STATIC TESTS REGARDING AN ADVANCED SANDWICH COMPOSITE STRUCTURE

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Abstract: The paper presents static tests like tensile and bending tests accomplished on an advanced sandwich composite structure. Various test specimens for tensile and bending tests were presented. A comparison between the experimental tests and theoretical approach is shown.

Keywords: tensile test, bending test, sandwich composite structure, twill weave, carbon fiber reinforced skins

1. INTRODUCTION

The sandwich presents two carbon/epoxy skins reinforced with a 300 g/mm^2 twill weave fabric and an expanded polystyrene (EPS) 9 mm thick core with a density of 30 kg/m^3. The final thickness of the structure is 10.4 mm (fig. 1).

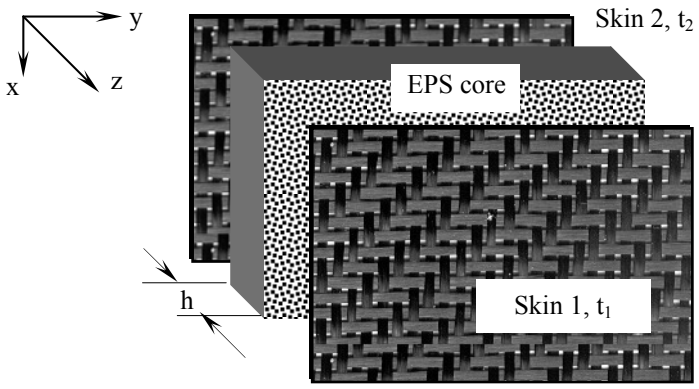

Fig. 1. The sandwich composite structure

The carbon-fiber fabric used in this structure is a very high rigidity one, that presents a so-called twill weave. The main feature of this weave is that the warp and the weft threads are crossed in a programmed order and frequency, to obtain a flat appearance (fig. 2). The equivalence model of the twill weave fabric is presented in fig. 3.The skins were impregnated under vacuum with epoxy resin and sticked to the core with polyurethane adhesive.

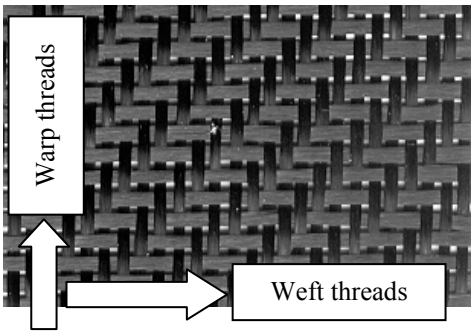

Fig. 2. The architecture of carbon/epoxy twill weave fabric skins

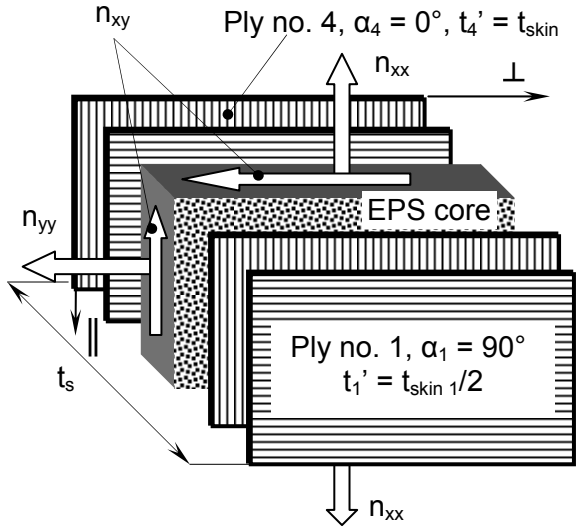

Fig. 3. The structure with an equivalence model of the twill weave fabric skins

The data regarding the architecture of the sandwich structure are:
Structure's thickness: t_s = 10 mm; skins plies number: N = 2; thickness of each ply: $t'_{1...4}$ = 0,175 mm; skins thickness: t_{skin} = 0.35 mm; core thickness: h = 9 mm; fibers disposal angle of each ply: $\alpha_{1,\ 3} = 90°$, $\alpha_{2,\ 4} = 0°$; fibers volume fraction of each ply: $\varphi_{1...4}$ = 56%.

The data regarding the structure features are: skins reinforcement: HM carbon fibers; fabric type: twill weave; fibers specific weight: 0,3 kg/m^2; matrix type: epoxy resin; core type: expanded polystyrene; core density: ρ_{core} = 30 kg/m^3; core Young's modulus: E_{core} = 30 MPa; core Poisson's ratio: υ_{core} = 0,35; core shear modulus: G_{core} = 11 MPa; fiber Young's modulus in longitudinal direction: $E_{F\parallel}$ = 540 GPa; fiber Young's modulus in transverse direction: $E_{F\perp}$ = 27 GPa; fiber Poisson's ratio: υ_F = 0,3; fiber shear modulus: G_F = 10,38 GPa; matrix Young's modulus: E_M = 3,5 GPa; matrix Poisson's ratio: υ_M = 0,34; matrix shear modulus: G_M= 1,42 GPa.

2. TYPES OF SPECIMENS USED IN TENSILE TESTS

From the cured plates, the following types of specimens were cut:

- Specimens type 1t, numbered from 1t/A to 1t/O (green label identification), with 10,4 mm thickness (fig. 4 and 5), specimens that present ends manufactured from glass fiber fabric called Stratimat. The ends were sticked between the sandwich structure's skins with bicomponent epoxy adhesive.

- Specimens numbered from A to L (green label identification) having 4 mm thickness and being accomplished from laminas of twill weave carbon fiber fabric, laminas that were impregnated with epoxy resin and cured afterwards (fig. 6).

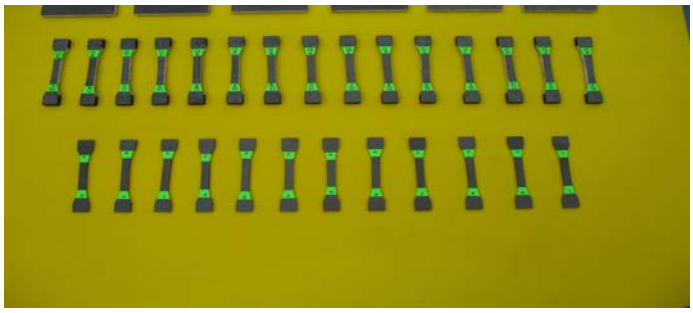

Fig. 4. Specimens used in tensile tests (general view)

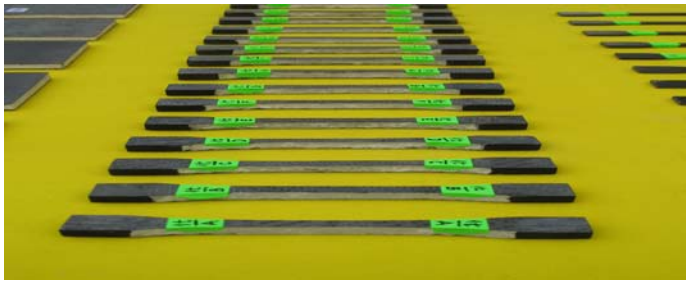

Fig. 5. Specimens type 1t/A...1t/O used in tensile tests

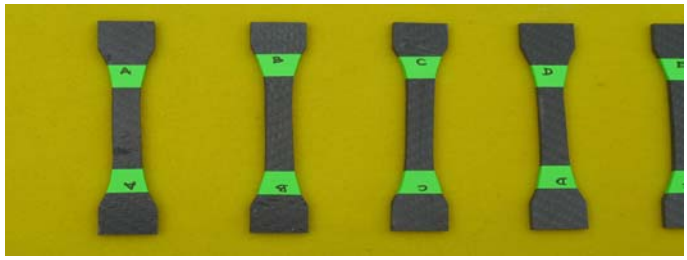

Fig. 6. Specimens type A...L used in tensile tests

3. TYPES OF SPECIMENS USED IN BENDING TESTS

From the cured plates, the following types of specimens were cut:

- Specimens type 1t, numbered from 1t/01 to 1t/14 (orange label), with 10,4 mm total thickness (fig. 7);
- Specimens type 2t, numbered from 2t/01 to 2t/10 (orange label), with 19,4 mm total thickness (fig. 8);
- Specimens type 3t, numbered from 3t/01 to 3t/10 (orange label), with 28,4 mm total thickness (fig. 9);
- Specimens type 4t, numbered from 4t/01 to 4t/10 (orange label), with 37,4 mm total thickness (fig. 10);
- Specimens numbered from I/01…I/07 (orange label identification), with 4 mm thickness, accomplished from laminas of twill weave carbon fiber fabric, laminas that were impregnated with epoxy resin and cured afterwards (fig. 11).

Fig. 7. Specimens type 1t

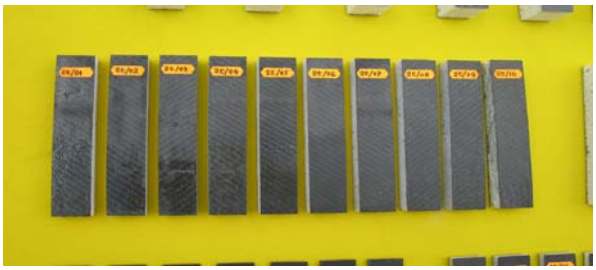

Fig. 8. Specimens type 2t

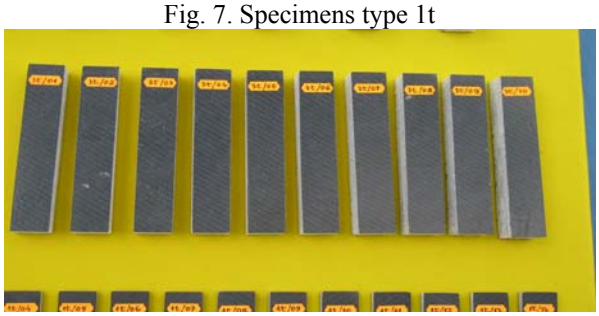

Fig. 9. Specimens type 3t

Fig. 10. Specimens type 4t

Fig. 11. Specimens type I

4. RESULTS OF THE TENSILE TESTS

Table 1. Tensile features of 6 specimens, numbered A to F

	Tensile strength [MPa]	Arithmetic media of measurements $\bar{x}$ [-]	Standard deviation s [-]	Variation coefficient v [%]
Specimen no. A	3865	3960,3	6,149	1,03
Specimen no. B	3920			
Specimen no. C	3842			
Specimen no. D	4060			
Specimen no. E	3973			
Specimen no. F	4102			

Table 2. Tensile features of 6 specimens from type 1t

	Tensile strength [MPa]	Arithmetic media of measurements $\bar{x}$ [-]	Standard deviation s [-]	Variation coefficient v [%]
Specimen no. 1t/A	593,2	596,6	6,149	1,03
Specimen no. 1t/B	589,5			
Specimen no. 1t/C	591,6			
Specimen no. 1t/D	602,4			
Specimen no. 1t/E	604,7			
Specimen no. 1t/F	598,3			

5. RESULTS OF THE BENDING TESTS

Table 3. Bending features of 6 specimens from type 1t

	Bending strength [MPa]	Arithmetic media of measurements $\bar{x}$ [-]	Standard deviation s [-]	Variation coefficient v [%]
Specimen no. 1t/01	9,23	9,49	0,775	8,16
Specimen no. 1t/02	9,85			
Specimen no. 1t/03	8,76			
Specimen no. 1t/04	10,46			
Specimen no. 1t/05	8,52			
Specimen no. 1t/06	10,12			

Fig. 12. Grip detail of the specimen 1t/A

Fig. 13. Test detail of a specimen type 4t

6. CONCLUSIONS

The comparison between the bending rigidity of the structure obtained experimentally and that obtained through the theoretical approach is presented in fig. 14. The comparison shows a good agreement between the experimental data and the theoretical approach.

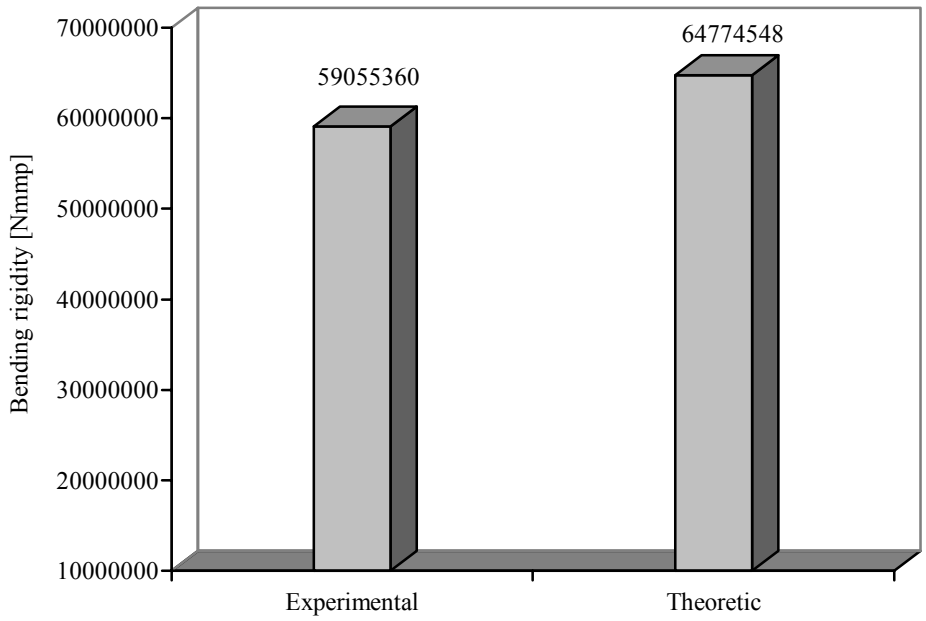

Fig. 14. Comparison between the bending rigidities of the structure determined experimentally and theoretic

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