DEVELOPMENT AND EVALUATION OF A SELF-REPAIRING CONCEPT FOR COMPOSITE MATERIALS.

Ms. Jody Pang, Dr. Ian Bond

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Overview

• Background
• Why self-repair?
• Possible Approaches
• Chosen Approach
• Experimental
• Results
• Modelling
• Conclusions
• Ongoing/Further Work
Background – Ongoing Fibre Work at Bristol

WHY SELF-REPAIR?

50µm triangular fibres
50µm star shaped fibres
Damage Susceptibility

- Continuous fibre reinforced plastics - 2D ply structure
- Excellent in plane properties
- **BUT** susceptible to ‘delamination’ after a damage event!
- Minor external, major internal damage
Self-Healing / Self-Repair
Possible Approach: Microencapsulation

(a) Basic method of the microcapsule approach, (b) ESEM image showing ruptured microcapsule

Possible Approach: Hollow Fibres

Possible approaches for FRP’s
Chosen Approach

Objectives:

- Develop a FRP which employs a biomimetic approach to perform a self-repair function
- Restore mechanical strength by self-activated, self-repairing process
- Enhance damage visualization by the bleeding action of highly conspicuous media
Experimental Approach

- Hollow glass fibre used for storing functional components
- Sandwich of Hollow Fibre & Solid E-glass with epoxy
- Damage created by indentation
- Healing process investigated under different conditions prior to 4-point flexural testing
Lay up Configuration

90° - MY750 epoxy resin + 20% acetone + fluorescent dye

0° - Solid E glass/913 epoxy

90° - Hollow glass/913 epoxy (60 µm/50% hollow)

90° - Hardener

{[90°/0°]_{(solid)}, [90°/0°/90°/0°]_{(hollow)}, [90°/0°/90°]_{(solid)}}_s
Test Specimen (ASTM-790M-93)

- Length: 80mm
- Width: 64mm
- Height: 25mm
- Thickness: 2mm

Hollow glass fibre plies
Mechanical Testing

Indentation test fixture

4-point bending test
Typical Load-Displacement Curves During Indentation To Create Damage Site

With repairing agent

Without repairing agent
4-Point Bend Testing of Undamaged, Damaged and Self-Repaired Specimens

Flexural Strength (MPa)

- A undam.
- B 0wks
- C 3wks
- D 6wks
- E 9wks
- F dam.
Cross-Section Through Hybrid Hollow/Solid Glass/Epoxy Laminate.

Resin has ‘bled’ out and penetrated cracked matrix.
Modelling

• Urgently needed but NOT trivial!
• Understand/predict (impact!) damage type/location
• Where to place fibres/repair plies for maximum benefit
• Model healing/repair mechanism – improve!
Conclusions

• **Self-repair ability demonstrated** - significant fraction of flexural strength restored after damage

• **Repair efficiency decreases** over time

• **Problems to be addressed:**
  - Optimise location of hollow fibre plies within laminate for maximum benefit – damage specific!
  - Select/tailor resins to improve repair, environmental stability/longevity.
  - Supply/replenishment of repair resin
Ongoing/Further Work

- European Space Agency – investigation application to space environment
- EPSRC - 'Bleeding Composites' - Damage Detection And Self-Repair Using A Biomimetic Approach
- Collaboration with UIUC (Scott White et al.)
Questions?