MODELING THE PROGRESSIVE DAMAGE IN 2D AND 3D WOVEN FABRIC COMPOSITES

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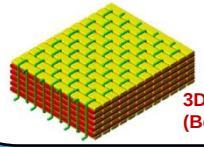
BACKGROUND

- Advantages of 3D Fabric Composites:
  - High Fracture Toughness (G_{IC}, G_{IIC}, G_{IIIC})
  - Damage Tolerance
  - Easy Handling & Infusion
- Prediction of the Properties of 2D/3D Woven Composites
  - Micro- or Meso-scale Levels through Theoretical and Finite Element (FE) Analysis
  - Non-linear Responses and Softening Behaviors after Damages Have Been Hardly Studied



3D Orthogonal Weave Fabric (Bogdanovich, J Mater Sci (2006))

RESEARCH GOAL AND SCOPE

- Research Goal:
  - Modeling Damage of 3D S-2Glass/SC15 OWF (orthogonal weave fabric) Composite using UCM (unit cell model) Approach
- Research Scope:
  - Single Element (SE) Analysis (SEA) of Uni-Directional (UD) S-2 Glass/SC15 Composites & Pure SC15 Resin
  - Mechanical Response Simulation of 3D S-2 Glass/SC15 OWF Composite using the Meso-Mechanical UCM
  - Homogenization of 3D S-2Glass/SC15 OWF Composite Properties

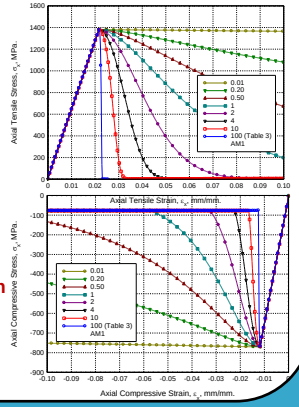
PROGRESSIVE DAMAGE MODEL FOR UD S-2 GLASS/SC15

- Progressive Composite Damage Model MAT162 in LS-Dyna
- Stress-Based Failure Criteria (Hashin , J Appl Mech, 1980), and Matzenmiller's Damage Model (Compos Struc, 1995)
- Damage Modes for UD Composite
  - Fiber Tension/Shear
  - Fiber Compression
  - Fiber Crush
  - Transverse Compression
  - Perpendicular Matrix Crack
  - Parallel Matrix (Delamination)

SINGLE ELEMENT ANALYSIS OF UD S-2 GLASS/SC15

Tension

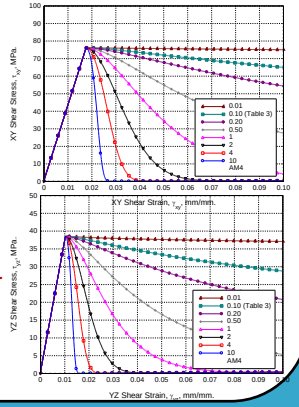
Compression



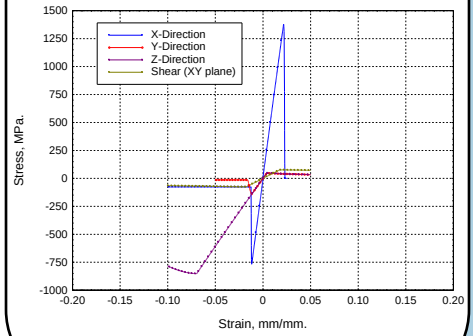
SINGLE ELEMENT ANALYSIS OF UD S-2 GLASS/SC15

In-Plane Shear

Inter-Laminar Shear

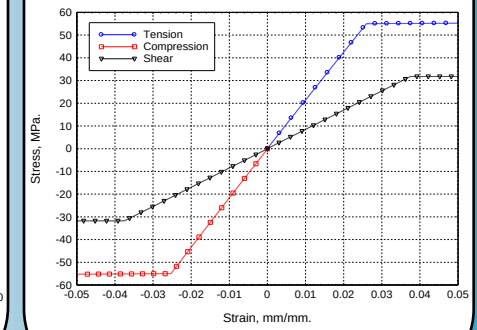


SUMMARY OF UD S-2 GLASS/SC15 MODEL



Progressive Damage Model

SUMMARY OF SC15 INTERSTITIAL RESIN MODEL

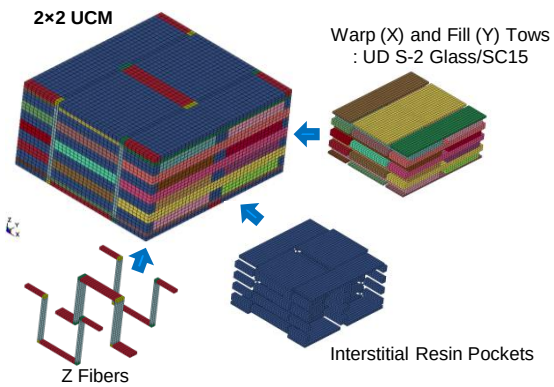


Elastic-plastic Model

MODELING PROGRESSIVE DAMAGE IN 2D AND 3D WOVEN FABRIC COMPOSITES

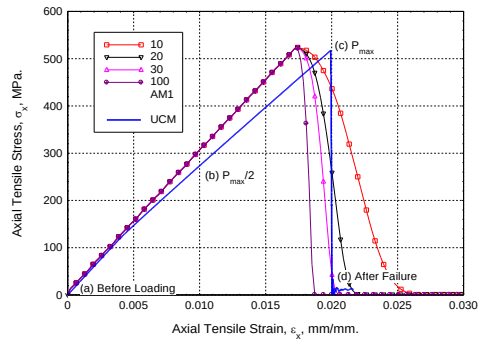
(Continued)

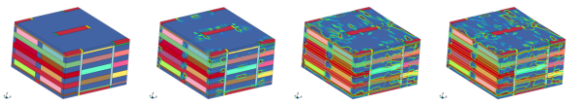
UNIT CELL MODEL (UCM) OF 3D OWF COMPOSITE



- **Composite Density: 1720.30 kg/m^3**
- **Aerial Density: 9.271 kg/m^2 (1.9 psf)**

X-TENSION

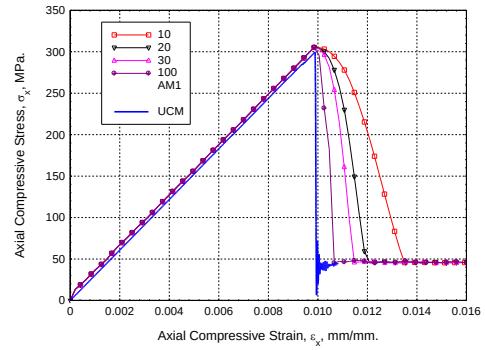




(a) Before Loading (b) $P_{max}/2$ (c) P_{max} (d) After Failure

Damage Propagation

X-COMPRESSION



Homogenized Properties from Tension/Compression

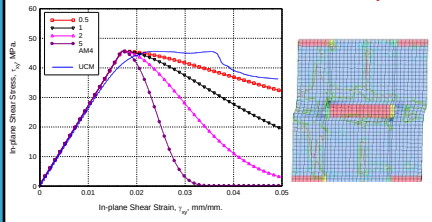
$$E_X = 30.2GPa \qquad \upsilon_{12} = 0.0961$$

$$S_{XT} = 517.5MPa \qquad S_{XC} = 299.8MPa$$

$$m1 = 30 \qquad m2 = 30 \qquad SFFC = 0.15$$

XY-IN-PLANE SHEAR

Stress-Strain Curve and Deformed Shape



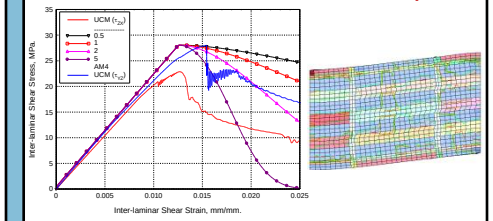
Homogenized Properties

$$G_{XY} = 2.67GPa \qquad S_{XY} = 45.6MPa$$

$$m4 = 2$$

XZ-INTER-LAMINAR SHEAR

Stress-Strain Curve and Deformed Shape



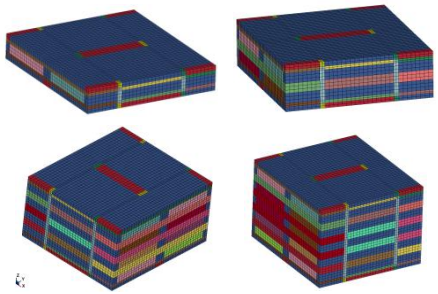
Homogenized Properties

$$G_{YZ} = 2.20GPa \qquad G_{ZX} = 2.08GPa$$

$$S_{YZ} = 28.0MPa \qquad S_{ZX} = 22.8MPa$$

$$m4 = 2$$

APPLICATION



Prediction of Effective Property For Different 3D OWF Composites

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