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FINITE ELEMENT ANALYSIS OF DYNAMIC RESPONSES FOR HONEYCOMB SANDWICH PLATES INITIALLY DAMAGED BY SKIN/CORE PARTIAL DEBONDING

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ABSTRACT

Advanced properties of sandwich materials have provided them broad use in a large number of engineering applications where high strength to weight and stiffness to weight characteristics are important. However, sandwiches are very sensitive to the damage induced during their fabrication and/or in-service life. Debonding (or delamination) at the interface between the skins and the core are found to be one of the main pre-failure modes in the sandwich constructions that determines their integrity and safety. The presence of debonding can be identified from some of the non-destructive approaches. The vibration-based damage detection techniques are widely applied methodology among them [1]. These techniques take any construction as a dynamic system and analyze its dynamic responses such as natural frequencies, mode shapes, modal damping etc. Then, the change of the structural modal parameters is interpreted as a signal of damage occurrence in the structural system [2]. Thus, the prediction accuracy of the vibration parameters can be considered as an important precondition to ascertain damage existence. Finite element method is a powerful engineering tool that can be alternatively used along with complex and expensive experiments for acquisition of the structural vibration responses of the structure with damage.

In the present study, the free and forced vibration analyses of sandwich plates with honeycomb core having delamination embedded at the interface between the face sheets and the core is carried out. The commercially available FE code ABAQUS [3] was used to analyze the debonding effect on natural frequencies, mode shapes as well as dynamic responses from the applied harmonic loading of the sandwich plates. In order to overcome modelling difficulties related to naturally complex three-dimensional FE model of the honeycomb sandwich structure, the homogenization technique for the core was adopted. The calculation of the effective material properties was performed using FE approach based on the unit cell conception [4]. The debonding between the face and the core was treated as a plane interface with no contact or adhesion between the two solids. The debonded face skin and the underlying core were

assumed to be intact and homogeneous in all cases. The cohesive interface elements were inserted between the skins and the core for geometrical representation of the adhesive at the undamaged region while them absence is considered as the result of the debonding. A local damage (debonding zone) arbitrary form was located arbitrarily along the skin-core interface of the sandwich. The delamination, due to disbonding between the skin and the core was assumed to be predetermined before the vibration start and to be constant during oscillations.

Parametric studies over a range of damage zone sizes and locations as wells as external loading frequencies and positions were carried out to study the effects of these parameters on the overall behavior of the damaged plates. The influence of skin-core debonding on the vibration responses of damaged sandwich plates was studied by comparing calculated results of the dynamic analysis of both intact and delaminated sandwich plates. The results demonstrated that sandwich plates are sensitive to the presence of predetermined debonding zone. A local damage at the interface of a sandwich plates leads to the reduction in the natural frequencies and to the shifting of the mode shapes as well as changes displacement responses related to forced oscillations. Moreover, the influence of various effects such as core-to-skin thickness ratio and boundary conditions on the vibration responses of the debonded sandwich plates was also considered.

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