The Effect of Surface Treatment on The Degradation of Composite Adhesives

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The Effect of Surface Treatment on The Degradation of Composite Adhesives

- Motivation and Key Issues
  - Adhesive bonding is required for composite structural efficiency
  - Surface preparation is not standardized and affects bond integrity
  - Long term durability of composite adhesive bonds is not well understood

- Objective
  - Compare the effect of surface preparation on bond durability
  - Investigate approaches to accelerate environmental degradation

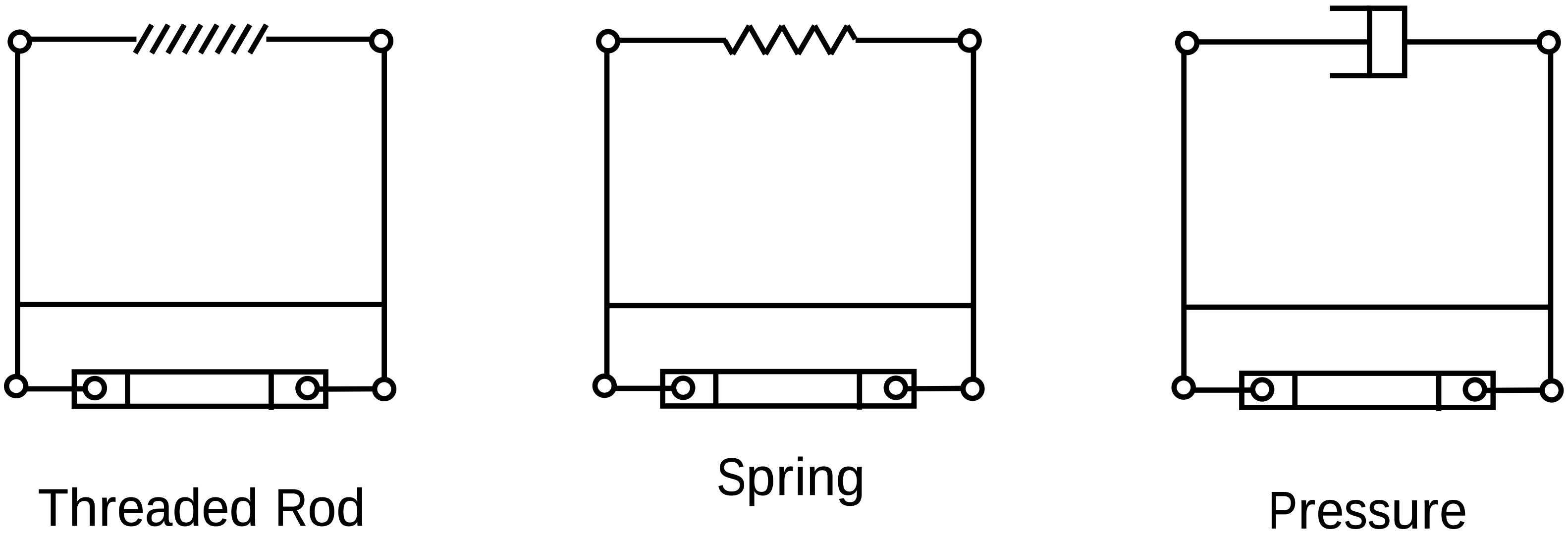
The Effect of Surface Treatment on The Degradation of Composite Adhesives

- Approach
  - ➢ Surface preparation
    - Prebond moisture
    - Peel ply
    - Abrasive techniques
  - ➢ Accelerated degradation
    - Modify wedge crack specimen
    - Combine moisture, temperature, and stress
    - Creep and fatigue of DCB
  - ➢ Material
    - BMS 8-276 form 3 prepreg (low cost)
    - 3M AF555 adhesive

FAA Sponsored Project Information

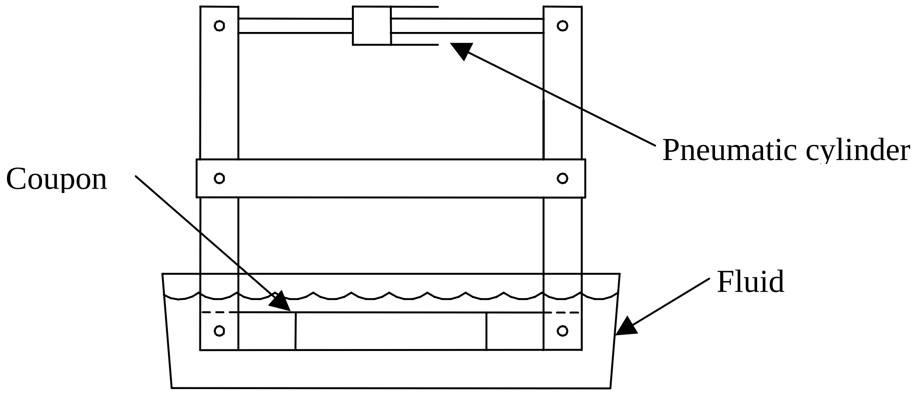
- Principal Investigators & Researchers
  - Lloyd Smith
  - Prashanti Pothakamuri
- FAA Technical Monitor
  - Peter Shyprykevich
- Other FAA Personnel Involved
  - Curt Davies
- Industry Participation
  - Boeing: Peter VanVoast

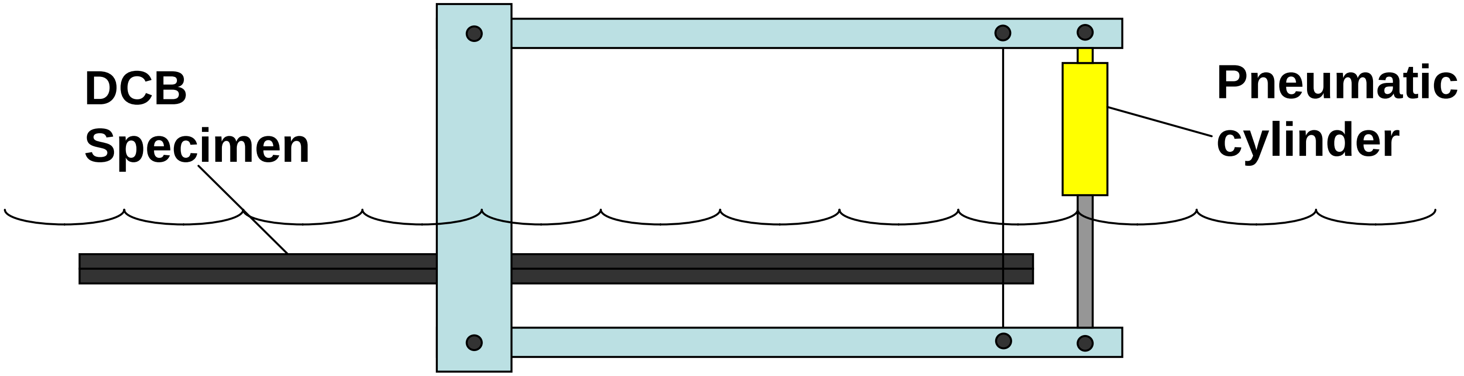
Combining Load and Environment



Combining Load and Environment

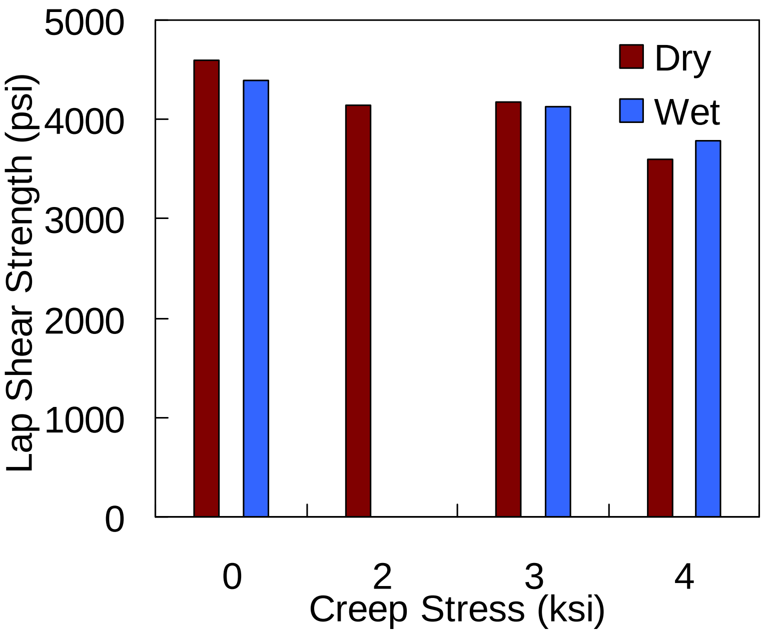
- Compact Pneumatic Creep Frames





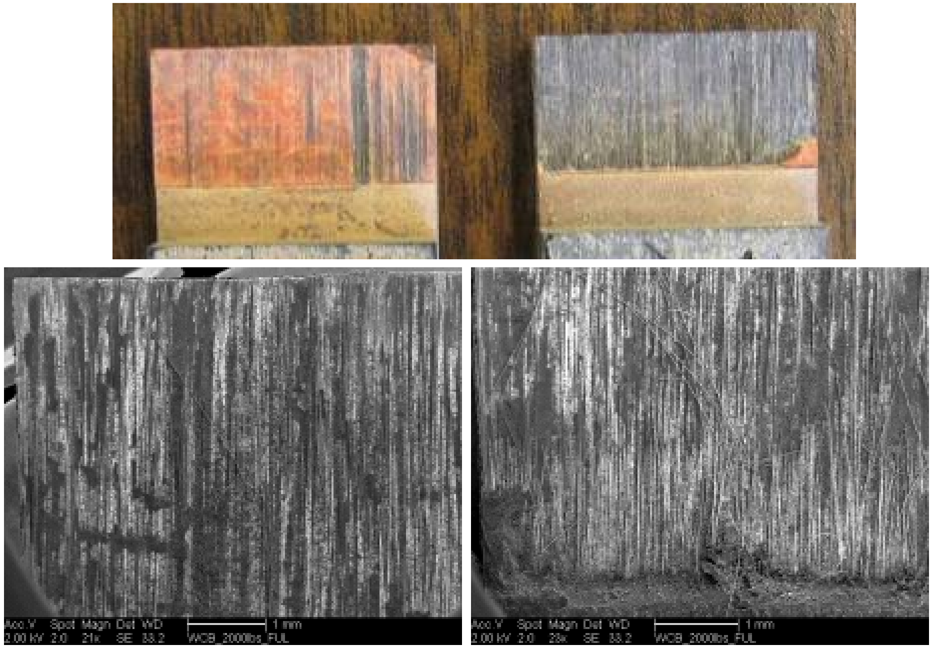
Moisture Effects

- Polyester peel ply
- Adherends dry or wet prior to bonding
- Immersed in 140F water with creep load
- Residual shear strength decreased with increasing creep load
- AF555 adhesive was relatively insensitive to prebond moisture content



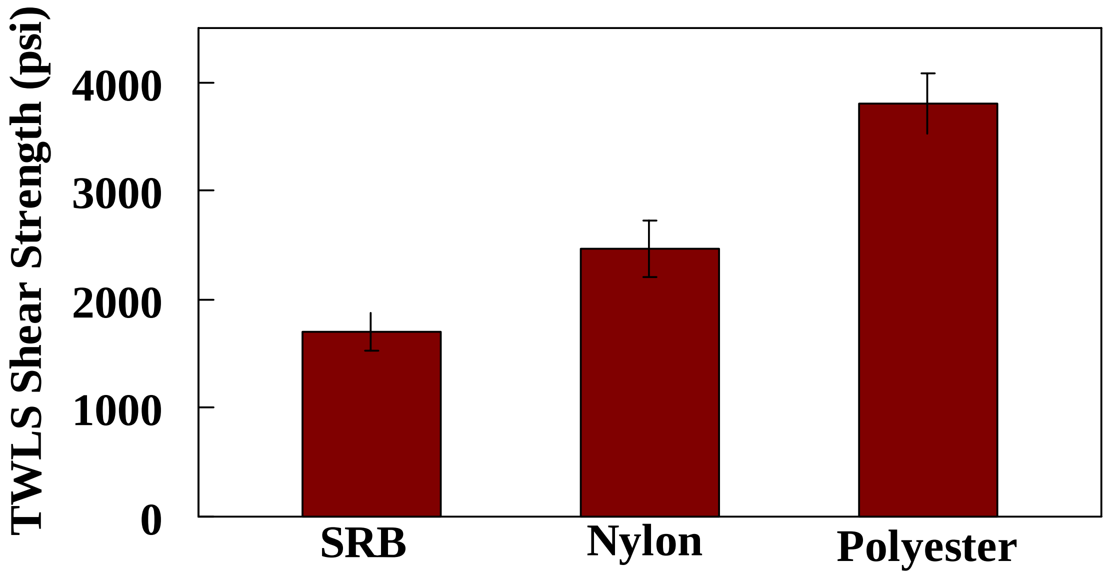
Moisture Effects

- Failure modes were predominantly in the adherend
- Adherend failure studies without adhesive (IPS, CILS)
- Classic and low cost material forms showed similar response



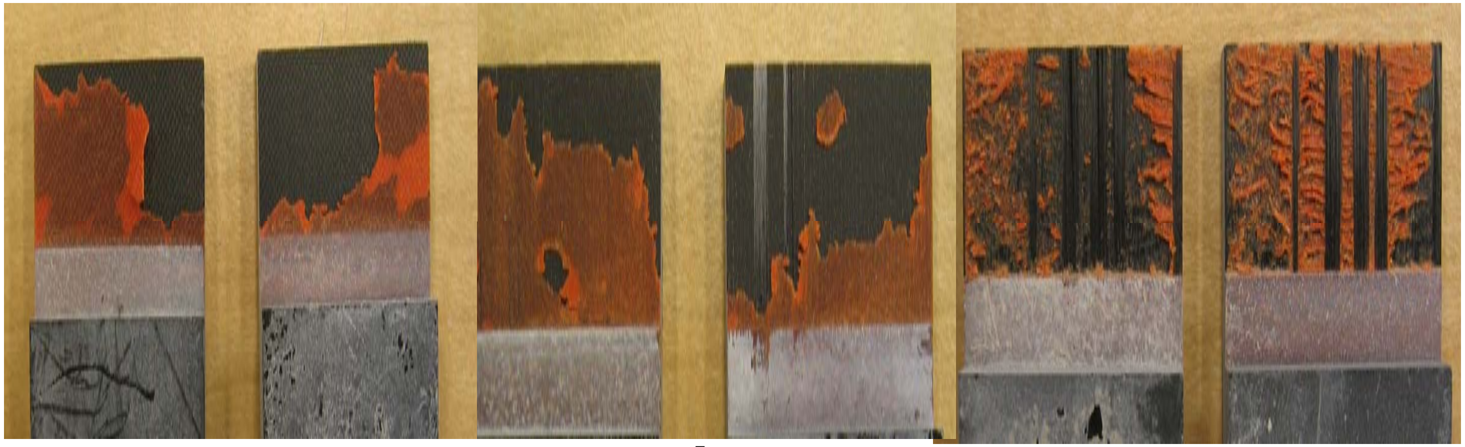
Peel Ply

- SRB (Super Release Blue)
- Nylon (Precision Fabrics 52006)
- Polyester (Precision Fabrics 60001)
- Saturated in 160F water (1.3%, 6k hrs)



Peel Ply

- TWSL failure modes



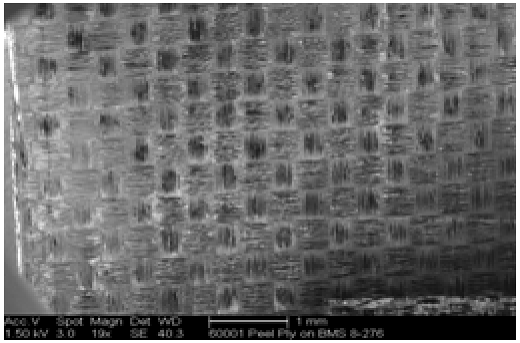
SRB	Nylon	Polyester
100% adhesion	100% adhesion	50% adherend, 50% cohesive

- Similar results observed with Creep-Rupture, DCB and Wedge Crack

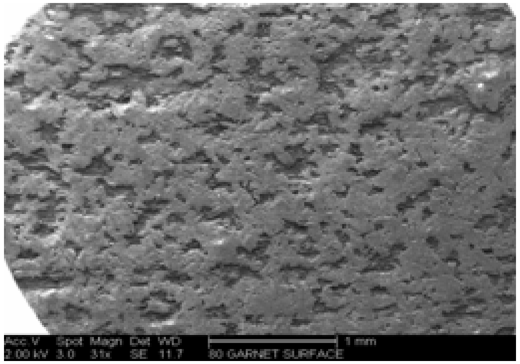
Peel Ply

- Test sensitivity to Peel Ply
  - DCB and Creep rupture were most sensitive
  - Wedge crack was least sensitive
    - Improved slightly by decreasing adherend stiffness
  - Suggests bond durability is affected by stress

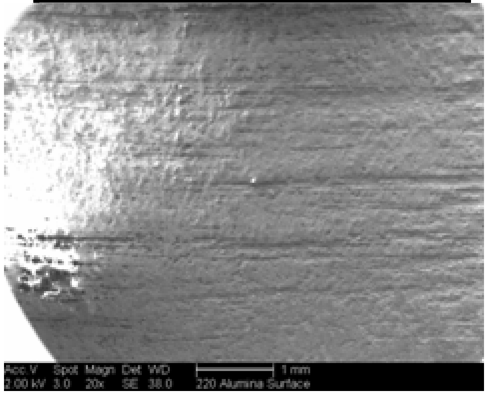
Surface Abrasion



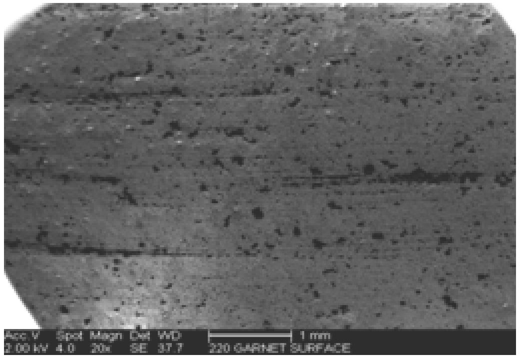
Polyester peel ply



Grit blast 80

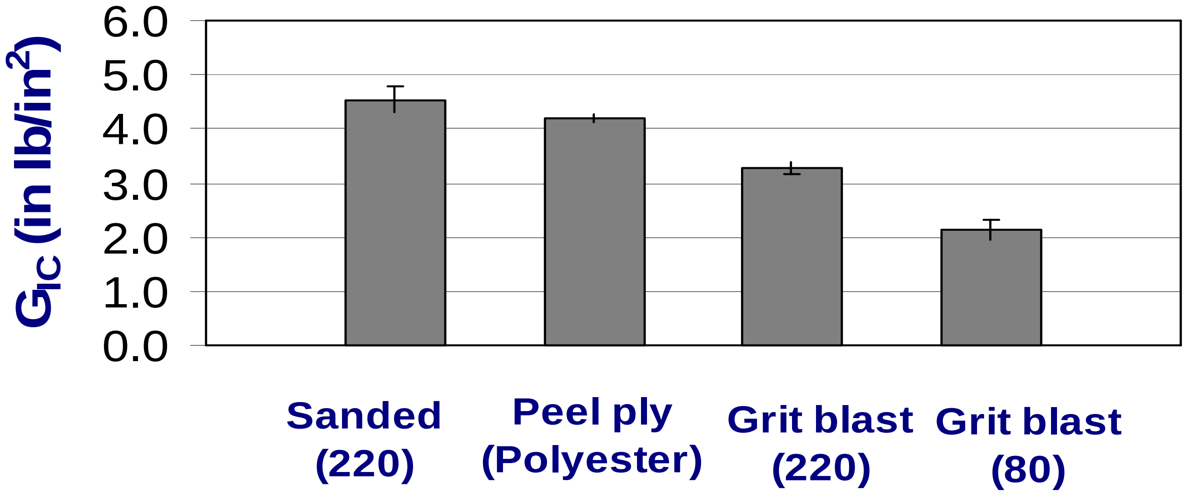


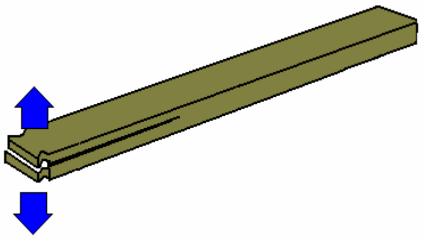
Sanding 220



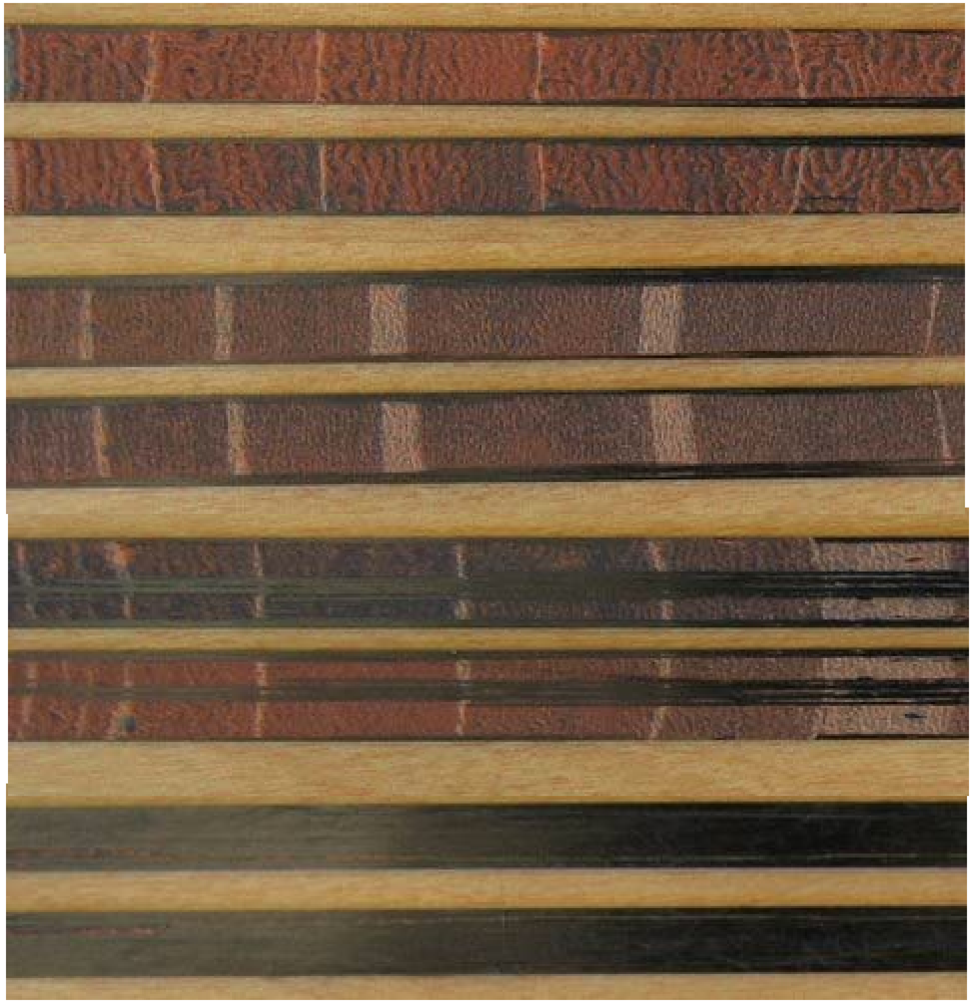
Grit blast 220

Surface Abrasion





Surface Abrasion



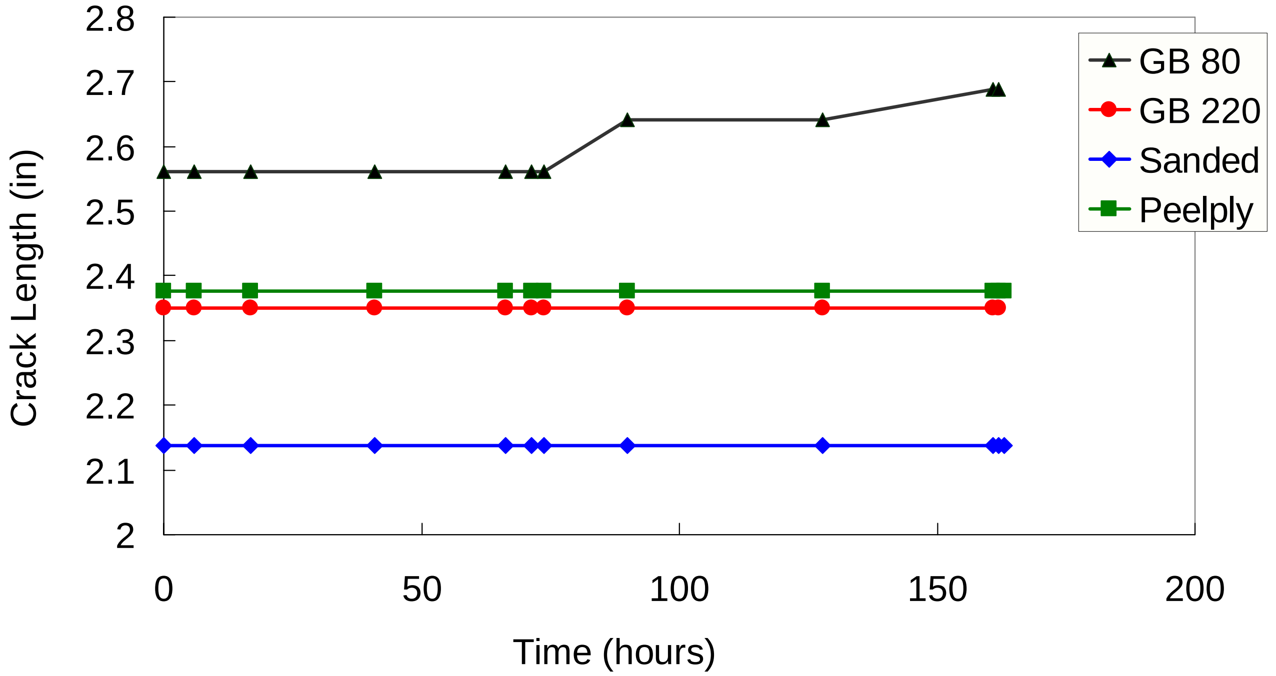
Sanded
99% cohesive, 1 % adherend
Polyester
90% cohesive, 10% adherend
GB 220
70% cohesive, 30% adherend
GB 80
100% adherend

Surface Abrasion

- Accelerated degradation
  - DCB specimen
  - Temperature (140F)
  - Moisture (immersion)
  - Load

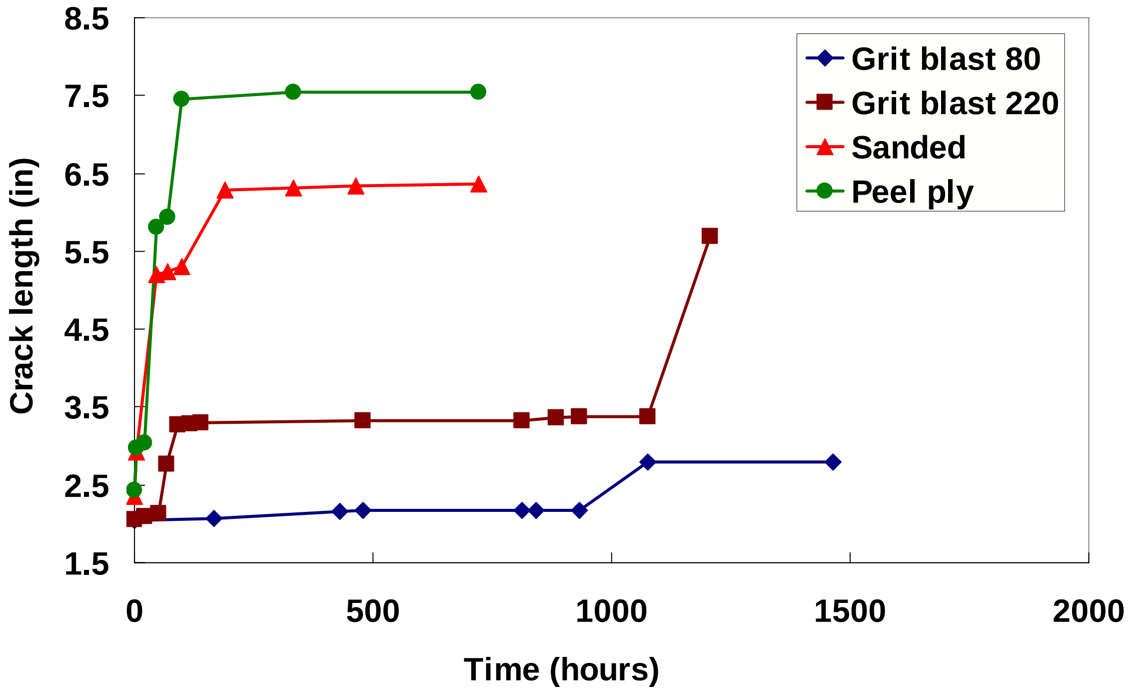
Surface Abrasion

- Creep load of 90% baseline crack initiation load
- Minimal crack growth observed



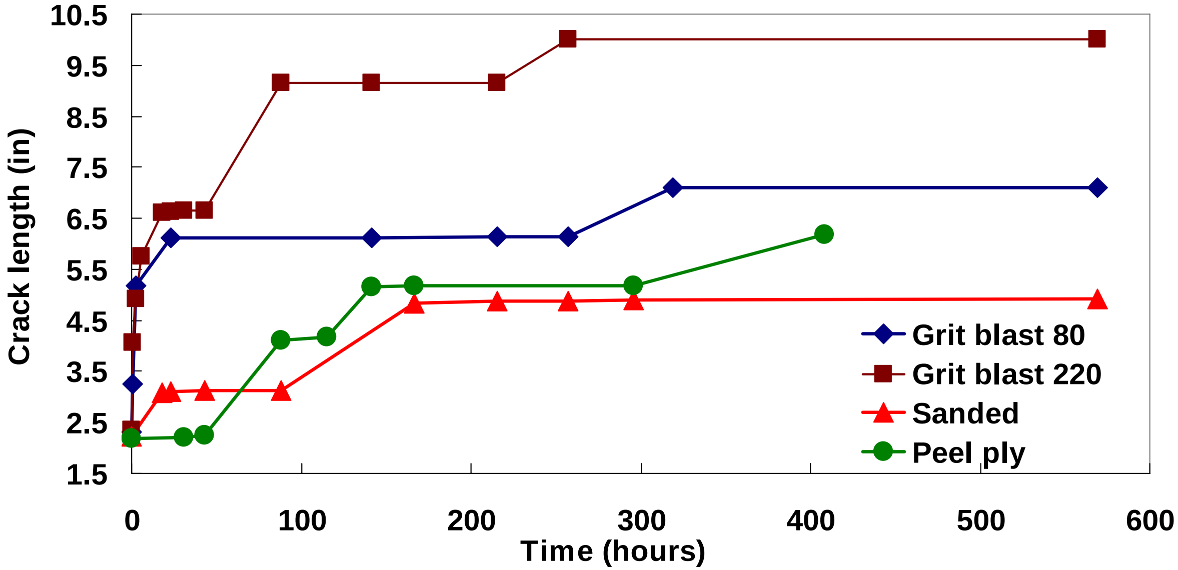
Surface Abrasion

- Load of 90% baseline crack initiation load
- Fluctuated at 0.5 Hz
- Measurable crack growth



Surface Abrasion

- Same load applied to all DCB specimens
  - 9.5 lbs
- Slopes of GB 80 and 220 are higher



Surface Abrasion

- Failure modes similar to baseline results

- GB 80 - 100% adherend
- GB 220 - 60% cohesive 40% adherend
- Peel ply - 50% adherend 50% cohesive
- Sanded – 20% adherend 80% cohesive

Summary

- Integrity of composite bonds using AF555 is relatively insensitive to prebond moisture content
- Moisture tends to encourage interlaminar failure of BMS 8-276 form 3 laminates
  - May be due to toughening system
- Peel ply can produce surfaces acceptable for direction adhesion
  - Peel ply should be matched with prepreg

Summary

- Surface abrasion did not significantly improve bond integrity
  - Slight improvement with sanding
  - Decrease with grit blasting
- Components of service exposure should not be studied individually in the laboratory
- Stress accelerated adhesive degradation
  - Residual shear strength
  - Creep rupture
  - Strain energy release rate

Summary

- Load control appears to accelerate degradation more than displacement control
  - Repeated loading accelerated degradation further

A Look Forward

- Benefit to Aviation
  - Improved understanding of processes used in adhesive bonding
  - Moisture resistance of AF555
  - Environmental degradation can be accelerated
- Future needs
  - Correlate accelerated laboratory exposure with service life
  - Application to other composite systems and adhesives
  - Durability of differing joint designs