NEW COMPOSITE SANDWICH WITH ALUMINUM CORE

Horatiu TEODORESCU-DRAGHICESCU*, Mariana Domnica STANCIU*, Florin TEODORESCU-DRAGHICESCU**

*Transilvania University of Brasov, Braşov, Romania
(draghicescu.teodorescu@unitbv.ro, mariana.stanciu@unitbv.ro)
**Politehnica University, Bucharest, Romania (florin.teodorescu@ltpc.pub.ro)

DOI: 10.19062/2247-3173.2017.19.1.40

Abstract: *This paper presents a new developed ultra-lightweight composite sandwich with very good mechanical properties suitable for aerospace and defense applications. The 13.8 mm thick structure has a 3003 aluminum honeycomb core with 5.2 mm cell size and two opposite skins made of woven glass fabric reinforced epoxy resin laminates. Very good stiffness and mechanical work have been obtained during three-point bend tests. Samples have been subjected to load at break and up to 50 mm deflection. More compact values of mechanical properties have been obtained at break than at 50 mm deflection.*

Keywords: *sandwich, aluminum honeycomb core, composite skins, stiffness, mechanical work*

1. INTRODUCTION

Sandwich structures present a wide range of applications. Basically, a sandwich has a continuous or discontinuous core made of lightweight materials providing mechanical stiffness [1, 2, 3]. This core with more or less thickness is bonded with similar or dissimilar opposite skins to form a load-bearing structure. The quality of interface between core and skins will depend the subsequent mechanical behavior of the sandwich structure. Therefore, this interface plays a major role in determining the structure's mechanical properties. It is essential that the core should be as lightweight as possible taking loads only perpendicular to its surface [4]. To avoid skins buckling in compression loadings, the core must have a satisfactory stiffness. Skins can be metal sheets or polymer matrix composite laminates based on thermoplastic or other resins [5]. Polyester and epoxy reinforced composite laminates are usually used in a wide range of composite structures. As reinforcement, glass fibers in form of chopped strand mats and roving fabrics of various specific weights are commonly used. To choose a material for a specific application is quite a challenging task. The user should consult the supplier for detailed mechanical property data on current materials, together with wider databases required for other property data (e.g. electrical, thermal, fire properties, surface finish, etc.), process information (e.g. gel time, working life, curing temperature, cure time, mold release temperature, etc.), as well as material or process costs [6]. For composite applications, most design procedures, whether simple or sophisticated, will be based initially on stiffness data and will often relate to strain or deflection limits design [7, 8]. Consequently, Young's modulus values are normally required for the main in-plane directions of a composite laminate using orthogonal axes [9, 10, 11, 12]. Young's modulus is an important feature of any kind of material since represents its stiffness [13, 14, 15].

In addition, many applications of composites are based on thin-walled structures (e.g. thin pultruded profiles, skins of sandwich structures, etc.) [16, 17, 18, 19, 20, 21].

2. MATERIAL AND EXPERIMENTAL SET-UP

Following new lightweight composite sandwich has been designed and developed presenting this architecture (Fig. 1): two skins (0.55 mm thickness) composite laminates based on two layers of 380 g/m^2 specific weight woven glass fabric impregnated with epoxy resin and a 3003 aluminum honeycomb core with 5.2 mm cell size (12.7 mm thickness). These skins have been separately cured and glued to core using high performance epoxy adhesive film. From a panel (1250x380x13.8 mm), ten samples with following dimensions have been cut: samples length: 280 mm; samples width: 30 mm; samples thickness: 13.8 mm. The sample width is measured with an accuracy of 0.1 mm in its central section, then three thickness measurements with 0.02 mm accuracy are performed and the arithmetic mean of these measurements is used for subsequent calculations. The test speed is determined in the following manner:

- For material's characterization, the speed value is equal to half the value of the specimen thickness;
- For common tests, the speed is set to 10 mm/min.

The sample is put symmetrically with respect to the parallel supports ensuring that the sample length is perpendicular to them. The central crosshead is positioned exactly at the middle of the span and a load is applied with uniform speed avoiding shocks. To determine the Young's modulus of bending, the load/deflection values are read simultaneously. The machine software is able to draw a true load-deflection distribution. The experimental set-up and details of three-point bend tests are shown in Figs. 2-4.

FIG. 1. Sandwich with 5.2 mm cell size

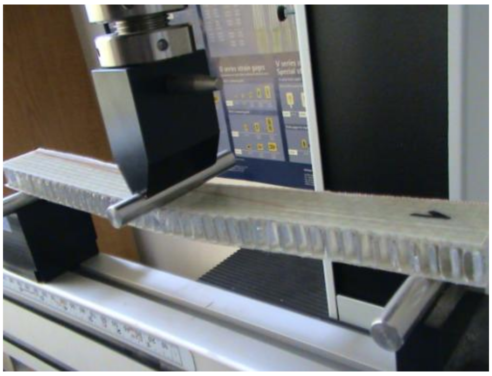

FIG. 2. "LR5K Plus" materials testing machine

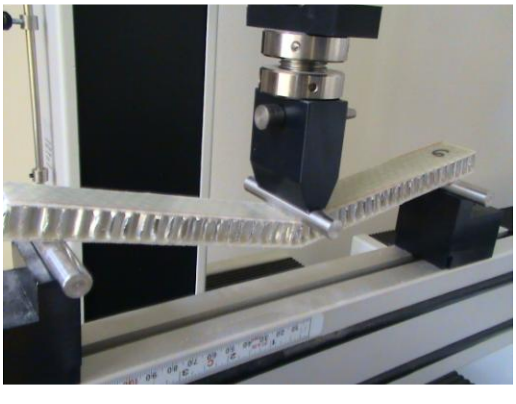

FIG. 3. Sample on three-point bend device

FIG. 4. Loading detail

3. RESULTS

From total number of samples, half of them have been subjected to three-point bend tests up to break and half to 50 mm maximum deflection on a "LR5K Plus" Lloyd Instruments materials testing machine. The three-point bend test characteristics are: testing direction: compression; test speed: 10 mm/min; test method: three-point bending; span between supports: 240 mm. Load-deflection distributions up to break of five sandwich samples with 3003 aluminum honeycomb core (5.2 cell size) have been experimentally determined using "Nexygen Plus" materials testing machine software developed by Lloyd Instruments (Fig. 5). Distributions up to break of Young's modulus of bending versus stiffness as well as work to maximum load versus work to maximum deflection are shown in Figs. 6-7. To see the subsequent behavior of the composite, other bending tests have been carried out on five samples up to 50 mm deflection. These distributions are presented in Figs. 8-10 and a comparison between distributions at break and at 50 mm deflection are shown in Figs. 11-12.

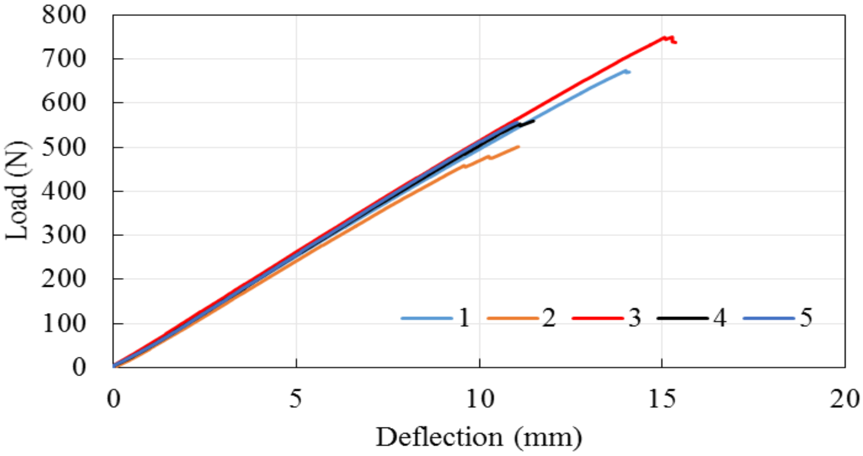

FIG. 5. Five load-deflection distributions up to break

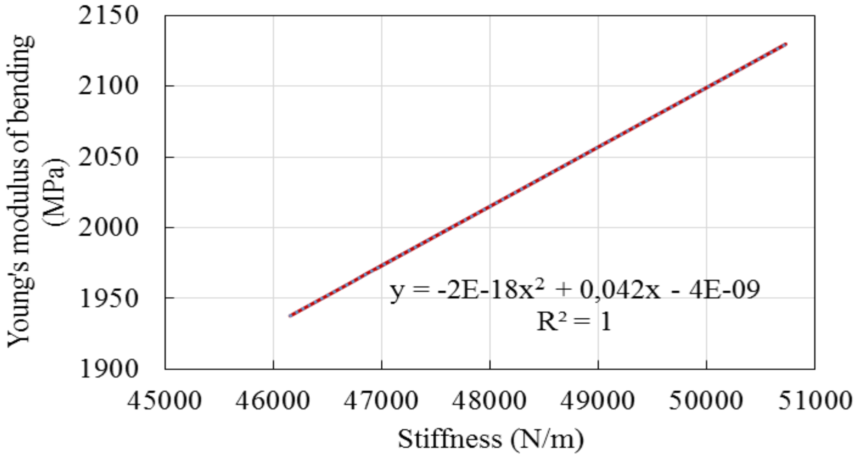

FIG. 6. Distribution up to break of Young's modulus of bending versus stiffness

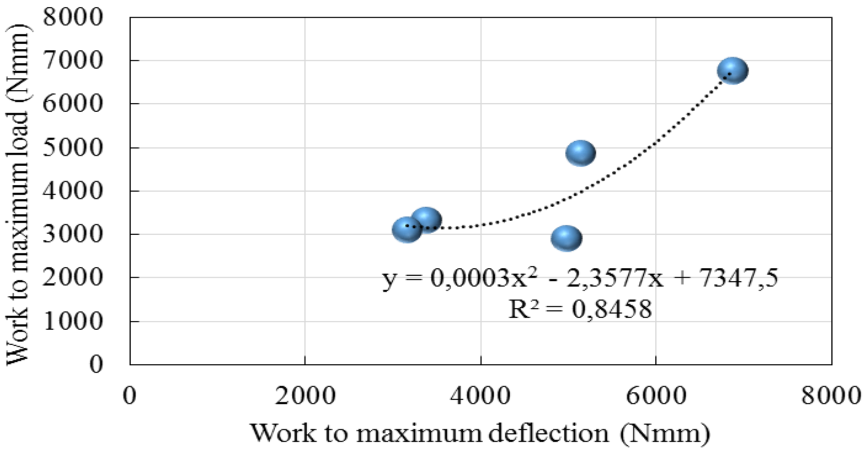

FIG. 7. Distribution up to break of work to maximum load/deflection

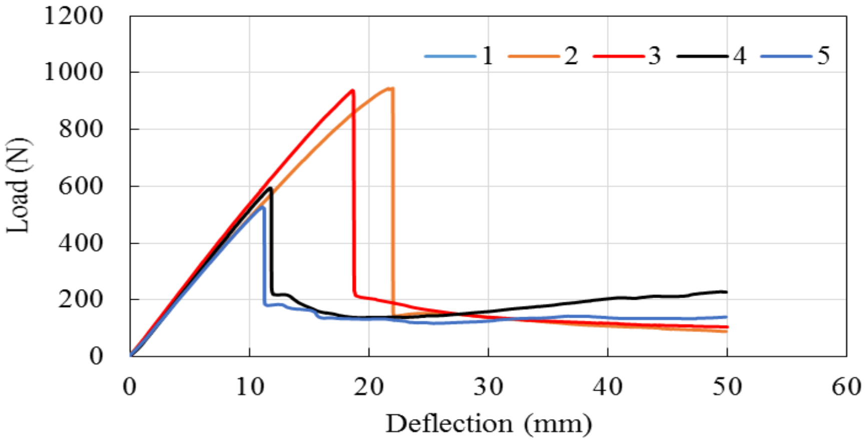

FIG. 8. Five load-deflection distributions up to 50 mm deflection

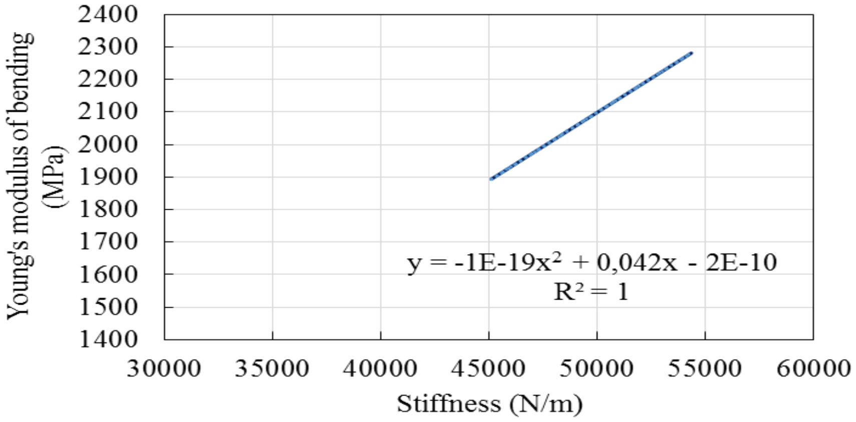

FIG. 9. Distribution up to 50 mm deflection of Young’s modulus of bending versus stiffness

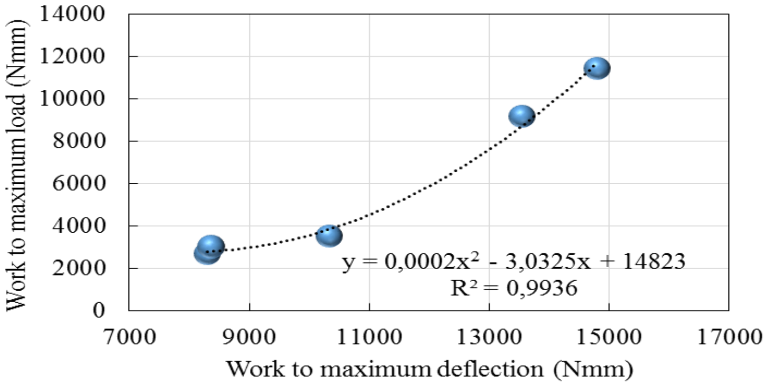

FIG. 10. Distribution up to 50 mm deflection of work to maximum load/deflection

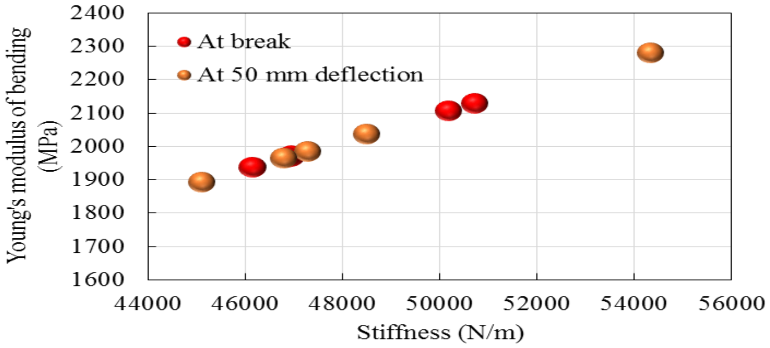

FIG. 11. Young's modulus of bending versus stiffness at break and 50 mm deflection

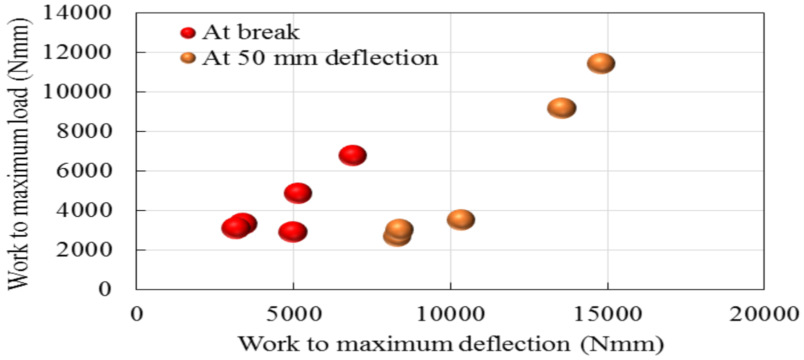

FIG. 12. Distributions of work to maximum load/deflection at break and 50 mm deflection

4. CONCLUSIONS

Load-deflection distributions of sandwich samples present a load variation between 500 - 950 N until irreversible damage occur. It can be noticed that the deflection that caused irreversible damage (drop of load) inside the composite material varies between 10.5 mm and 22 mm. Frequent deflection value at which irreversible damage has occurred was 10.5 mm. The developed sandwich of 3003 aluminum honeycomb core with 5.2 mm cell size, bonded with two layers of 380 g/m^2 specific weight woven glass fabric impregnated with epoxy resin presents low weight (under 10 kg for a panel with dimensions 2500x1200x13.8 mm) and high stiffness. These unique characteristics make this structure suitable especially for aerospace and defense applications, like shelters, doors, floors and other specific panels with maximum temperatures range up to 80°C.

REFERENCES

[1] D. B. Miracle and R. L. Donaldson, *ASM Handbook Volume 21: Composites*, ASM International, 2001;

[2] I. M. Daniel and O. Ishai, *Engineering of Composite Materials*, Oxford University Press, 2nd ed., 2005;

[3] J. R. Vinson, *Plate and Panel Structures of Isotropic, Composite and Piezoelectric Materials, Including Sandwich Construction*, Springer, 1st ed., 2005;

[4] L. C. Bank, *Composites for Construction: Structural Design with FRP Materials*, Wiley, 2006;

[5] D. G. Lee and N. P. Suh, *Axiomatic Design and Fabrication of Composite Structures: Applications in Robots, Machine Tools, and Automobiles*, Oxford University Press, 2005;

[6] A. B. Strong, *Fundamentals of Composites Manufacturing: Materials, Methods and Applications*, Society of Manufacturing Engineers, 2nd ed., 2007;

[7] B. F. Backman, *Composite Structures, Design, Safety and Innovation*, Elsevier Science, 2005;

[8] J. R. Vinson and R. L. Sierakovski, *The Behavior of Structures Composed of Composite Materials*, Springer, 2008;

[9] H. Teodorescu-Draghicescu and S. Vlase, Homogenization and Averaging Methods to Predict Elastic Properties of Pre-Impregnated Composite Materials, *Computational Materials Science*, vol. 50, no. 4, pp. 1310-1314, 2011;

[10] H. Teodorescu-Draghicescu, S. Vlase, M. L. Scutaru, L. Serbina and M. R. Calin, Hysteresis Effect in a Three-Phase Polymer Matrix Composite Subjected to Static Cyclic Loadings, *Optoelectronics and Advanced Materials – Rapid Communications*, vol. 5, no. 3, pp. 273-277, 2011;

[11] S. Vlase, H. Teodorescu-Draghicescu, D. L. Motoc, M. L. Scutaru, L. Serbina and M. R. Calin, Behavior of Multiphase Fiber-Reinforced Polymers Under Short Time Cyclic Loading, *Optoelectronics and Advanced Materials – Rapid Communications*, vol. 5, no. 4, pp. 419-423, 2011;

[12] S. Vlase, H. Teodorescu-Draghicescu, M. R. Calin and L. Serbina, Simulation of the Elastic Properties of Some Fibre-Reinforced Composite Laminates Under Off-Axis Loading System, *Optoelectronics and Advanced Materials – Rapid Communications*, vol. 5, no. 4, pp. 424-429, 2011;

[13] H. Teodorescu-Draghicescu, A. Stanciu, S. Vlase, M. L. Scutaru, M. R. Calin and L. Serbina, Finite Element Method Analysis Of Some Fibre-Reinforced Composite Laminates, *Optoelectronics and Advanced Materials – Rapid Communications*, vol. 5, no. 7, pp. 782-785, 2011;

[14] A. Stanciu, H. Teodorescu-Draghicescu, S. Vlase, M. L. Scutaru and M. R. Calin, Mechanical Behavior of CSM450 and RT800 Laminates Subjected to Four-Point Bend Tests, *Optoelectronics and Advanced Materials – Rapid Communications*, vol. 6, no. 3-4, pp. 495-497, 2012;

[15] S. Vlase, H. Teodorescu-Draghicescu, M. R. Calin and M. L. Scutaru, Advanced Polylite composite laminate material behavior to tensile stress on weft direction, *Journal of Optoelectronics and Advanced Materials*, vol. 14, no. 7-8, pp. 658-663, 2012;

[16] H. Teodorescu-Draghicescu, M. L. Scutaru, D. Rosu, M. R. Calin and P. Grigore, New Advanced Sandwich Composite with twill weave carbon and EPS, *Journal of Optoelectronics and Advanced Materials*, vol. 15, no. 3-4, pp. 199-203, 2013;

[17] A. Modrea, S. Vlase, H. Teodorescu-Draghicescu, M. Mihalcica, M. R. Calin and C. Astalos, Properties of Advanced New Materials Used in Automotive Engineering, *Optoelectronics And Advanced Materials – Rapid Communications*, vol. 7, no. 5-6, pp. 452-455, 2013;

[18] S. Vlase, R. Purcarea, H. Teodorescu-Draghicescu, M. R. Calin, I. Szava and M. Mihalcica, Behavior of a new Heliopol/Stratimat300 composite laminate, *Optoelectronics And Advanced Materials – Rapid Communications*, vol. 7, no. 7-8, pp. 569-572, 2013;

[19] T. Heitz, H. Teodorescu-Draghicescu, S. Lache, A. Chiru and M. R. Calin, Advanced T700/XB3585 UD carbon fibers-reinforced composite, *Journal of Optoelectronics and Advanced Materials*, vol. 16, no. 5-6, pp. 568-573, 2014;

[20] H. Teodorescu-Draghicescu, S. Vlase, M. D. Stanciu, I. Curtu and M. Mihalcica, Advanced Pultruded Glass Fibers-Reinforced Isophtalic Polyester Resin, *Materiale Plastice*, vol. 52, no. 1, pp. 62-64, 2015;

[21] M. L. Scutaru, H. Teodorescu-Draghicescu, S. Vlase and M. Marin, Advanced HDPE with increased stiffness used for water supply networks, Journal of Optoelectronics and Advanced Materials, vol. 17, no. 3-4, pp. 484-488, 2015.