Impact Damage Formation on Composite Aircraft Structures

Hyonny Kim, *Ph.D.* – Dept. of Structural Engineering, University of California at San Diego

ABSTRACT

The ongoing FAA research activities at UCSD are focused on impact sources that have realistic potential of producing widespread internal damage to composite fuselage and primary structure with little or no external visual detectability. Such damage that is difficult to detect, if large enough or if it can grow to critical length, is a safety threat. Two impact sources are being actively investigated: A. wide area high energy blunt impact damage from ground service equipment/vehicle contact, and B. high velocity hail ice impact. The research objectives of each of these topic areas are**:** A. Low-Velocity Wide-Area High Energy Blunt Impact: (i) Develop general methodology for blunt impact threat characterization and prediction. (ii) Experimental identification of key phenomena and parameters governing high energy blunt impact damage formation, particularly focusing on what conditions relate to the development of massive damage with little or no visual detectability on the impact side. (iii) Damage tolerance assessment of blunt impact damaged structures. B. High Velocity Hail Ice Impact: (i) Investigate impact damage initiation and damage formation to composite panels, including those of skin-stiffened and sandwich construction. (ii) Develop models capable of predicting impact damage to composite panels. (iii) Develop unified treatment methodology for predicting damage initiation by variety of impactor projectile types – e.g., bird, hail, tire fragment, runway debris, etc.

In the blunt impact topic, stringer and frame-stiffened composite panels, designed to represent wide-body composite fuselage structure, have been designed and fabricated and were subjected to indentation loading using actual bumpers from ground service equipment (GSE). Significant internal damage to structural elements, including frame cracking, severed stringers, stringer-skin delamination, and shear tie crushing, was found to be created with little to no visual detectability. Models for predicting the damage onset and propagation, as well as “low-order” spring-mass or energy/momentum based models relating test data to ground operations are under development. The hail ice impact activity is establishing a database for the formation of damage by high velocity ice impacts onto monolithic panels at normal and glancing angles. Numerical simulation models for predicting damage initiation failure thresholds as well the final state of damage produced (using cohesive zone approach) are under development. Interactions with internal structural elements, such as stringers, for both of these impact threats is a key consideration, as these transitions are often “weak” areas where damage initiates easier that at “free span” skin locations. Major technical challenges at present are: scaling up to larger-sized test specimens composed of five frame elements, and formulating the relationship between lab/test data and field-operation threat conditions.

The research outcomes are expected to benefit the aviation industry directly. Close industrial interactions help to insure the connectivity of UCSD’s research projects to aviation. These research outcomes are expected to: (i) provide knowledge that assists one to improve the resistance of composite structures to blunt impact threats – in particular from GSE and large hail, (ii) provides critical information on mode and extent of seeded damage, particularly non-visible impact damage (NVID) from blunt impact threats, (iii) establishes modeling capability and experimental methodology for reduced-sized specimen testing, (iv) aids in assessing whether an blunt impact incident could have caused damage, and (v) if so, what inspection technique should be used? …when? …where?