Development of Quality Verification Methods for Adhesively Bonded Joints

AMTAS Research Topic Proposed by

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April 23, 2009

Motivation and Approach

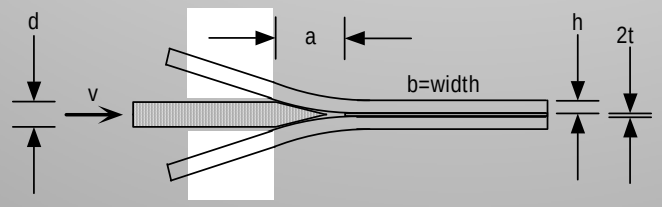
- Non destructive methods not available to measure bond strength in adhesive joints
- Method needed to determine if glue “stuck”
- Proposed research supports the FAA’s mission- Flight Safety
  - Structural Integrity of Adhesive Joints
  - Educational Development-Hands On“ Training

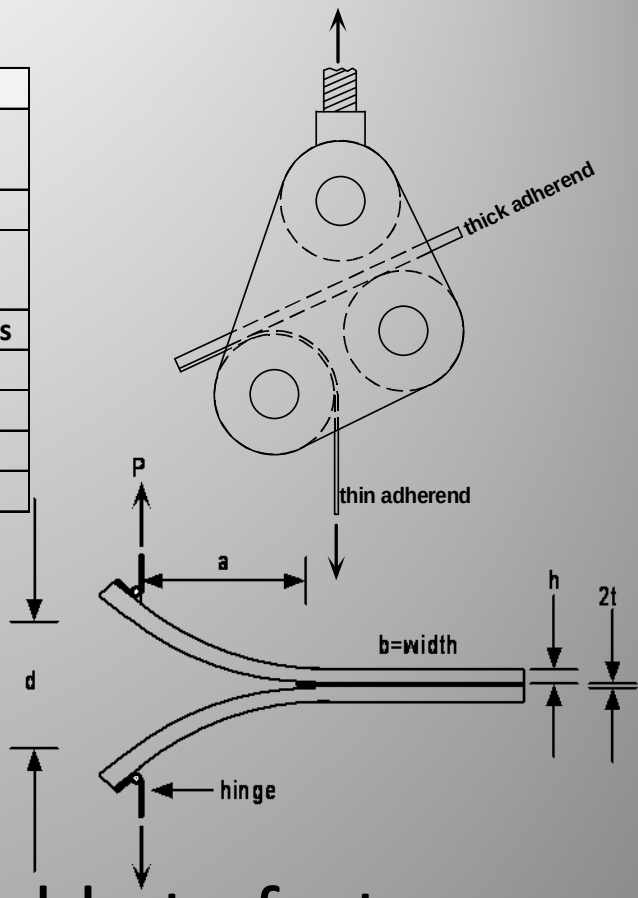
- Propose to develop quick, low cost method(s) suitable for factory, field and training applications using “witness coupons” to verify a good bond was produced. These methods would evaluate adhesive bonding materials and processes including surface preparation and cure with a Mode I fracture test.

Background-Current Test Methods

ASTM Mode I fracture tests

Test	Specimen	Purpose
D903	180° peel, thick adherend to thin, flexible adherend	Peel/stripping adhesive characteristics
D1062	Thick DCB-like bonded metal	Adhesive cleavage properties
D1781	Climbing drum peel	Peel resistance between flexible & rigid adherends
D1876	T-peel, bonded joint	Peel resistance between flexible adherends
D3762	Wedge test	Durability of metal bond specimens
D3433	Fracture Strength in Cleavage	Metal Bond strength
D3807	Plastic DCB with long starter crack	Adhesive cleavage/peel strength
D5528	DCB with starter crack	Interlaminar Toughness, G_{1C}

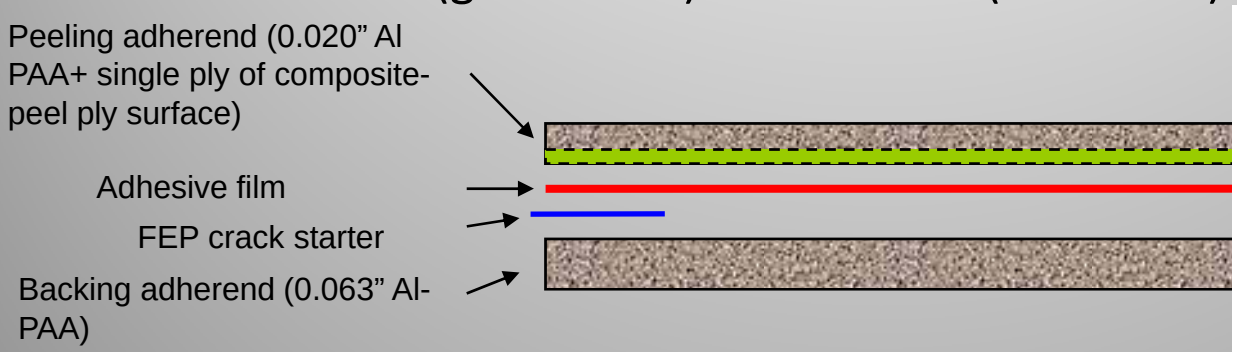




- Current test methods not applicable to factory or field applications.

Background- Current FAA Project

- Use quick, inexpensive test used to evaluate surface preparation on bond quality
  - Rapid Adhesion Test (RAT) gives fracture mode
    - Failure modes correlate with DCB test @ ~90% less cost and flow time
    - Cohesive (good bond) or Adhesion (bad bond)

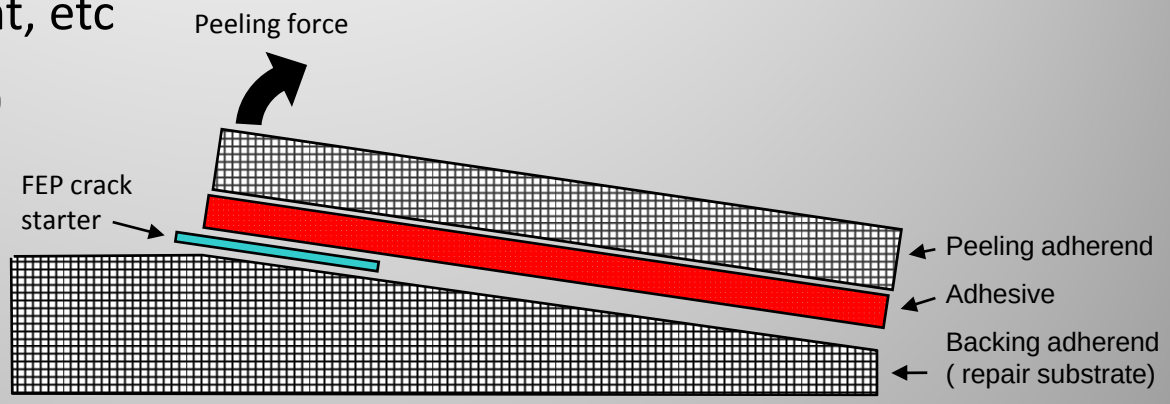


- Test geometry drives failure to peeling adherend interface
  - No cohesive failures in adhesive
  - Evaluates only one side (top) of the joint

Proposed Research

Fracture mechanics and FEA guided design of:

1. New test specimen geometry(s) based on industry need
   - Lap Joint, Scarf Joint, etc
2. New test fixture(s)



that overcome limitations of the RAT method and allow true behavior of the joint (both adherends and adhesive) to be quickly and easily evaluated.

Bond Quality measured by:

- Fracture Mode (cohesive or adhesion)
- Force required (independent of crack length)

Applications of Proposed Research

- Repair and Manufacturing
  - Witness coupons prepped, bonded and cured using same materials and process and at same time as repair/joint (possibly in same vacuum bag). Test coupon in the field/on floor with hand operated fixture
- Training and Assessment of Technicians
  - Similar to welder training and certification
  - Technicians would have to prep and bond samples
- Materials and Processes development
  - Less expensive, faster testing

➢ Provides quick feedback that would detect improper/out of spec materials, improper surface preparation, and/or improper cure.

Considerations to be addressed

- Fracture Path as function of geometry (specimen & fixture)
  - Preliminary results in lab promising- cohesive failure in adhesive
- Correlation with DCB results on good and bad bonds
  - Fracture mode
  - Peel force vs. G_{IC}
- Sensitivity of new method to surface prep, materials and processes
- Conditioning of witness coupons to reflect actual (or worst case) conditions (moisture, oil, etc)
- Practicality- added time and cost to repair/manufactering
  - Net shape specimens (no machining)
  - Representative of actual joint geometry

Expertise, Resources and Schedule

Expertise

- Materials and Processes, Fracture Mechanics, FEA

Resources

- Salaries (1 month PI & ½ month Co-PI)
- Research Assistants (1.5/year)
- Supplies
- Services (autoclave/oven, machining, test frame time)
- Benefits and Indirect Costs

Schedule

- Year 1 Proof of concept & test development
- Year 2 Analysis, correlation verification on representative applications