Energy Absorption and Progressive Failure Response of Circumferential Composite Frames

by

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(ABSTRACT)

Vertical drop testing of transport aircraft fuselage sections indicates that the frames play a major role in the process of absorbing the impact energy in the crushing of the substructure below the main passenger deck. Hence, static tests are performed on individual circumferential frames under a radially inward load to assess their progressive failure response and energy absorption characteristics. The test articles in first series of tests are six-foot diameter, semicircular, I-section frames fabricated from graphite-epoxy unidirectional tape. The test articles in the second series of tests are J-section frames subtending a forty-eight degree circular arc, having an inside radius of 118 inches, a depth of 4.8 inches, and manufactured by resin transfer molding into a 2X2 2D triaxial braided textile composite preform made of AS4 graphite yarns. Frames of both materials exhibit fractures at the point of load application and at selected locations around the circumference, but the delamination prevalent in the tape layup frames is not evident in the textile frames.

A mathematical model developed to optimize open section curved composite frames for improved energy absorption is used to redesign the I-section frames by resizing the flanges. The test results of the redesigned frames show that the mathematical model predicted the correct sequence and locations of the failure events. However, the mathematical model does not predict the magnitudes of the force and displacement at the first major failure event, which maybe due to the fact that delamination is not included in the progressive failure model.

Tests results from two of the J-section frames are compared with a beam finite element analysis using the computer code ABAQUS. Effective elastic moduli for the textile material are obtained from the computer code TEXCAD. The ABAQUS results correlate reasonably well with the experimental results prior to the first major failure event.