

FAA Bonded Structures Workshop

Certifying Bonded Structure – Adam Aircraft's Experience

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Outline

- What does Adam Aircraft do?
- Focus on secondary bonded structure (via paste adhesive)
- Material and Process Specifications
- Adhesive Characterization and Design Allowables
- Examples of Bonded Structure
- Wrap up

A500 & A700



A500 specifications



- ✈ 6-place cabin
- ✈ 2 Continental TSIO-550 engines
- ✈ Retractable gear
- ✈ Max gross weight – 6500+ lb
- ✈ Fuel capacity – 230 gal
- ✈ Max speed – 250 KTAS/288 mph
- ✈ Max ceiling – 25,000 ft
- ✈ Pressurized 8,000-ft cabin at 25,000 ft



A500 Timeline

- 1998 Adam Aircraft Formed
- 2000 March M309 Proof of Concept Aircraft Flew 03/21/2000
- 2000 December Headquarters and Factory Building Complete
- 2001 March Applied for TC
- 2001 July Production Loft Complete
- 2001 August First Production Tool
- 2001 October First Development Components
- 2002 January First Flying Components
- 2002 July A500 First Flight 7/11/2002
- 2003 July A700 First Flight 7/23/2003
- 2004 Planned Type Certificate – A500



Materials

- Composite Parts
 - Vacuum bag, oven cure prepreg system
 - Toray Composites AGATE system
 - PW Carbon fabric, uni and FG fabric
- Secondarily Bonded Assemblies
 - Paste adhesive
 - Room temp or accelerated cure
 - Some cobonded and cocured structure
 - Fasteners used in some joints



Processes

- Prep
 - Clean parts
 - Grit blast primarily, hand sanding allowed
 - Controlled environment
 - Control time to bond
- Adhesive application
 - Semkits or hand mix
 - Bond thickness control
 - Acceptable range (0.005”-0.080”)
 - Shims, Glass beads, Fixturing stops
 - Moving to automated mixing (\$\$)
- Curing
 - Room temp or accelerated



Quality

- In-process Inspection
 - Bond prep
 - Visual - Squeeze out and fillets
 - Monitor cure time
- Process Verification
 - Sample cups
 - Panels
- Curing
 - Room temp or accelerated
- Post-inspection for voids
 - Visual
 - Tap test on thin laminates
 - NDI for large overlaps and hard to access areas



Qualification

- Used supplier's extensive database
- Multiple batches
- Characterize the adhesive properties
- Stress-strain behavior
- Chemical and Physical properties
- Shear strength (ASTM 1002 and 5656)
- Acceptance criteria
- Room temp and accelerated cure (150°F)
- Nominal and range of acceptable mix ratios
- With and without glass beads



Design and Allowables

- 500 psi rule of thumb
 - No data exists at small startups, have to start somewhere
 - Adhesive qualification is expensive and takes time
- Element tests – Overlap joints
 - Modified ASTM D3165 lap shear
 - Representative of the majority of bonded structure on the aircraft
 - Generate allowables for the joint's load carrying capability
 - Vary bondline thickness – 0.005", 0.030, 0.080 and thicker
 - Vary substrate thickness – thin, medium, thick
 - Vary overlaps – 1", 2", 3"
 - Bond prep – Grit and Hand
 - Environments
 - Tg? – test for strength at temps above MOL
 - Substrate failures
 - Wedge crack
 - Industry standard/consensus for composite substrates?



Bonded Structure



- ✈ Fuselage
 - ✈ 2 halves
- ✈ Wing
 - ✈ Spars, ribs, skins
- ✈ Tailbooms
 - ✈ 2 halves and internal structure
- ✈ Horizontal Tail
 - ✈ Cured and bonded

Fuselage



- 2 halves bonded at BL0
- Wet layup doubler for redundancy
- Local fasteners
- Floors bonded
- Engine gussets cocured
- Door cobonded

Wing

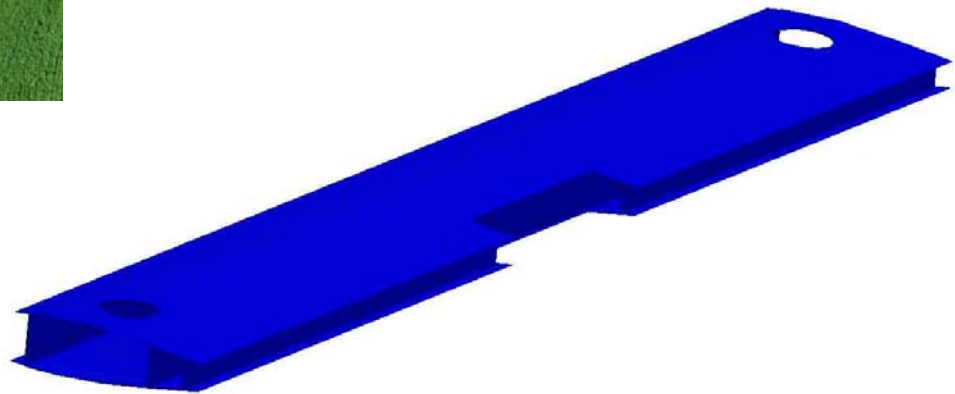


- 2 spars
- Internal ribs
- Skins
- Wing tips

Tail



- Booms/Vertical Tails
 - Inboard and outboard skins
 - Internal structure bonded
- Horizontal
 - Cocured lower skin and spars
 - Bonded Upper skin





Summary

- Small startups don't have time and money to develop costly databases – SHARE data for adhesive properties
- How does the bonded joint behave?
 - Adhesive characterization is important
 - Joint characteristics are more important
 - Thick vs thin substrate, overlap lengths and bondline thickness
 - Full-scale tests indicate hard to predict modes
- Wish-list
 - More shared data
 - Industry standards on durability tests
 - Industry standards for training – approved stations?
 - Industry standards for repair