ABSTRACT

Fracture Progression of Sandwich Plate

Pascalis K. Gotsis[1] and Christos C. Chamis[2]

[1]Dept. of Mechanical Engineering, Technological Educational Institute, Serres
Terma Magnisias, Serres, 62120, Greece, pkgotsis@teiser.gr

[2]NASA Glenn Research Center,
21000 Brookpark Road, Cleveland, OH 44135, USA, Christos.C.Chamis@grc.nasa.gov

KEYWORDS: sandwich, temperature, composites, fracture, simulation, residual stresses.

INTRODUCTION

Sandwich fiber-reinforced composite plate is evaluated via computational simulation to study damage and fracture progression. Each face of the sandwich consist of 8 plies with laminate configuration $[0/\pm45/90/]_s$ made of S-Glass/Epoxy and the core is made of Epoxy. The sandwich plate is reinforced with stiffeners well bonded to the plate. The applied loads is uniform pressure at room temperature 21^o C (case I). For comparison reason another case was examined by taking into account the curing temperature 149^o C (case II), and the residual stresses are computed. The applied pressure is increased gradually and an integrated computer code GENOA was augmented for the simulation of the damage initiation, growth, accumulation, and propagation to fracture and to structural collapse references (1 to 3). The sandwich composite structure used for this investigation is a stiffened plate, figure 1. The length of the stiffened plate is 254 mm and the width is 127 mm. The boundary conditions are fixed supported in all edges. Each face of the sandwich made of S-Glass/Epoxy, with laminate configuration $[0/\pm45/90/]_s$ with thickness 2.54 mm , the fiber volume fraction is 55% , the moisture is 1% and void volume is 2%. The core is made of Epoxy with thickness 5.08 mm. The total thickness of the sandwich panel is 10.16 mm . The stiffened bands well bonded to the bottom surface of the panel, are made of the same material as the face of the sandwich, with thickness 1.27 mm. The 0^o plies are in the X-axis (fig. 1), and the first ply (0^o) lays at the bottom surface of the plate, while the last ply lies at the top surface of the plate. Damage initiation and progression were monitored as the sandwich structure was gradually loaded with the pressure. The results of the computational simulation follow below.

Damage initiation . The damage initiation in both sandwich structures with loading conditions cases I and II happened at the same load 4.412 MPa at the middle stiffener. The damage occurred: a) In the case I at the bottom ply (0^o) due to transverse compressive stresses and matrix cracking took place. b) In the case II at the top ply (0^o) due to transverse tensile stresses (matrix cracking) and also due to the relative rotation of the plies and delamination took place.

Fracture through the thickness. Fracture through the thickness at the sandwich structure occurred first in the case I at 24.68 MPa, and followed by the case II at the 25.51 MPa. In figure 2 is shown the position of the fracture initiation through the thickness and the fracture progression.

Collapse of the structure. The fracture initiation through the thickness follows a rapidly crack propagation, the structure becomes unstable and finally collapses. The collapse load started first in the case I, at 29.509 MPa and followed by the case II at 32.82 MPa.
It is concluded that the induced residual stresses due to curing processing (case II) of the sandwich composite structure, contribute to improve the damage tolerance, the fracture resistance and the collapse load of the structure.

REFERENCES

1. Chamis, C.C.; Gotsis, P.K. and Minnetyan, L.,"Damage Tolerance of Pressurized Fiber Composite Shell Structures." Proceedings of the 37th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Material Conference, AIAA-96-1556-CP, part 4, pp.2112-2121, 1996.
2. Gotsis, P.K.; Chamis, C.C. and Minnetyan, L., "Effect of Combined Loads in the Durability of a stiffened Adhesively Bonded Composite Structure." Proceedings of the 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Material Conference, AIAA-95-1283-CP, part.2, pp.1083-1092, 1995.
3. Abdi, F., Chamis C.C. and Minnetyan, L., Durability and Damage Tolerance of Composites, Chapter 8-Composites, Welded Joints, and Bolted Joints, Kluwer Academic Publisher, 2000.

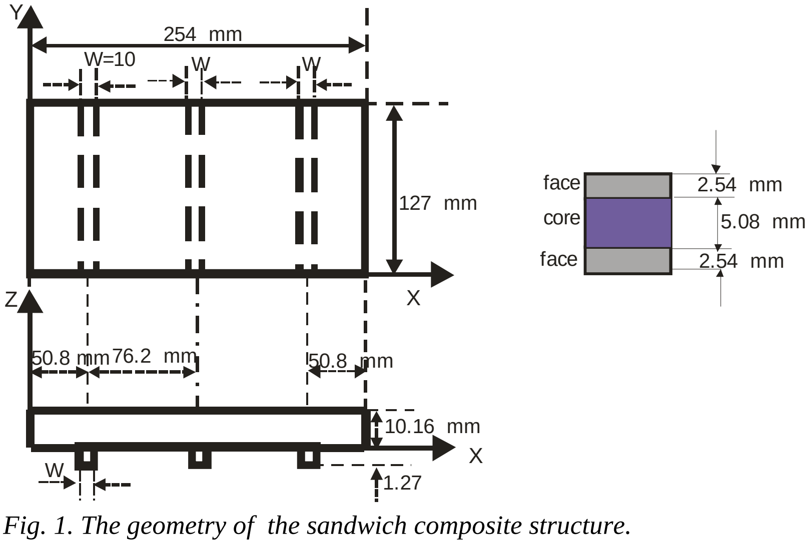

Fig. 1. The geometry of the sandwich composite structure.

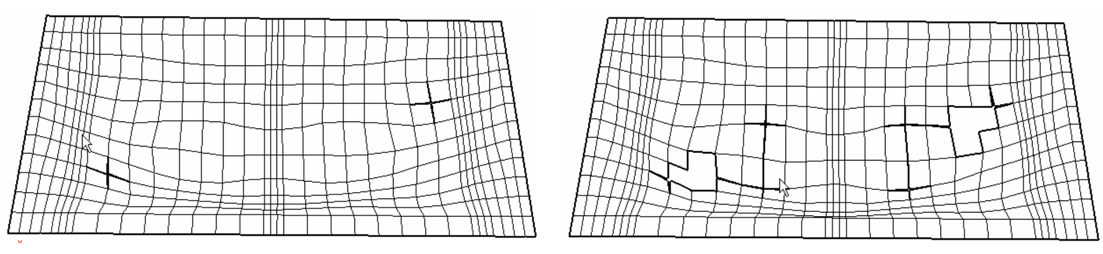

Fig. 2. Fracture through the thickness at 25.51 MPa, and fracture progression at 27.30 MPa for the loading case II .