DETERMINATION OF FLEXURAL PROPERTIES OF HYBRID COMPOSITE PARTS

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Abstract

The aim of this work was to determine the flexural properties of hybrid composites parts cut from trapezoidal core made of carbon/glass fibers impregnated in epoxy resin with help of filament winding technology. Values for stress, strain and module of elasticity were calculated using three point bending test according to ASTM standard. Hybrid fiber reinforced plastic laminates exhibit progressive failure consisting of fiber failure, debonding, and delamination.

Even though filament winding tension was constant during the winding process, it wasn't evenly distributed on trapezoid mandrel, due to it specific form. This caused different thickness and quantity of voids in composite walls and corners. Information about void content and fiber/matrix interface are also presented.

1. Materials

Matrix

Epoxy resin system

Araldite LY1135-1 /Aradur 917/Accelerator 960, Huntsman

Reinforcement

1. E-glass, continuous filament – P185 1200 tex, Owens Corning
2. Carbon fiber - T700S 12K, Toray

Fig. 1: Materials

2. Filament Winding Technique

Filament winding process was conducted on rotating collapsible trapezoidal mandrel with pins on both sides with help of laboratory filament winding machine MAW FB 6/1 with six axes, mechanical creel and roller type resin bath manufactured from Mikrosam A.D.

Trapezoid hybrid structure design:

$[90_c/0_{2c}/90_c/(0_{2c}/90_{2c}/45_{2c}/90_{2g}/0_{2g}/90_{2g}/45_g)_s/90_{2c}]$

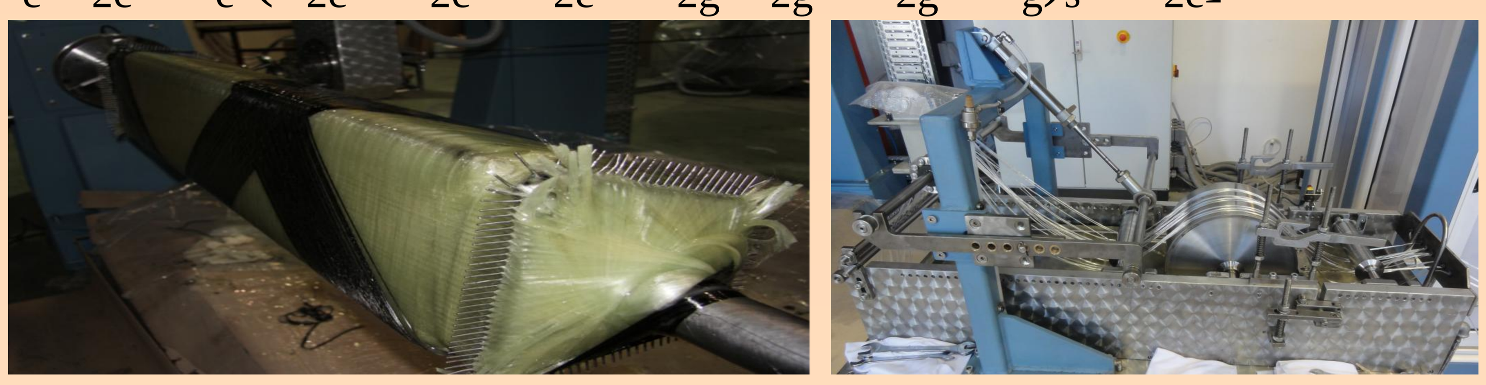

Fig. 2: Filament Winding process

3. Voids percent

Voids content in composite sample was determined according to ASTM D317. With help of experimental (ρ_e) and theoretical density (ρ_t), voids in final trapezoid part were calculated. Samples were cut from different places marked with numbers 1-16 on the structure (fig.3).

Table 1: Void content in hybrid composite part.

Trapezoid's	$\rho_{e.mid}$ (g/cm^3)	$\rho_{t.mid}$ (g/cm^3)	void$_{mid}$ (%)
side	1.68	1.77	5.5
corner	2.08	2.12	1.5

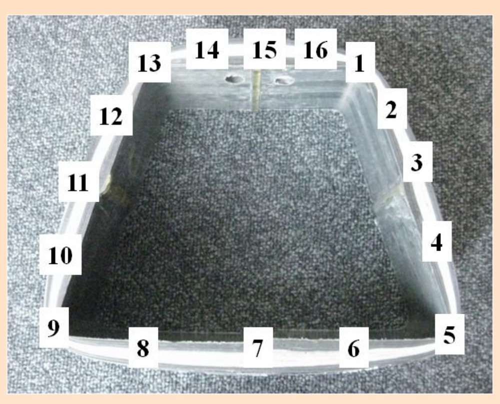

Fig. 3. Places for void measurement.

4. SEM images

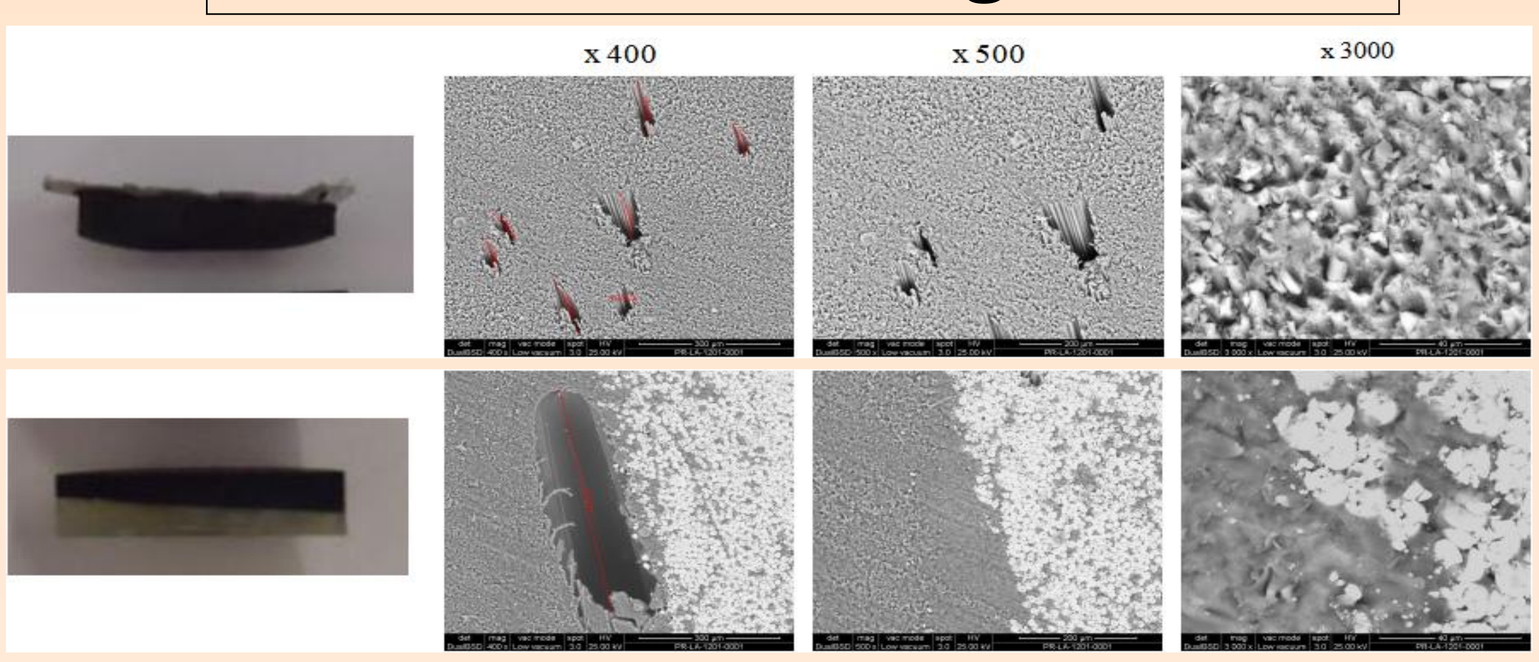

Fig. 4: SEM images.

5. Flexural properties

Seven rectangular forms were cut and tested on three point bending test. Samples were prepared according to ISO 14125 standard. Tests were performed on computer controlled universal testing machine from Shimadzu with maximal load 250 N.

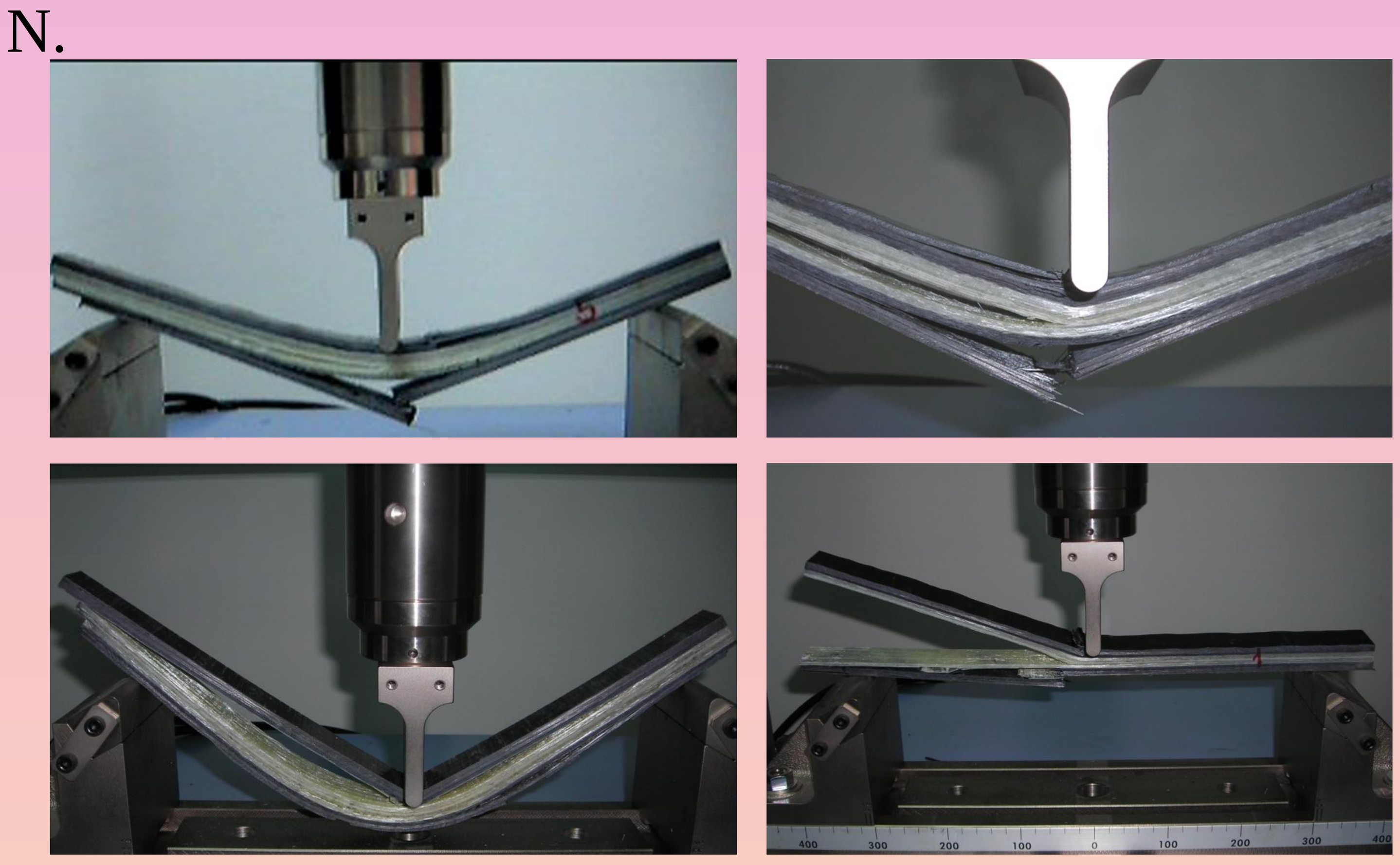

Fig. 4: Three point bending tests of hybrid composite specimens.

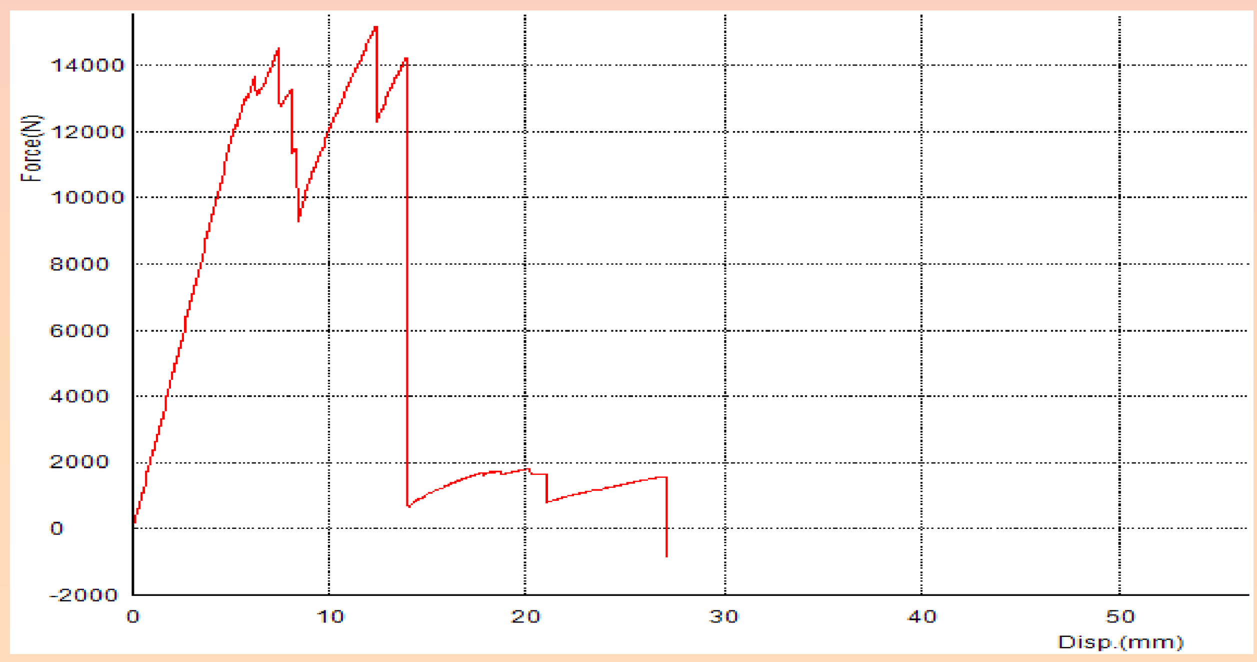

Fig. 3: Force - Deflection diagram of sample Nº 3

Table 2: Flexural properties of hybrid specimens.

Nº	s_0 (mm)	s (mm)	F_0 (N)	F_{max} (N)	ε (-)	E (GPa)	σ_f (MPa)	τ (MPa)
1	8.0	12.2	11200	13400	0.024	38.1	490.9	16.5
2	8.5	9.0	13500	14000	0.018	41.9	501.2	17.0
3	7.0	9.5	11000	14500	0.019	31.4	432.7	16.1
4	5.0	5.0	9000	12000	0.010	35.8	359.4	13.5
5	7.0	7.0	12000	12800	0.014	34.3	381.0	14.2
6	8.0	15.0	11000	12500	0.030	32.4	415.8	14.7
7	8.0	9.0	10500	14000	0.018	25.8	413.4	15.5

6. Conclusion

The experimental work show that specifically chosen filament winding design have significant load bearing qualities and elongation with delamination, as dominant fracture mechanism. Maximal flexural property of 501.2 MPa is reached when void percent in the sample is around 1.5 %, whereas void increase decreases flexural strength. SEM analysis present good merger between reinforcements and matrix, showing that manufactured hybrid composite samples has good quality. It can be concluded that voids presence in composite structure show negative effect on maximal flexural stress, which can be reduced if some contact method or higher winding tension will be used during sample fabrication. In this way sample delamination will be declined, which is consequence of smaller winding angles and use of pins during winding process.