Mechanical Properties of Additively Manufactures CF Composites

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MOTIVATION

- Traditional composite manufacturing methods face limitations:
  - high complexity, cost, and slow production.[].
- Continuous Fiber 3D Printing (CF3D®) offers intricate geometries, precise fiber control, and rapid prototyping.
- Insufficient mechanical property data exists for CF3D® printed composites using CereMat resin.

OBJECTIVE

- To fabricate tensile and shear test coupons using additive manufacturing per ASTM standards.
- To measure and analyze tensile and shear mechanical properties of CF3D® printed carbon fiber composite.
- Evaluate the structural performance to facilitate broader industrial adoption of CF3D® technology.

METHOD & PROCESS

1. Design:
   - Tensile and Shear test coupon geometry defined per ASTM D3039[] and D3518[]
   - Designed using Autodesk Fusion 360
2. Toolpath Planning:
   - CF3D® Studio for toolpath generation
   - Reasoned layer geometry per printer capabilities
3. Additive Manufacturing:
   - Printed using CF3D® printer
   - Material: Toray T1100-12K 50 SC® CF and CereMat® thermoset resin
4. Thermal Cure:
   - 25° C to 180° C (3° C/min), held for 4 hr, Cooled to room temperature (-3° C/min)
5. Sample Preparation
   - 6 tensile (6" × 0.5") and 6 shear (6" × 1") samples were waterjet cut.
6. Mechanical Testing:
   - Instron Universal Testing Machine (UTM) for Tensile and Shear.
7. Results & Analysis:

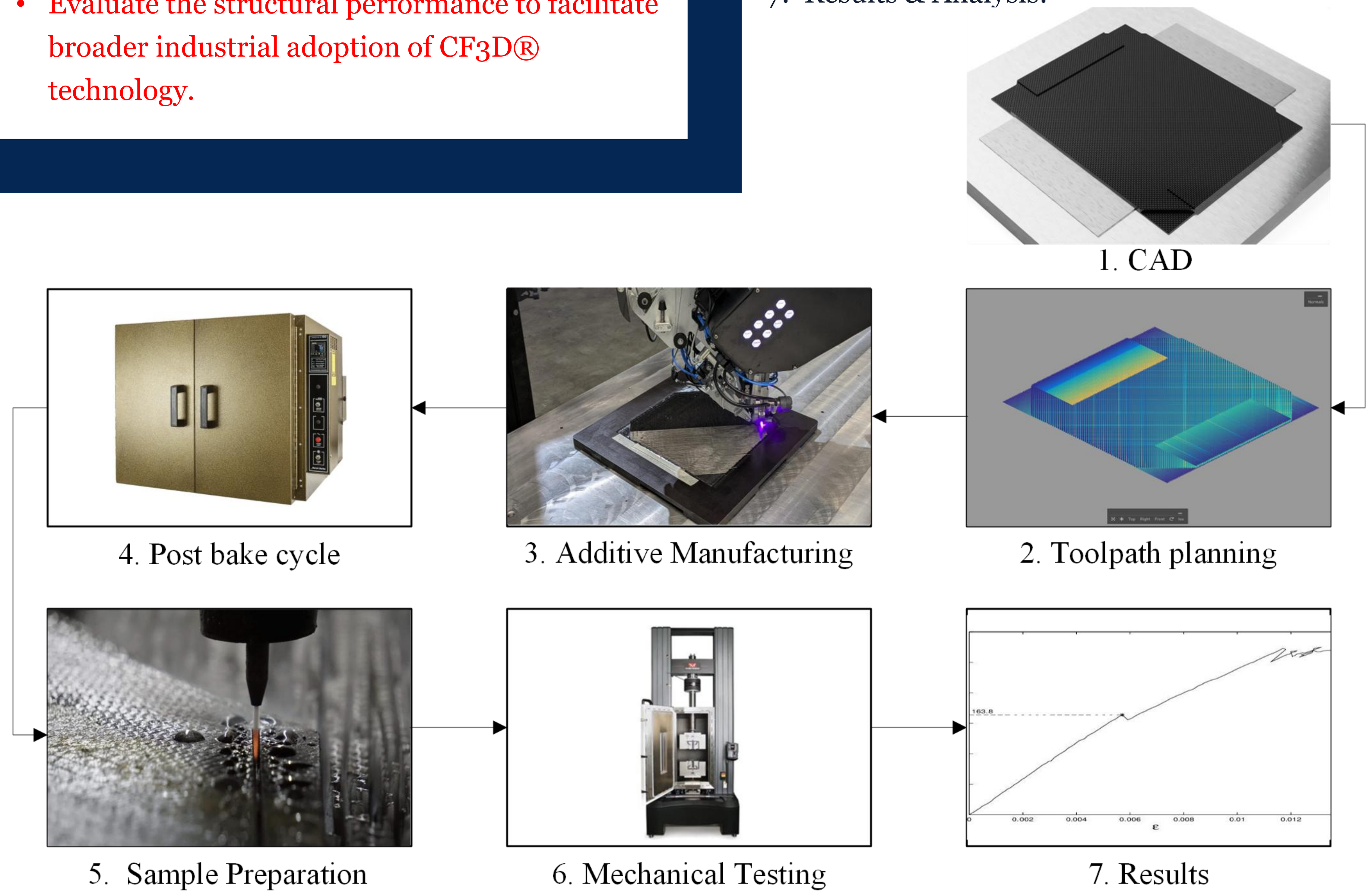

Figure 1: Methodology flowchart for CF3D® sample preparation

3D PRINTED TABS

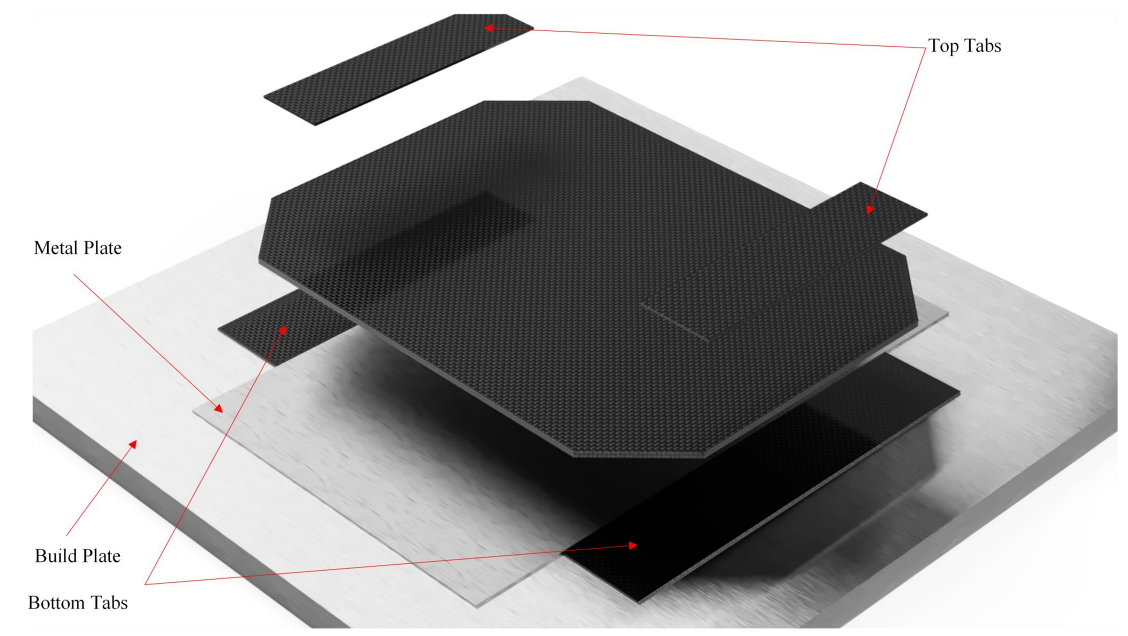

Figure 2: Exploded view of Shear Coupon samples CAD

- CF3D ® allows for tabs and coupon printed in one cycle
- Seamless tow transition via toolpath control instead of manual bonding.

EXPERIMENT & RESULTS

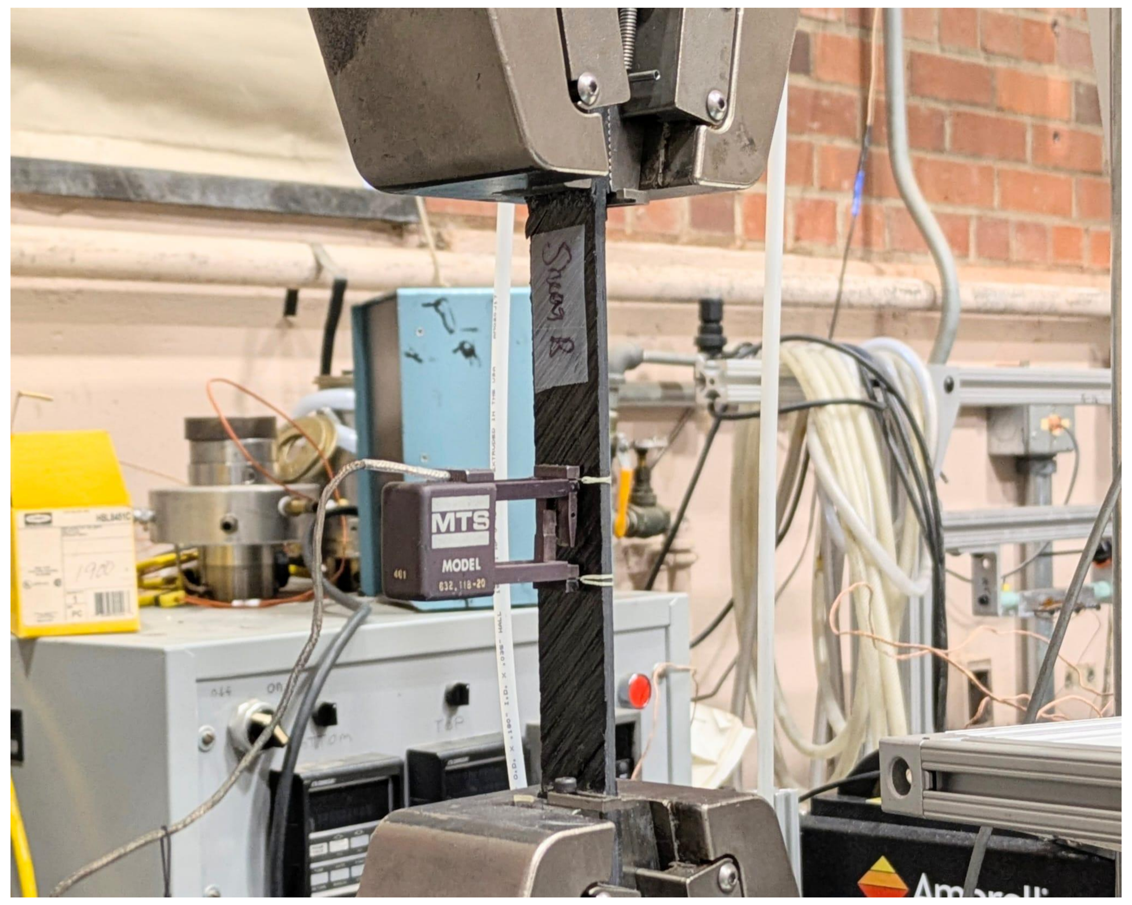

Figure 3: Sample being tested on Instron Testing Machine

Figure 4a

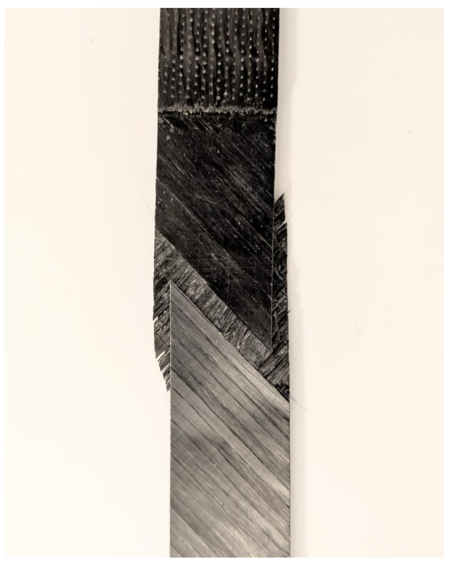

Figure 4b

Images of coupons (Tensile in figure 4a and Shear in figure 4b) after tensile test

DATA

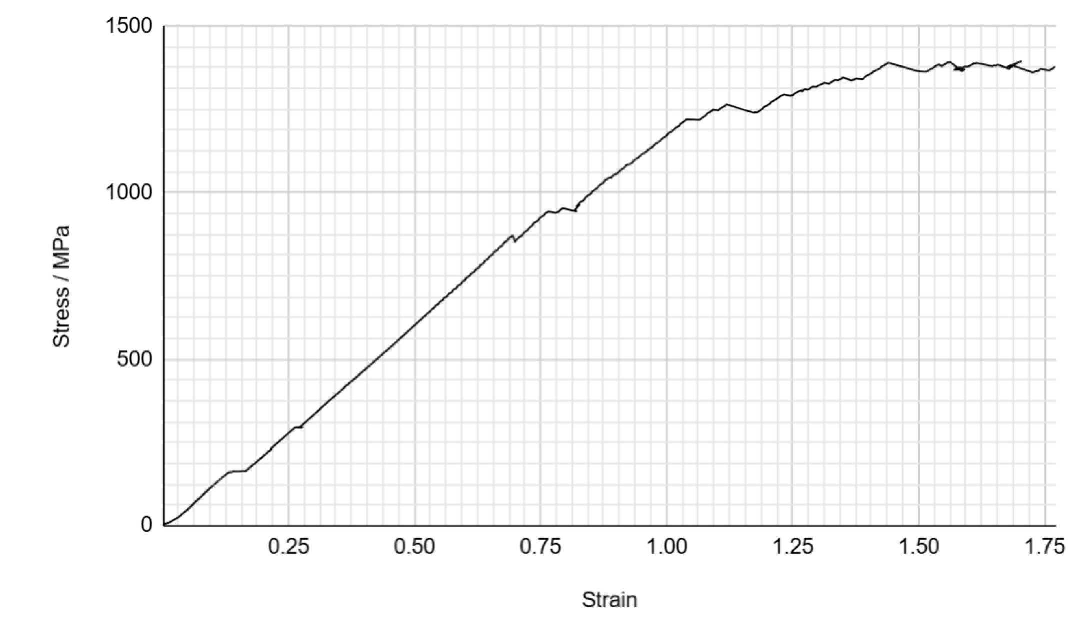

Figure 5: Stress vs Strain curve for CF3D printed unidirectional carbon fiber.

- Raw data collected from Instron: load (kN) and displacement (mm).
- Normalized and smoothened noise where necessary.
- Extracted key values: ultimate tensile strength and strain at failure.

CONCLUSIONS

- AM composite achieved an ultimate tensile strength (UTS) of 1393.9 Mpa(Tensile) and 66.3 Mpa(Shear).
- Reached within the expected range for CFR composites (1000–2000 MPa), demonstrating that CF3D® printing can produce structurally viable components when compared to traditionally manufactured composites.

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