Foreign Object Impact of Thick-Core Honeycomb Composite Panels: Experiment and Simulation

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A variety of structural configurations for the pressurized cover panel structure were evaluated in a preliminary design study of the mega-transport Blended-Wing-Body (BWB) [1]. On the basis of low weight, combined with ease of fabrication and assembly, a 5.5-inch-thick (140 mm) sandwich structure with carbon/epoxy facesheets and honeycomb core was chosen as the baseline cover panel structure concept. Foreign Object Damage (FOD) is the primary consideration for composite damage tolerance design honeycomb sandwich structures. Damage initiation thresholds, damage mechanisms, and damage extent depend on the properties of the facesheets and core materials, and on the interaction between the two.

This investigation is aimed at developing a preliminary understanding of the damage resistance characteristics of these unique composite panels, via quasi-static and impact experiments and simulations. This investigation will also contribute to identifying the effect of facesheet thickness and core density on the transverse response and damage characteristics of the panels. Five sandwich configurations are considered to study the effect of facesheet thickness, core density and core material on their impact damage resistance. The sandwich panels are 20 in x 10 in x 5.50 in. The core material is 5056 aluminum honeycomb, and three densities are considered for this investigation, namely 2.3, 3.1, and 3.8 pcf (lb/ft^3), or 36.8, 49.6, and 60.9 kg/m^3. The composite facesheets are fabricated from AS4/3501-6 carbon-epoxy Kevlar-stitched warp-knit preforms and manufactured using the Resin Film Infusion (RFI) process.

QSI and LVI tests are conducted on all panels using the same indenter/ impactor geometry and material, as well as boundary conditions. LVI tests are carried out at energy levels of 10, 20, 30, and 50 ft lb (or 13.6, 27.11, 40.7, and 67.8 J), to impart different degrees of damage. QSI tests are conducted up to maximum load, and force-deflection curves are recorded. LS-DYNA models are run for all five skin/ core configuration, in both static and dynamic conditions. Once the model is calibrated on one single QSI test for the baseline configuration, all LVI simulations for that same configuration, as well as all the QSI and LVI simulations for the remainder simulations are performed without making any changes to the model.

Through testing and simulation, for the cores and skins considered in this investigation, skin thickness has a primary effect on the damage resistance characteristics of the panel, while core density (varied by varying cell size, not cell gage) appears to have a secondary effect. This observation is in direct contrast with the results obtained from quasi-static compression (not indentation) of the core, which show great differences in compression and crushing strength. This difference could be attributable to the localized nature of the indentation response.

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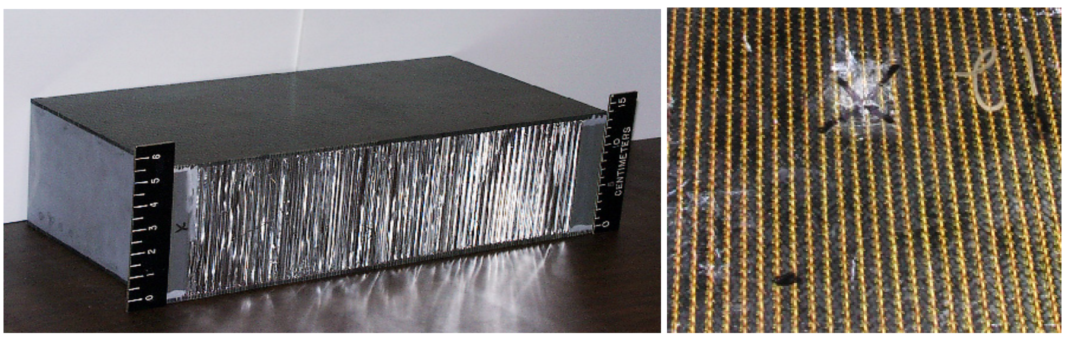

Figure. 1. Sandwich panels used in the present investigation, having dimensions 20 in. x 10 in. x 5.5 in., and close-up of the stitched CFRP skins.

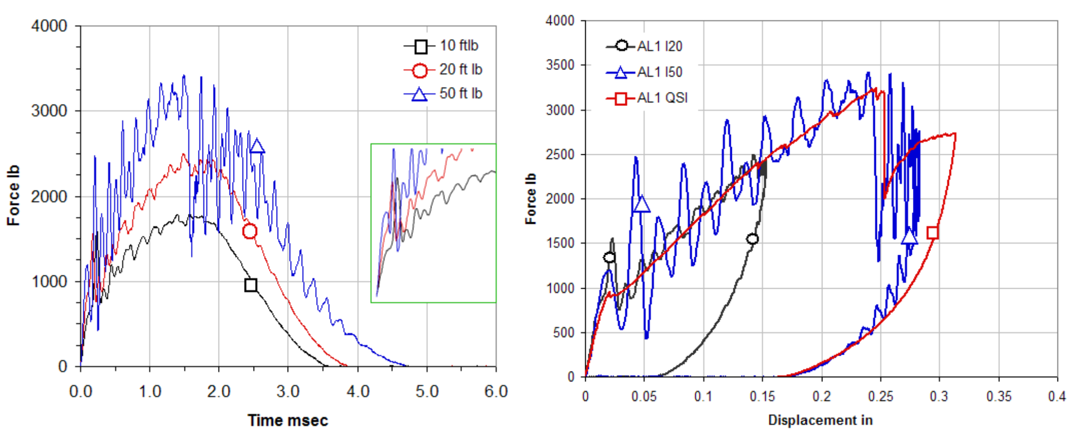

Figure 2. Representative impact force-time traces at increasing impact energy levels and QSI load-displacement curve for configuration.

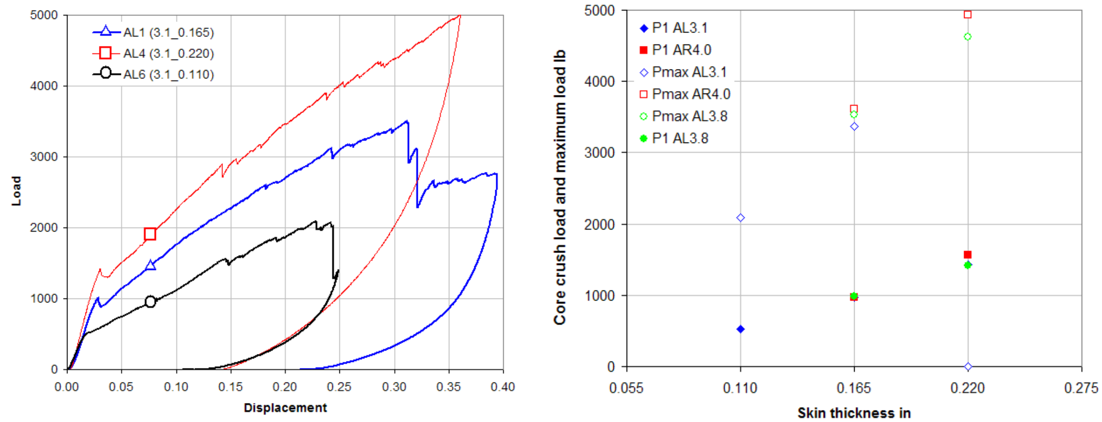

Figure 3. Effect of skin thickness (same core density) on load-displacement curves for three configurations. General trends observed for first and ultimate failure loads for various configurations tested.

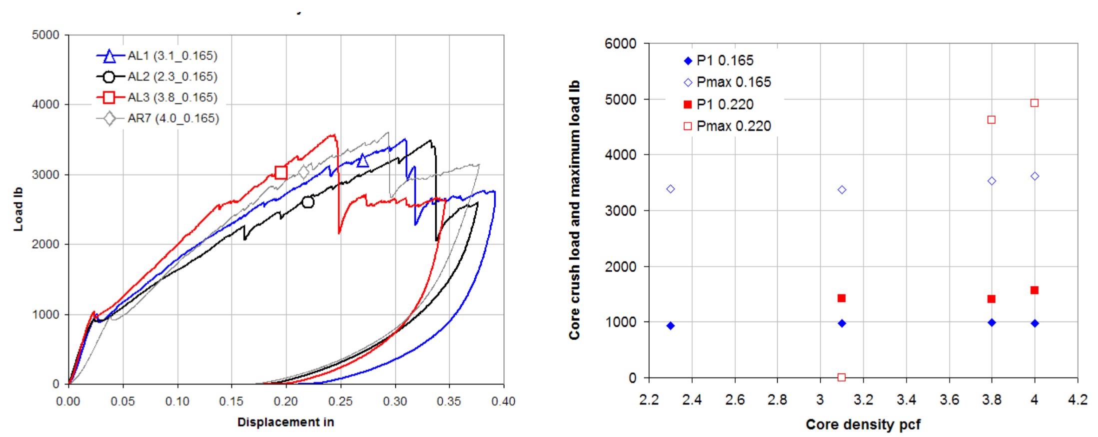

Figure 4. Effect of core density (same skin thickness) on load-displacement curves for four configurations. General trends observed for first and ultimate failure loads for various configurations tested.

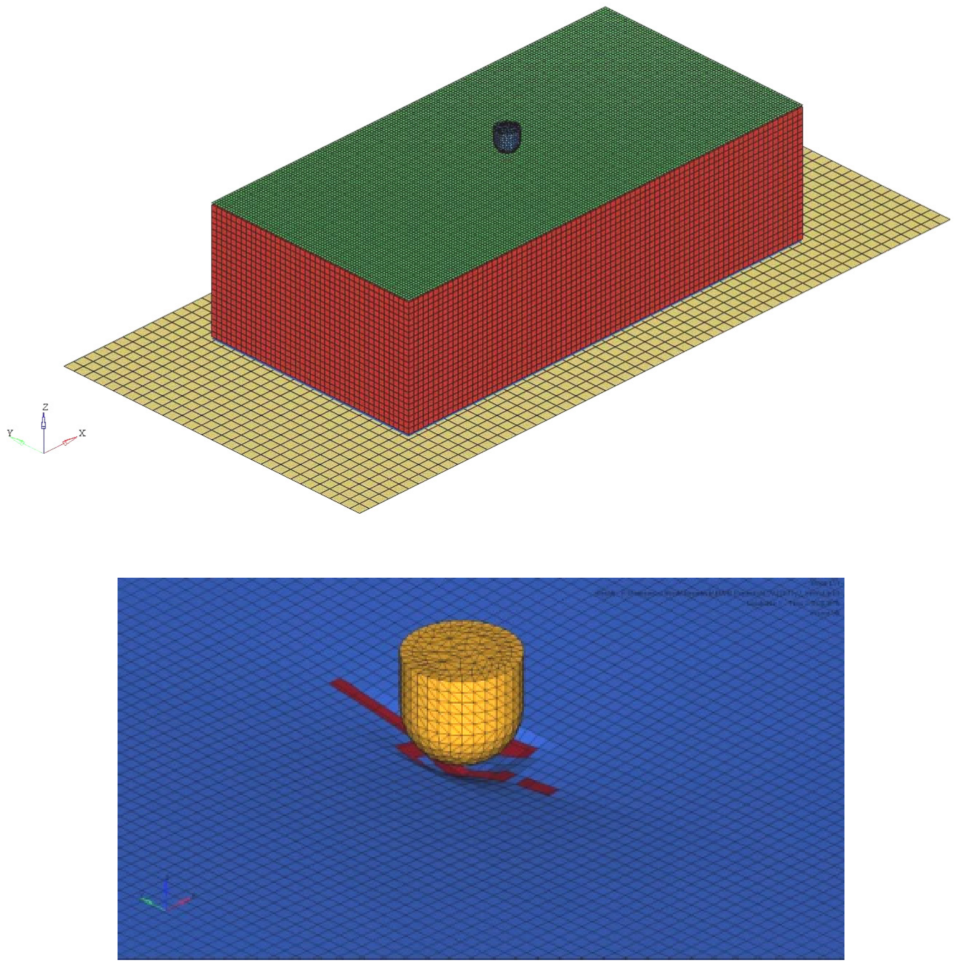

Figure 5. LS-DYNA model

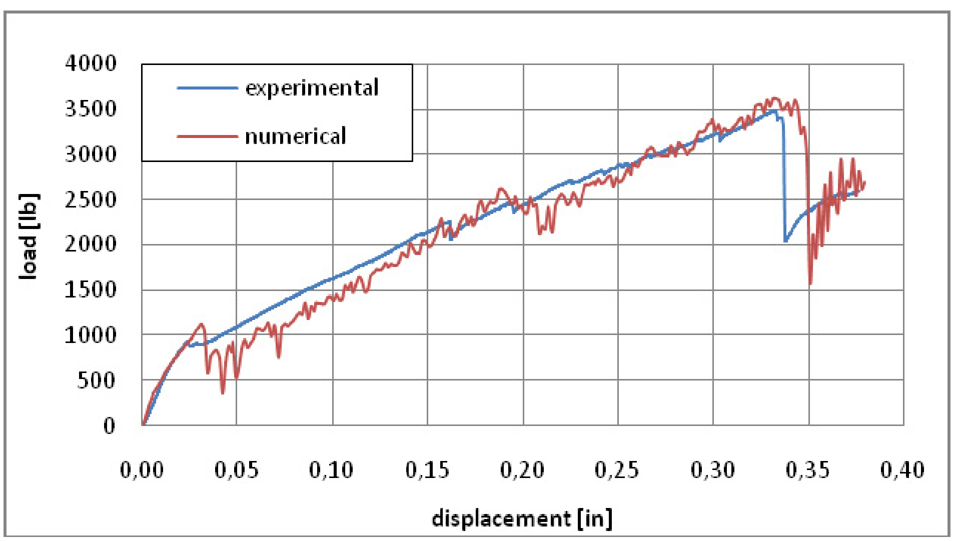

Figure 6.Experimental and numerical results for the QSI load-displacement curve for the baseline configuration of skin and core.

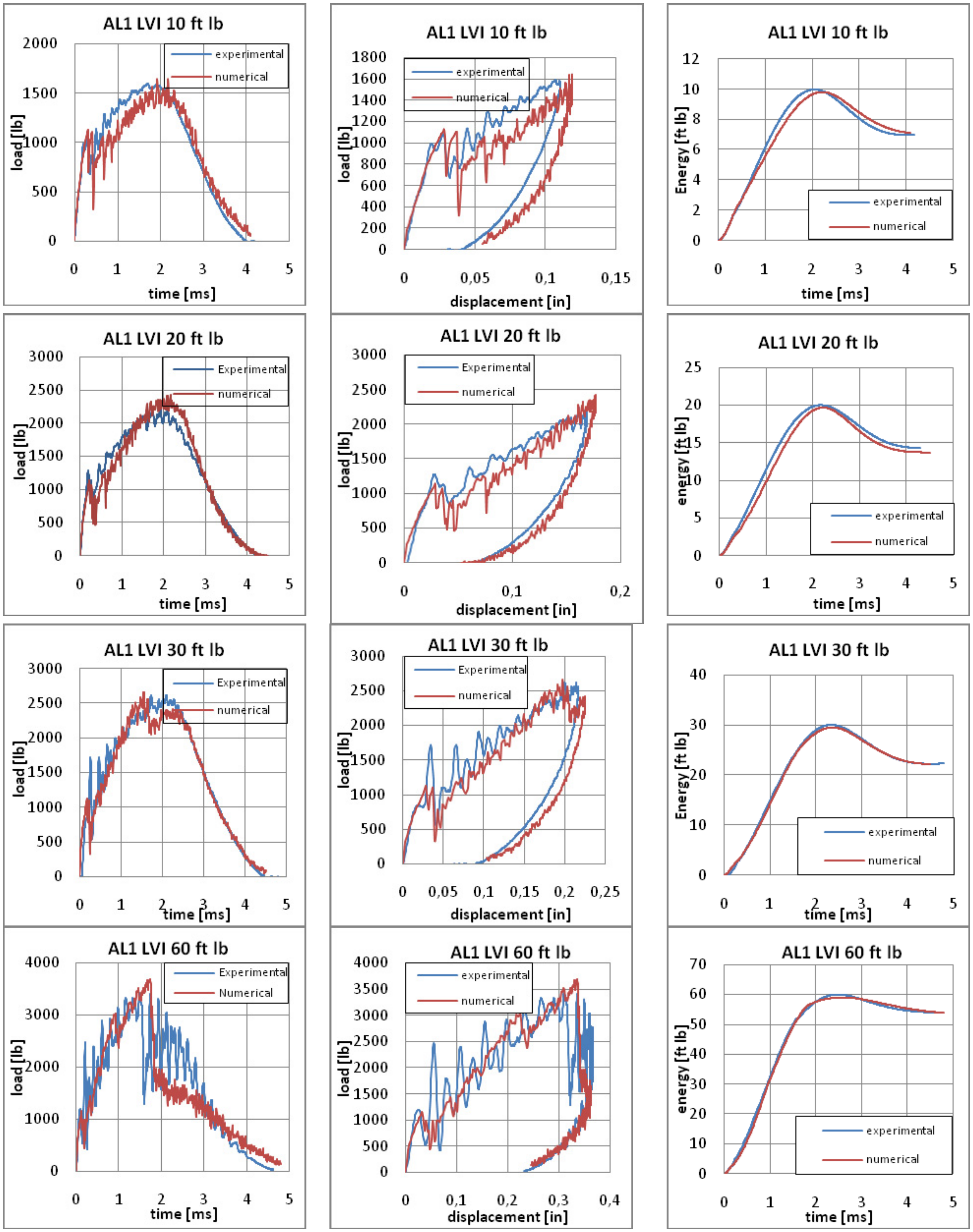

Figure 7. Experimental and numerical results for all low velocity impact events on the baseline configuration in terms of time, displacement and absorbed energy