Mechanical Characterization and Durability Study of Geopolymer Composites

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Research Objective: To develop a fireproof composite made with an inorganic matrix and high strength fibers for use in aircraft interiors. The goal of this research is to eliminate fire related deaths in aircraft accidents. The focus areas are: processing variables, fiber types, and mechanical properties of the composite at room and elevated temperatures.

Approach: The approach is basic in nature encompassing synthesis, processing, characterization and modeling of new fire-safe materials. In the area of processing, the main variables are: (i) prepregging techniques, (ii) curing pressures and temperatures, and (iii) final drying requirements. These variables were studied for various fiber types, plate thicknesses, and matrix formulations. The response variables were flexural strength, void content and density. The mechanical properties evaluation consisted of: (i) matrix strength and strain capacity in tension and compression., (ii) interlaminar shear strength of carbon fabrics and matrix, (iii) direct shear strength of the matrix, (iv) flexural and tensile behavior of the composite, (v) flexural fatigue strength of the composite, and (vi) the shear strength and flexural behavior of the composite at 200, 400, 600, and 800°C. Unidirectional and bi-directional carbon fabrics made using 3k tows were used for most of the tests. In addition, fabrics made of 1, 12, and 50k tows, E-glass fabrics, combinations of E-glass and carbon fabrics, combinations of E-glass and stainless steel fabrics, and graphite fabrics were evaluated. The long term durability of the composite under wet-dry conditions was also evaluated.

Accomplishment: Significant accomplishments have been achieved in the three focus areas. The optimum curing scheme has been established. Tests conducted with various combinations of carbon , graphite, glass, and stainless steel provided information on the interaction of the matrix with various fiber types. The strength tests established that flexural and tensile strengths of about 550 MPa can be achieved. More than 60% of the strength can be retained after exposure to temperatures of 800°C. The flexural fatigue tests have established that these composites perform as well or better than those materials that are currently used on aircraft. Matrix modifications were made to make it durable under wetting and drying. The successful formulation results in an increase of strength under wet-dry conditions.

Significance: It is extremely difficult to obtain an organic polymer that is unaffected by fire. Most of the commonly used organic matrices soften and ignite at temperatures less than 600°C. The inorganic matrix provides a unique opportunity to obtain a truly fire-proof material for use in aircraft cabin interiors

Expected Results: This program will contribute to the overall objective of fire prevention and the FAA initiative to eliminate fire as a cause of death in aircraft accidents. Guidelines will be developed for processing, design and quality control. Initially, it is envisioned that the composite will be used only for cabin interiors.

References:

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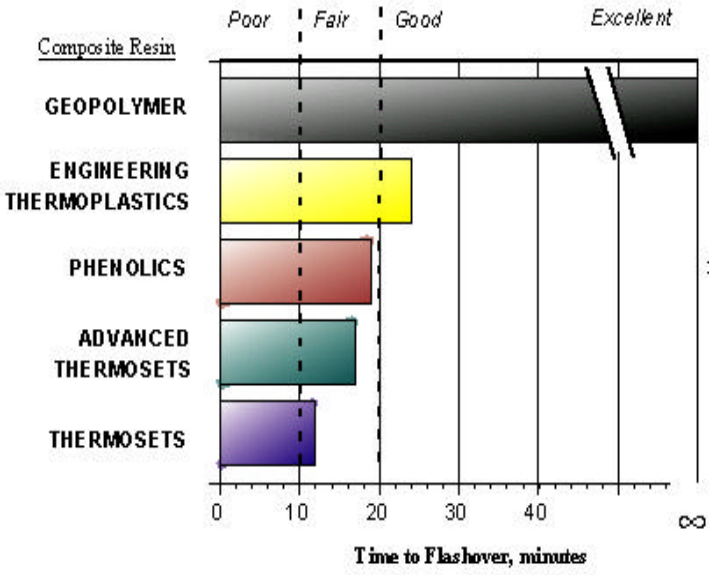


Figure 1. Time to Flashover vs. Composite Resin

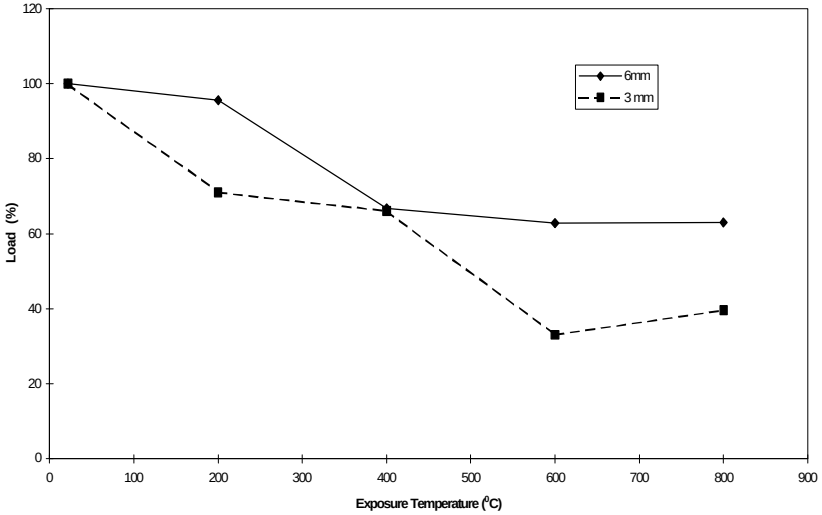
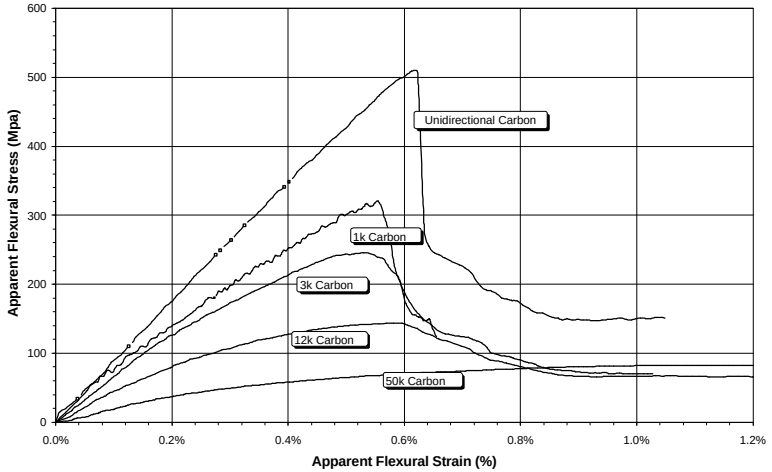


Figure 2. Flexural Failure Load vs. Exposure Temperature



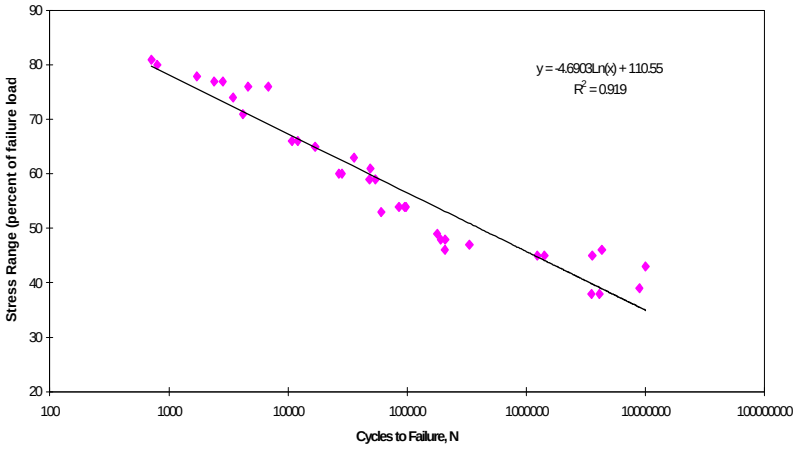


Figure 3. Flexural Strength of Various Carbon Composites

Figure 4. Flexural Fatigue S-N Curve for 3k Carbon-Geopolymer