Face sheet-to-core debonding analysis in sandwich panels under dynamic loading

Vyacheslav Burlayenko*†[1,2], Tomasz Sadowski[3], and Svetlana Dimitrova[4]

[1]National Technical University 'Kharkiv Polytechnic Institute' (NTU KhPI) – 2 Kyrpychova Str., 61002, Kharkiv, Ukraine

[2]Lublin University of Technology (LUT) – 40 Nadbystrzycka, 20-618, Lublin, Poland, Poland

[3]Lublin University of Technology (LUT) – 40 Nadbystrzycka, 20-618, Lublin, Poland

[4]National Technical University 'Kharkiv Polytechnic Institute' (NTU KhPI) – 2 Kyrpychova, 61002, Kharkiv, Ukraine

Abstract

The sandwich panels are widely used as structural members of aircrafts, and aero-space and transport vehicles, in primary due to their high stiffness and strength at a low specific mass. However, low fracture toughness of the face sheet-to-core interface in sandwich structural elements is the most important issue reducing the load bearing capacity of such structures. Interfacial stresses caused by dynamic loads during the service life may easy result in the debonding progression and, even, the eventual fracture of the sandwich structure. In order to improve fracture resistance of sandwich structures subjected to dynamic loading, it is essential to evaluate the strength and durability of the face sheet-to-core interface. Generally, the fracture resistance of composite sandwich structures is evaluated from the fracture tests prescribed by the ASTM standard procedures. In most such research the interface strength is discussed in terms of the singular stresses or energy release rate at the end of the interfacial crack in the fracture sandwich specimens under static loading, whereas dynamic loading conditions for three-layered composite structures have been considered in a limited number of works. The present research is concerned with predicting the dynamic fracture of sandwich panels due to deboning at the face sheet-to-core interface. In this regard, first, the dynamic stress intensity factors are extracted from the sandwich fracture specimens by using analytical approaches and numerical techniques for two-dimensional models. These fracture analyses allow us specifying appropriate material fracture properties and assessing the stress behaviour at the bi-material face sheet-to-core interface. The fracture models calibrated in such way further are used in dynamic debonding analysis of a three-dimensional sandwich panel. The finite element model of the debonded sandwich panel is created using the capacities available in the commercial finite element code ABAQUS. Simulations of debonding initiation and propagation are carried out by using the cohesive layer model, which is incorporated into the finite element mesh via cohesive elements. Contact and friction behaviours possible due to dynamic debonding progression are taking into account in the modelling procedure as well. The strain rate sensitivity of the fracture behaviour depending on the velocity of debonding growth is accounted for using a visco-elastic constitutive model of the cohesive material law. The model is incorporated into the ABAQUS code by programming the appropriate user-defined material subroutine. The fracture features of the

*Speaker

†Corresponding author: burlayenko@yahoo.com

sandwich panel obtained in the simulations are compared with those known in the literature to validate the developed model. Thereafter, various types of dynamic loads are considered in the simulations and their influence on the debonding resistance of the face sheet-to-core interface in the sandwich panel is studied. The results obtained are discussed in detail at the end.

Keywords: Sandwich panels, debonding, dynamic fracture analysis, finite element modelling