Crashworthiness by Analysis: Vertical Drop Test and Simulation of a Composite H4000 Fuselage Section

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Abstract

In order to support the development of airframe-level crash requirements for Federal Aviation Regulations (FAR) Part 25 category airplanes, a drop test was conducted using a Hawker 4000 (H4000) fuselage section. The H4000 is a Part 25 certified, high performance twin-turbo fan, narrow-body aircraft capable of carrying 8 to 12 passengers. The fuselage structure is constructed using honeycomb core composite skin; metallic components are used for internal elements such as floor and keel beams. A finite element model representing the test was also created to understand the influence of composite modeling methods.

An 8 ft 2 in long fuselage section, consisting of only structural components, was used for the drop test. The fuselage interior furnishings other than seats (panels, tables, etc.) and the wing box structure were not included. Ballast weights were used to represent interior furnishings. Two H4000 Part 25 seats were installed and two different anthropomorphic test dummies (ATDs) were used: a 50th Hybrid II ATD and an FAA 50th Hybrid III ATD. Accelerometers and strain gages were mounted on the floor and ceiling of the fuselage section. Digital image correlation (DIC) systems, along with high-speed camera systems were used to study the fuselage section deformations and kinematics. The fuselage section was dropped at 30 ft/s onto 1.5 in thick aluminum plates supported by a robust I-beam steel structure. The fuselage section was able to meet the Part 25 requirements regarding maintaining a survivable volume for the passengers, retaining items of mass, and maintaining a passenger egress path. In addition, the fuselage sustained small permanent deformations and damage (skin disbonds and delaminations) in certain localized areas. Nevertheless, the drop test resulted in ATDs' lumbar loads of over 2400 lbf, which exceed current allowable limits, and peak acceleration values over 100 *g* throughout the fuselage section.

The finite element model of the fuselage section drop test was used to evaluate two different composite modeling methodologies. The global response of the fuselage section was compared for the two methods. In the first method, a perfect connection between the core and facesheet was assumed, with their inherent strength-based failure criterion. The second method, on the other hand, also included methodologies to simulate interfacial debond between the core and facesheet, and interlaminar failure within the composite laminate.

The test results show that the H4000 fuselage section with honeycomb core composite skin was over-designed for crashworthiness with limited energy absorption. The energy from a 30 ft/s drop is not sustainable by the occupants and the study indicates that additional energy absorption elements may be required to meet occupant safety criteria. An integrated design approach is required, wherein energy absorption is offered by both the airframe and seat.