

JOINT ADVANCED MATERIALS & STRUCTURES  
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# Durability of Bonded Aerospace Structures

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# Introduction

## Why use adhesives?

- High strength
- Low weight
- Reduced holes or no holes
- Join thin materials
- Join dissimilar materials
- High fatigue resistance

Significant use aboard current and future aircraft.

Low confidence in our ability to describe durability.

# Introduction

- Aim
  - Consider the relation between adhesive quasi-static and fatigue performance.
    - Shear and peel stress
    - Toughened and brittle systems

# Literature Review

- Fatigue response of double cantilever beam specimen – Azari et al.
- Variable amplitude fatigue testing of single Lap shear specimen – Shenoy et al.
- Fatigue performance versus scarf angle – Jen

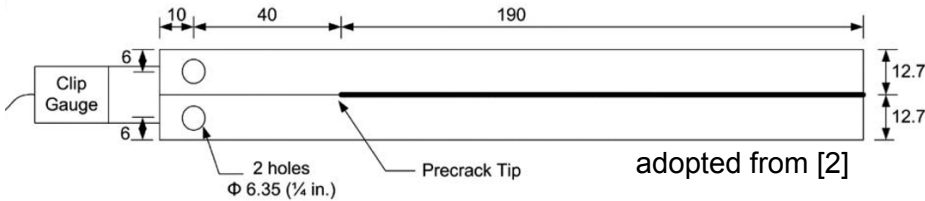
None address the role of toughness

# Quasi-static Testing

- Wide Area Lap Shear



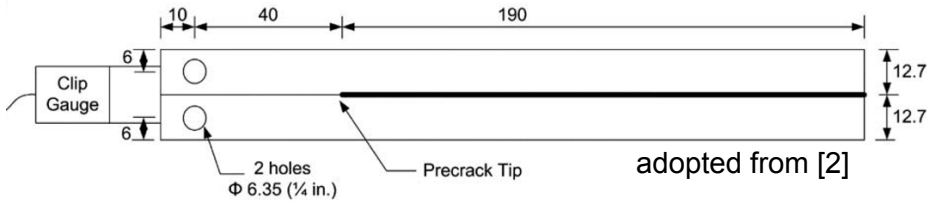
- Double Cantilever Beam



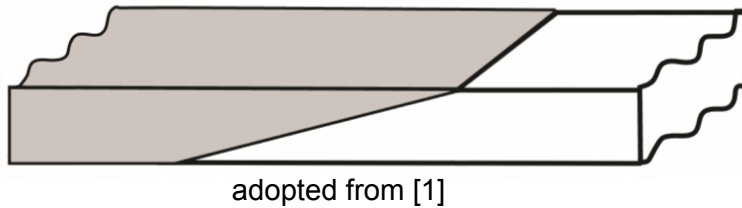
	Number of Coupons	Adherend	Adhesive	
Quasi-Static	5	2024-T3	FM300-2	WALS
	5	2024-T3	EA9696	
	5	2024-T3	EA9394	
	5	2024-T3	EA9380.05	
	5	2024-T3	FM300-2	DCB
	5	2024-T3	EA9696	
	5	2024-T3	EA9394	
	5	2024-T3	EA9380.05	

# Fatigue Testing

- Double Cantilever Beam



- Scarf



	Number of Coupons	Adherend	Adhesive	
Fatigue	5	2024-T3	FM300-2	DCB
	5	2024-T3	EA9696	
	5	2024-T3	EA9394	
	5	2024-T3	EA9380.05	
	25	2024-T3	FM300-2	Scarf Joint
	25	2024-T3	EA9696	
	25	2024-T3	EA9394	
	25	2024-T3	EA9380.05	

# Adhesive Selection

- 65% variation in Peel Strength
- 33% variation in Lap Shear Strength

Adhesive	Peel Strength	Peel Test	Tensile Lap Shear Strength	Toughness	Form
Hysol EA 9696 (0.060 psf)	100 in-lb/in	Metal to Metal Climbing Drum	6300 psi	Toughened	Film
Cytec FM 300-2K (0.08 psf)	35 in-lb/in	Metal to Metal Climbing Drum	5900 psi	Brittle	Film
Hysol EA 9394	20 lb/in	Floating Roller Peel Strength	4200 psi	Brittle	Paste
Hysol EA 9380.05	*	*	*	Toughened	Paste

\*No data available

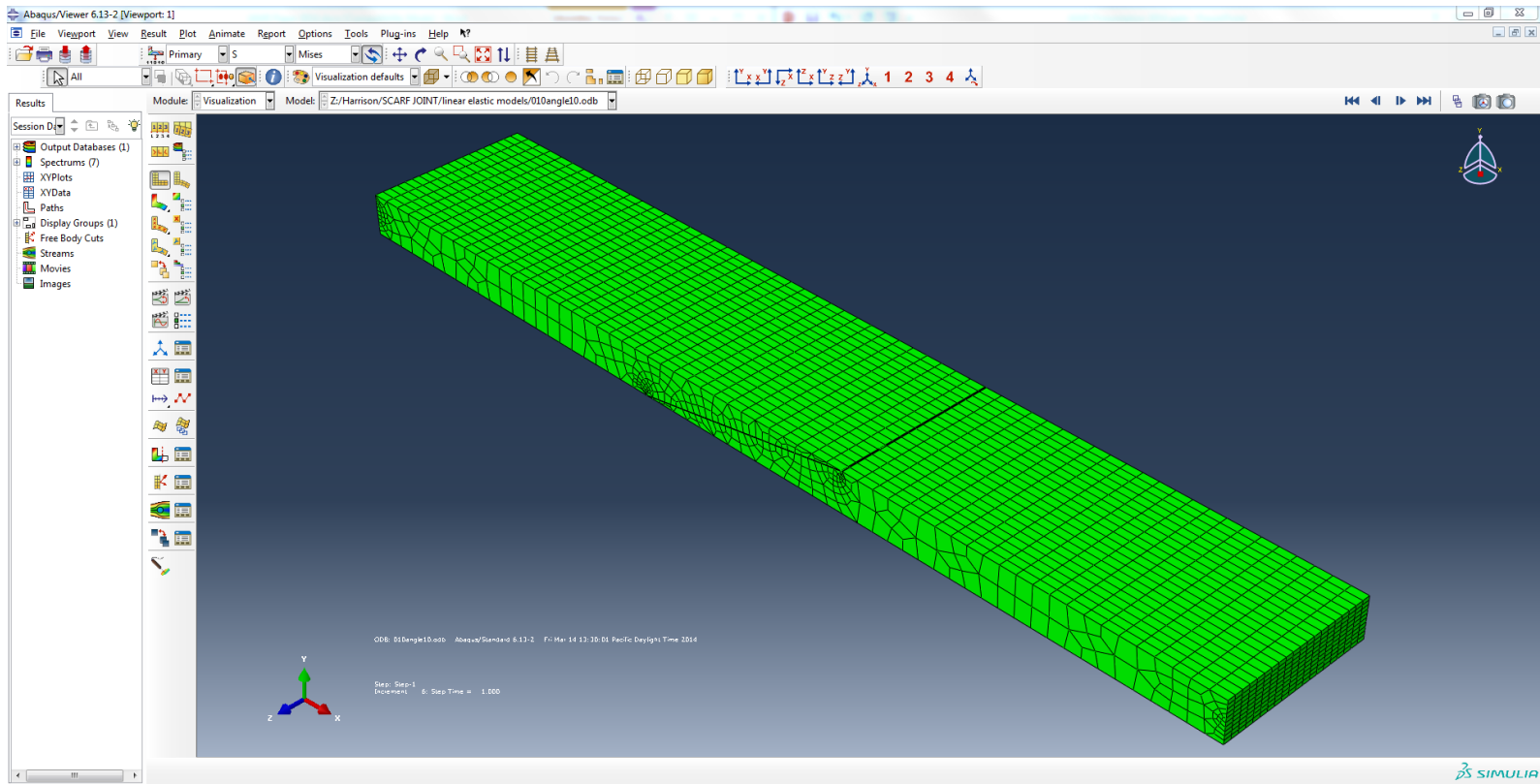
# Adherend Selection

- 2024-T3 Aluminum
  - High fatigue resistance
  - Higher stiffness compared to 6061-T6
  - Lower corrosion resistance
    - Phosphoric acid anodized per BAC5555 both sides
    - Primed per BAC5514-589 using Cytec Engineered Materials BR6747-1 Bonding Primer
  - Common in aerospace structures



# Finite Element Analysis (FEA)

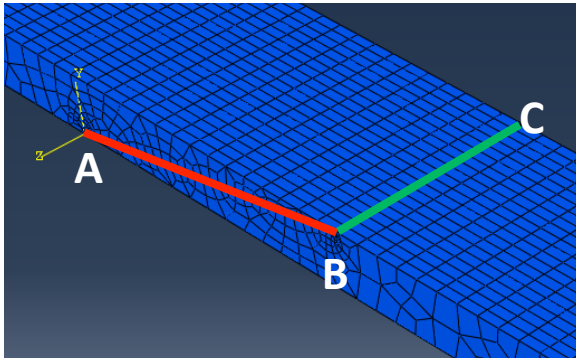
- Abaqus



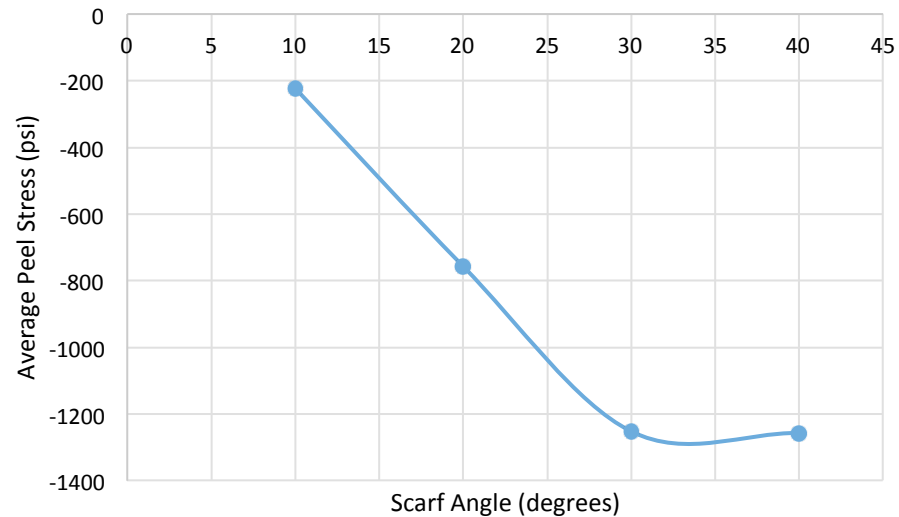
1"x0.25"x6" – 2,000 lb load

# Finite Element Analysis (FEA)

- Peel stress along line A-B



***10 degree scarf joint will provide shear stress testing with minimal peel stresses.***



# Summary

- Compare static and fatigue response
  - Consider the roll of toughness on fatigue
  - Consider shear and peel dominated stress
- 
- Results will lead to improved life prediction methodologies