Crashworthiness by Analysis: Vertical Drop Test and Simulation of a Challenger 601 Metallic 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 Challenger 601 (C601) fuselage section. The C601 is a Part 25 certified, high-performance twin-turbo fan, narrow-body aircraft capable of carrying 8 to 13 passengers (including crew). The fuselage structure is constructed using traditional metallic components. A finite element model representing the test was also created to support testing preparations and conduct parametric studies to further understand the effect of impact velocity in the crashworthiness behavior of the structure.

A 12 ft 5 in long fuselage section, consisting of only structural components, was used for the drop test. The section contains 4 window openings on the left side and 3 window openings on the right. It also contains an opening for the over-wing emergency exit on the right side. The actual windows and exit door are not available. The section does not have any interiors furnishings other than one seat. The wing box structure is also included without the main landing gear or related supporting structure. One commercial wall-mounted aircraft seat (2 occupants) and two rigid test seats were installed to accommodate ATDs and PMHSs. Four seated occupants were included on the drop test: Two FAA 50th Hybrid III and two PMHS (one on the commercial seat and one on the rigid seat). Additionally, one litter was also installed, oriented along the fuselage length, for an additional PMHS. Ballast weight was added to the fuselage section to represent missing components and balance its center of gravity. Instrumentation was used throughout the section and for occupants to gather the required information.

Accelerometers were mounted on the floor and ceiling of the fuselage section. Digital image correlation (DIC) systems and high-speed camera systems were used to study the fuselage section deformations and kinematics. The fuselage section was dropped at 30 ft/s onto a 1 in steel plate supported by a concrete pad 3ft thick. The fuselage section met 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 in certain localized areas. Nevertheless, the drop test resulted in ATDs' lumbar loads of over 3000 lbf, which exceed current allowable limits, and peak acceleration values around 100 *g* throughout the fuselage section. In addition, seated PMHS also show severe injuries throughout the body, mainly in the pelvis and thorax regions.

The test results show that the C601 fuselage section has limited energy absorption capabilities due mostly to the airworthiness design requirements of the wing-box structure. The energy level from a 30 ft/s drop is not survivable for the seat configurations evaluated in this test. The study indicates that additional energy absorption elements may be required to meet occupant safety criteria. A future integrated design approach could improve the occupant's survivability, wherein both the airframe and seat offer energy absorption.