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A failure mechanism based model for numerical modeling the compression-after-impact of foam-core sandwich panels

Jie Wang[a,1,*], Hai Wang[b,2], Baoxing Chen[a,3] Haojie Huang[a], Shuaicai Liu[a]
[a]Shanghai Aircraft Design and Research Institute, Shanghai, 201210, P. R. China
[b]Shanghai Jiao Tong University, Shanghai, 200240, P. R. China

Abstract

A failure mechanism-based progressive damage growth model is developed, applied and validated for modeling woven polymer-based foam-core sandwich panels under compression-after-impact. A Schapery theory based constitutive model, which takes account of intra-ply shear inelasticity and fiber kinking and resulting fracture is developed for the impacted plain weave fabric laminated face-sheets under compression loading. Each ply of the face-sheets is modeled as an orthotropic nonlinear elastic lamina degrading as characterized through laboratory experiments. The behavior of woven plies in the warp and fill directions is elastic until the attainment of local instability in compression. The phenomenon of fiber micro-buckling leading to kink banding, which was observed to be the mechanism controlling failure of the impacted face-sheets and hence the sandwich panels, is explicitly accounted for by allowing the fiber rotation at a material point. In the shear direction, plasticity is also considered to represent the elastic-plastic in-plane shear behavior of woven fabric plies. The constitutive model is numerically implemented using the commercially available finite element package ABAQUS through a user defined material subroutine (UMAT). The previous 3D damaged FE model which was proven to accurately capture the low–velocity impact damages is imported and subjected to a compression loading modeling. The numerical results in terms of deformation, failure mode and residual strength show a remarkable agreement with experimentally measured ones, allowing the model to be validated.

Keywords: compression-after-impact, sandwich panels, Schapery theory, progressive damage, kink banding

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*Corresponding author
Email address: wangjie2@comac.cc (Jie Wang)
[1]Senior engineer, Stress Department.
[2]Professor, School of Aeronautics and Astronautics.
[3]Vice director, Stress Department.

1. Introduction

In the few past decades, considerable efforts have been directed into