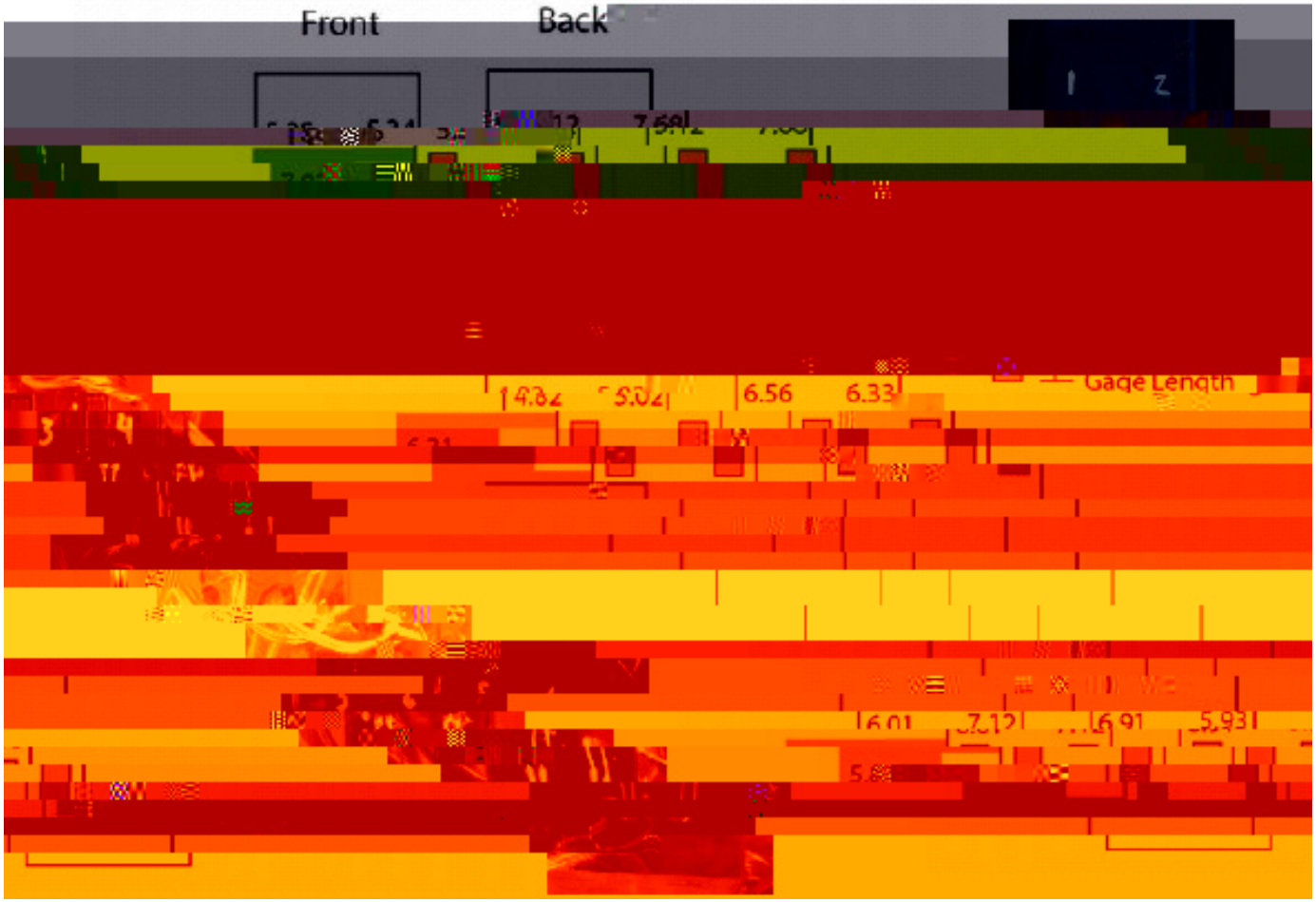
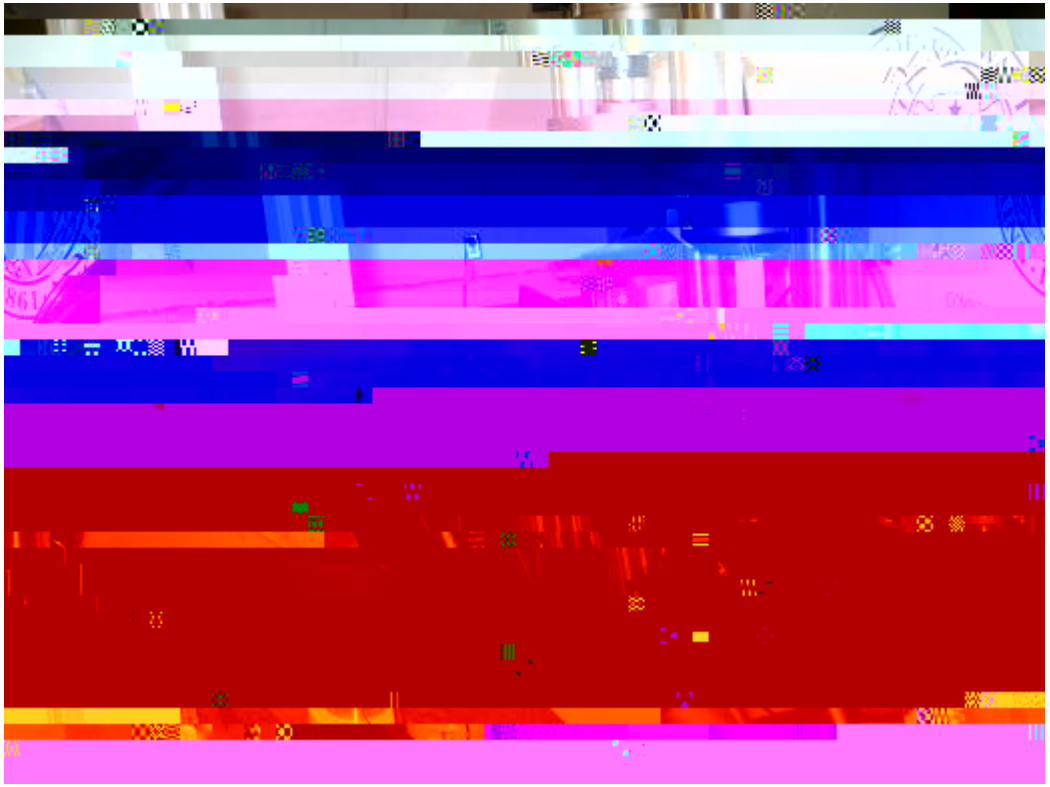
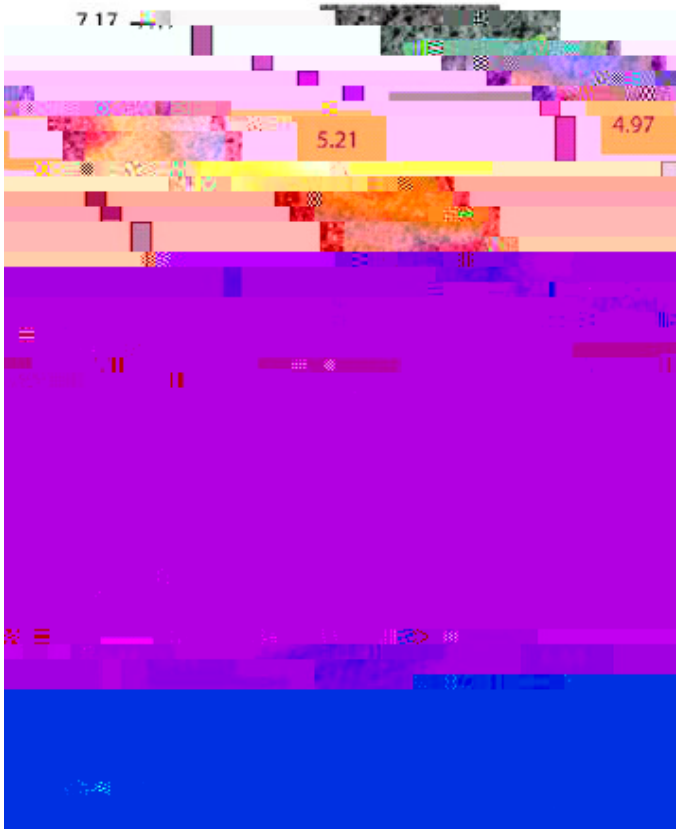


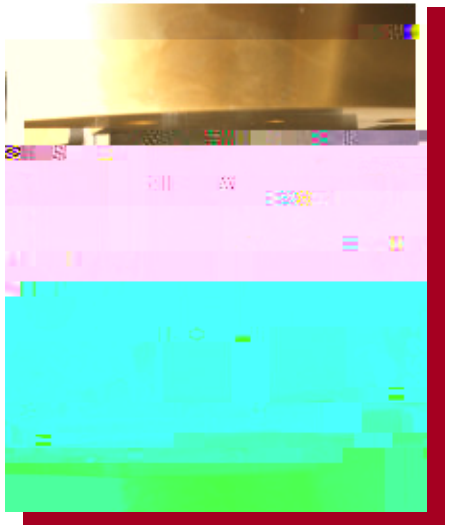
Modulus Measurements

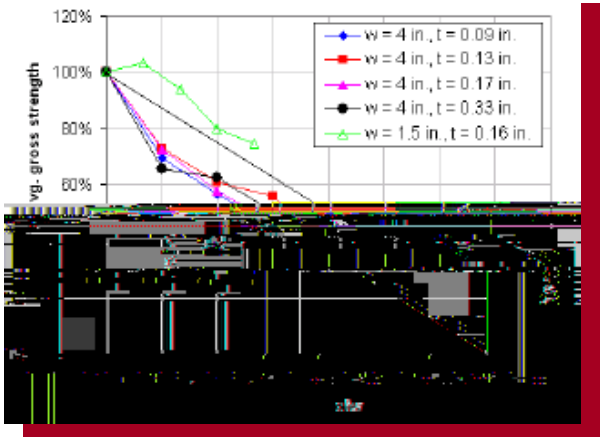
D C e s res ho e fie d es





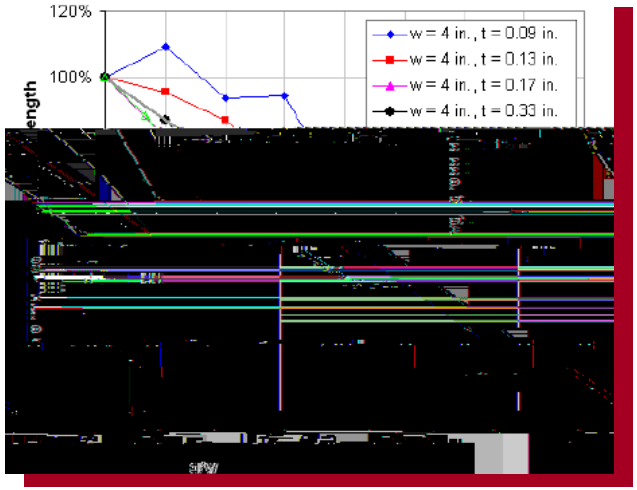
OHT Tests





- Straight-sided tensile specimens w/square end-tabs (4 x 6 in CAI specimens)
- Five thicknesses: 0.09,0.13,0.17,0.33 in
- Four hole dia: 0.0, 0.5, 1.0, 2.0 in
- Three replicate tests (60 tests total)
- All failed at hole (or within gage)
- Gross strength independent of thickness
- Modest notch sensitivity (differs from 1.5 in coupon results)
- CoV: 2-15%, average = 9.7%

OHC Tests

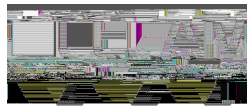


- Boeing CAI Fixture (4 x 6 in specimens)
- Five thicknesses: 0.09,0.13,0.17,0.33 in
- Four hole dia: 0.0, 0.5, 1.0, 2.0 in
- Three replicate tests (60 tests total)
- All failed at hole (or within gage)
- Gross strength thickness-dependent
- Lesser notch sensitivity
- CoV: 2-14%; average = 7.7%

Beam Flexural Testing

Fixture assembled recently, no data yet

Benefit to Aviation



FAA: Program objective supports safety regulations for design, production, and airworthiness certification of DFC parts

Industry: Program will contribute towards broader use of DFC structures at lower cost and lower weight

Academia: Represents an applied research project addressing an immediate need in industry and providing pertinent research & educational training for new aerospace engineers

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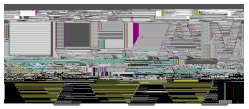

QUESTIONS ?