FE SIMULATION OF SANDWICH PANELS WITH FUNCTIONALLY GRADED CORE - PART I: LOW VELOCITY IMPACT

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Utilizing sandwich panels with a Functionally Graded Material (FGM) core is increasing because of their capabilities in reducing thermal- and residual-stresses induced between the face sheets and core materials in comparison to traditional sandwich panels. Mechanical properties (such as young modulus and Poisson's ratio) of FGMs vary continuously throughout the thickness direction. Analytical and numerical solutions are used to investigate the impact response of these sandwich panels [1,2]. In this work, three dimensional finite element simulations were conducted using ANSYS-LSDYNA for analyzing low velocity impact behavior of this new generation of sandwich panels. The Young's modulus of Functionally Graded (FG) core, E_c, was assumed to change linearly from 50 to 500MPa through the thickness (z-coordinate) either symmetrically about the mid-plane or asymmetrically [1]. The Poisson's ratio of the FGM core, however, was assumed to be constant.

There are different approaches for modeling functionally graded materials using finite element method [3]. In this study, the volume of FG core was divided through the thickness to several small volumes and then appropriate properties of each individual volume were assigned. Because of the symmetry conditions in the length and width directions (x, y coordinates), only a quarter of the rigid cylindrical projectile as well as the panel was modeled. To validate FEA results, a comparison was made with available analytical results and a good agreement was found. The indentation depth-force and displacement-force together with contact force history was investigated. Fig. 1 shows the contact force history for symmetrical, asymmetrical and homogenous (E_c=50MPa) cores. Further, in Table 1 the maximum contact forces for all cases are compared with those reported in reference [1].

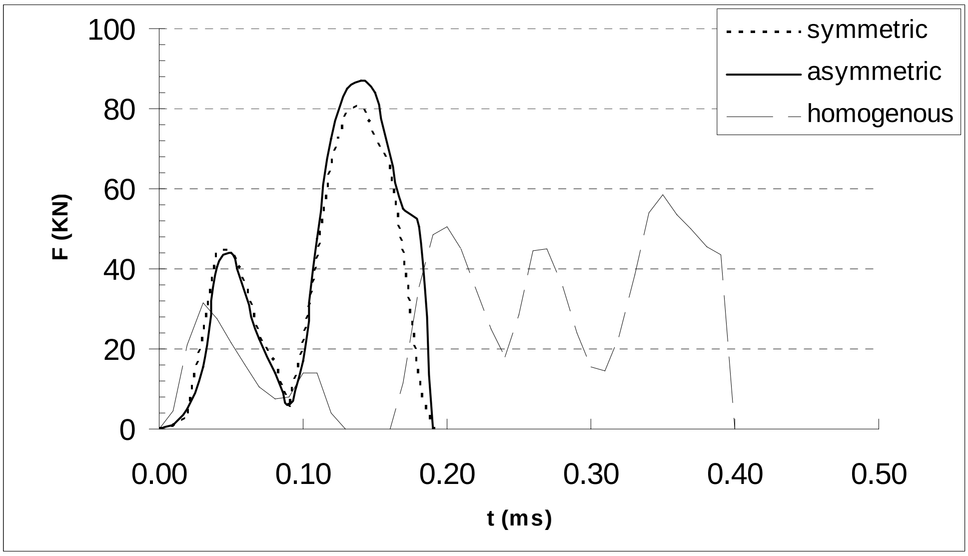

Fig. 1: Contact force history for symmetrical, asymmetrical and homogenous cores

Table 1: Comparison of maximum contact forces

	F_{max} (FEM)[N]	F_{max} (Ref [1])[N]
Symmetrical Core	8.10×10^4	7.89×10^4
Asymmetrical Core	8.68×10^4	8.31×10^4
Homogenous Core	5.85×10^4	5.45×10^4

Fig. 2 shows contours of strain in x direction for a sandwich panel with an asymmetrical FG core. The maximum x-strain for this panel was 0.01452 which is about 17% lower than that obtained in reference [1]. It is worth to mention that the maximum x-strain for a panel with homogenous core was 0.0308 from this study.

From these observations, it can be concluded that for both symmetrical and asymmetrical linear variation of Young’s modulus in FG core panels, the maximum contact force is increasing but the maximum strain is decreasing in compare to those of sandwich panels with homogeneous core. In addition, the panels with an asymmetric core are stiffer than those of symmetric ones. This can be contributed to the Young's modulus of contact face where in the asymmetric core it’s value is larger than that of a symmetric case. In conclusion, it can be stated that functionally graded cores can prevent from extensive damage in composites panels under low velocity impact.

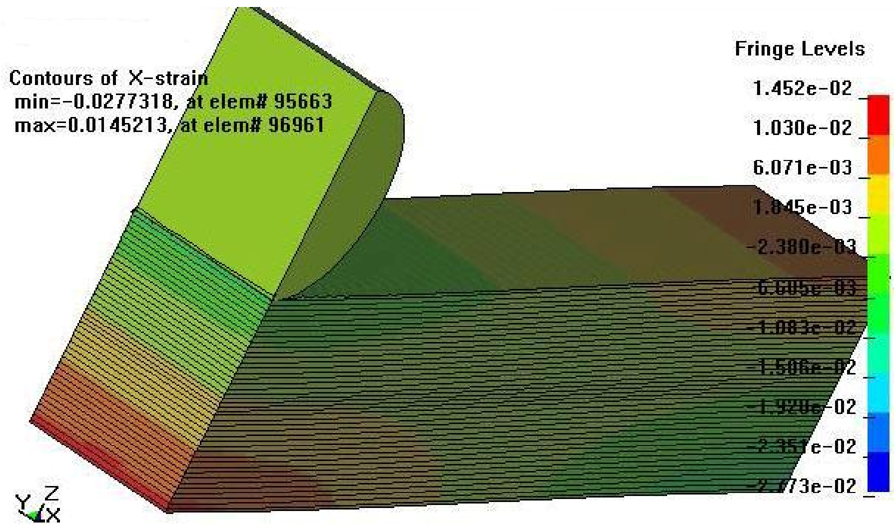

Fig. 2: Strain contours in x-direction for a panel with an asymmetrical FG core

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