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# Behavior Mecanique of One Laminates Crosses Bending Strain 3 Points Static and Cyclic

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**Abstract:** This experimental research has been achieved to the laboratory of group composites mechanical structures of the university of Maine, in collaboration with the laboratory of mechanics and structure of the university of Guelma It consists in testing a composite material in bending-three points, static and cyclic in Instron machine and to determine mechanisms of damage and failure. The gotten results show an elasticity and damageable kind of materials. The scattering results observed as well as for young's modulus that for the failure stress, has the appropriate reason for the mode work and microstructure of the elaborate material. The gotten curves in the case of cyclic bending clearly show the less of stiffness F/F0 according to the number of cycles. It confirms the short life of studied stratified. The facies exam of failure of tested tubes put in evidence a damage by delaminate of folds and transverse crack.

**Key words:** Mechancal, collaboration, composite, apporprite

## INTRODUCTION

A composite is a whole of at least two materials made up on the one hand fragile matrix (epoxy, polyester..etc.) and in addition of rigid reinforcements of very high modules (Carbon, glass… etc.)

The diversity of the basic components and the assemblies possible make a large variety of composites from which the mechanical characteristics and behaviors under requests are also different.

The interest of these materials is justified by the will to reduce the tare weight of the vehicles in order to be able to transport a greater quantity of goods and to have a better corrosion resistance. However some aspects of behavior under various requests remain misunderstood from where records several research orientations of them.

The damage of the laminated composites and heterogeneous materials was the subject of various modelings as well numerical as experimental (Mahi, 1991; Fatmi and Berthelot, 2001; Fatmi, 1994; Berthelot, 1992) and (Berthelot, 1992). A methodical design of the laminates exhibant of the properties of rigidities given and a description of the principal aspects of the implementation numerically was proposed in the literature (Grediac, 1998). Other work was interested in often noted significant dispersions resistance of the one-way composites and whose originator must hold account during the dimensioning of structures. The cause of this dispersion and its bonds with the microstructure of composite materials with long fibres are always of topicality. Even if the determination by standardized tests of the mechanical properties of material proves to be paramount, it is also very interesting to have models allowing the forecast of these properties according to those of the components. It should be noted that the studies on materials with short fibres, though already old remain limited (Redjel and Charentenay, 1987; Owen, 1974). Opinion of MJ Owen, in the case of the systems, resins polyester-chechmate of glass, the rupture of the interfaces and the matrix precedes the other forms by damages. The coalescence and the multiplication of these mechanisms are marked under cyclic request than in static loading.

In order to know the performances of studied composite material, we were interested in two of its aspects which are the mechanical behavior and the damage in inflection 3 points as well static as cyclic.

## MATERIALS AND METHODS

**Development of the laminates:** The cross laminate containing 16 folds differentiated by their sequences from stacking was worked out by the Composites Group and Structures Mechanics (G.C.S.M) of the university of

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Table 1: components of material studied before and after pyrolysis

| | Weight (g) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Material | Sample | Before pyrolyse | After pyrolyse | Résine | Fibres | Moyen des fibres | Résine | Moyen de résine |
| $(0_6/90_2)$s | 1 | 0.81 | 0.48 | 0.33 | 59.26 | 61.46 | 40.74 | 38.54 |
| | 2 | 0.79 | 0.50 | 0.29 | 63.30 | | 36.70 | |
| | 3 | 0.79 | 0.50 | 0.29 | 63.30 | | 36.70 | |
| | 4 | 0.80 | 0.48 | 0.32 | 60.00 | | 40.0 | |

Fig. 1: Test bench

Maine, France.This material consists of an one-way glass fibre fabric of surface mass 300 G $m^{-2}$ and of epoxy resin SR 1500/SD 2505. These components are manufactured by company SICOMIN. The mode of obtaining these materials is the vacuum moulding using the technique known as of the bag. The folds are laminated and impregnated at ambient temperature, then vacuum with depression of 30 Kpa during 10 h between the mould and it against mould. This laminate thick and is noted by [ $0_6/90_2$]s .

**Pyrolysis of studied material:** To check the rates of resin and reinforcements contained in studied material we had recourse to a technique called Pyrolyse This technique consists of the cutting of four samples of surfaces roughly equal to ç$m^2$ each one. A weighing of each sample is carried out before the setting with the furnace and is noted M1 in grams. Then, the four samples are fixed in the furnace at renewal of ignited air. The calcination of these samples takes place with 600°C for one 10 h duration.

After cooling, the residue of glass is weighed for each sample and is noted m2 in grams. Thus the resin loss by the calcination is M = M1-m2. The resin rate can be expressed by R = M/M1% and the rate of fibre by the complement is (100 R)%.

The results obtained are represented on the Table1.

Table 2: Thicknesses of the test-tubes used

| Test-tubes | h (mm); ( $0_6$/902 )]$_s$ |
|---|---|
| 1 | 5.05 |
| 2 | 5.31 |
| 3 | 4.40 |
| 4 | 5.26 |
| 5 | 4.96 |

**Banc D'essai:** The deflection tests 3-points statics and cyclic are carried out on a machine of the Instron type controlled by computer and equipped with a system of data acquisition show in Fig. 1.

**Preparation of the test-tubes:** Parallelepipedic test-tubes were cut out using a slicer with set with diamonds disc starting from plates of 300×300 $mm^2$ of dimensions, L = 20 h, L = 16 h and B = 15 mm according to standard AFNOR NF T 57-105, where L, L, B and H are, respectively the overall length, the length between supports, the width and the thickness of the test-tube. The following Table 2 comprises the thicknesses of the test-tubes used.

## OBTAINED RESULTS

**In static inflection 3 points:** The curves of mechanical behavior charges-displacement obtained in static inflection 3 points are represented on the Fig. 2.

The calculation of the mechanical characteristics in inflection 3 static points is based on the relation (Mahi, 1991) for stresses the rupture in inflection $\sigma_F$ and by the use of the relation (Fatmi and Berthelot, 2001) for the values of the Young modulus in inflection $E_f$.

$$\sigma F = \frac{3.F.l}{2.b.h^2} \quad (1)$$

$$E_F = \frac{l^3}{4.b.h^3}\frac{\Delta F}{\Delta d} \quad (2)$$

where
F: the load with the rupture applied (N); L: length between supports (mm); b: width of the test-tube (mm); H: the thickness (mm); ΔF: variation of the force on the rectilinear part of the curve charges displacement; ΔD: variation of the arrow in (mm), corresponding to the variation of the force (Table 3).

Table 3: Stresses the rupture and calculated Young modulus in static inflection three points

| | $(0_6/90_2)_{sEp}$ | | | | |
|---|---|---|---|---|---|
| Test-tubes | F(KN) | $\sigma_f$ (MPa) | $\sigma_{fmoy}$ (MPa) | $E_f$ (MPa) | $E_{fmoy}$(MPa) |
| 1 | 2.118 | 671 | 625 | 109197 | 124625 |
| 2 | 2.071 | 624 | | 120662 | |
| 3 | 1.828 | 664 | | 127286 | |
| 4 | 1.683 | 542 | | 141316 | |

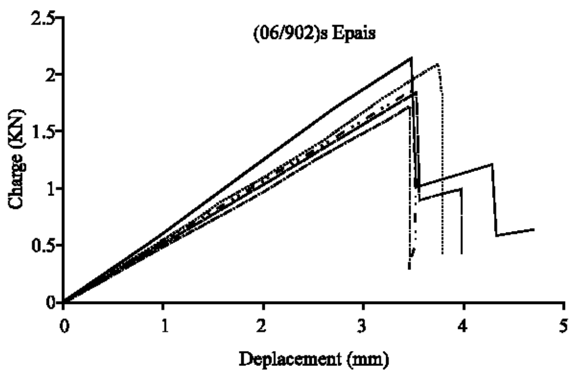


Fig. 2: Curves of experimental behavior charges-displacement in static inflection 3 points

Fig. 3: Optical microscope

**Results analyze from the behavior point of view:** Experimental shape of the curves of behavior load-displacement in inflection 3-points statics highlights an elastic linear zone associated a delamination of the layers. The creation of first macrofissures and their coalescences lead directly to the rupture of the test-tubes.

In addition the results obtained by the calculation of stress the rupture and the modulus of elasticity for each test-tube indicate a small variation in their values and that is explained by the defects of development (bubbles, porosité..etc.) for the 1er case and by the heterogeneity of the microstructure (rate and orientation of fibres) for the 2è case

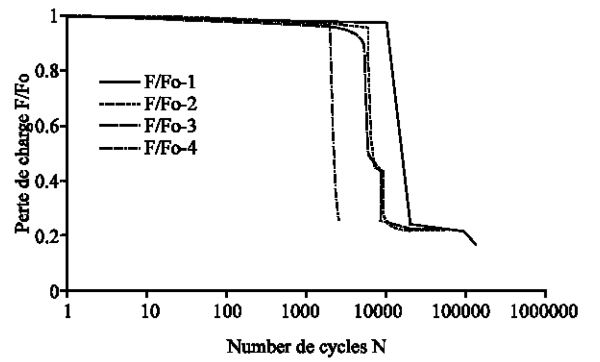


Fig. 4: Curves of experimental behavior pressure loss a Number of cycles. In cyclic inflection

delamination starting from a resin inclusion in the folds with 90° and incipient rupture of the folds with 0° (b)Rupture by delamination starting from a resin inclusion in the folds with 90°

**Results analyze from the damage point of view:** The photographs illustrating the mechanisms of rupture observed after rupture of the test-tubes were taken on an optical microscope (Fig. 3).

Les observations montrent un endommagement mixte délaminage des plis et fissuration transversale au niveau des couches les plus tendues

**Results analyze from the behavior point of view:** The analysis of the curves highlights two phases of decrease (Fig. 4).

A first phase of progressive linear decrease which occupies a significant part of the lifespan of this material. This decrease is explained by the appearance and the development of the localised sites of damage.

As for the second phase which is explained by a brutal fall of the rigidity of material, it is the consequence of a coalescence of microscopic cracks generating of the macrofissures which will be at the origin of the total rupture. The quantitative analysis of these results informs us about the behaviour of material from where one can consider that a loss of rigidity of 10% in fatigue is largely sufficient to consider that the damage of material is irreversible. Because beyond this value there is risk of brutal fall of the rigidity of material.

**Results analyze from the damage point of view:** These two photographs carried out on optical microscope illustrate examples of mechanisms of rupture and damage observed after rupture of the cyclic bend-test specimens (Fig. 5). The follow-up of the evolution of the damage during the cyclic inflection showed that the first damages appear in the center of the face opposed to the loading of the test-tube.

Fig. 5: Damaging modes observed after failure under static bending 3 points (a) Rupture by

These precursory damages lead to the creation of transverse cracks of the matrix according to the width of the test-tube. These cracks which are propagated then inside material are followed by a delamination of the folds leading to the rupture of the test-tube.

## CONCLUSION

The results, in the case of the inflection 3-points statics, made it possible to highlight an experimental elastic linear behavior charges-displacement of the test-tubes tested.

As for the dispersion of the results obtained for the Young modulus and stress the rupture in inflection, it is primarily related to the mode of placement of studied material and of its microstructure.

The curves obtained at the time of the cyclic inflection indicate a loss of rigidity F/F0 according to the number of cycles. The loss of rigidity of this material is explained initially, by the creation of sites of localised damages followed by another creation of macrofissures and their coalescences inevitably lead to the ruin of the test-tube.

The examination of the rupture and damage mechanisms by optical microscope highlighted a delamination of the folds and a transverse cracking.

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