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EXPERIMENTAL APPROACHES REGARDING THE ELASTIC PROPERTIES OF ROVING SUBJECTED TO BENDING

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Abstract: *Inside a composite material the fiber shaped materials take over the tensions acting directly upon the matrix, which presents less stiffness than the fibers. The assessment of the tensile behavior for a polymeric composite part is a more difficult issue than for example the assessment of a metal part in the same conditions. Finally, we will balance the individual ply stresses against the applied tractions and moments to develop matrix governing relations for the laminate as a whole.*
Keywords*: roving specimens, flexural stiffness, Young's module*

1. INTRODUCTION

This leter is intended to outline the mechanics of ber-reinforced laminated plates, leading to a computational scheme that relates the in-plane strain and curvature of a laminate to the tractions and bending moments imposed on it. Although this is a small part of the overall eld of berreinforced composites, or even of laminate theory, it is an important technique that should be understood by all composites engineers.
In the sections to follow, we will review the constitutive relations for isotropic materials in matrix form, then show that the extension to transversely isotropic composite laminae is very straightforward. Since each ply in a laminate may be oriented arbitrarily, we will then show how the elastic properties of the individual laminae can be transformed to a common direction.

2. MECHANICAL TESTS OF THE GLASS FIBERS REINFORCED LAMINATED COMPOSITES ROVING

The calculations for laminate mechanics are best done by computer, and algorithms are outlined for elastic laminates, laminate exhibiting thermal expansion effects, and laminates exhibiting viscoelastic response.
Glass-fiber reinforced plastics (GRPs) has enabled them to be candidate materials in many applications from small electrical products such as printed circuit boards to large mine-hunting ships greater than 50 m in length. In some cases, GRPs dominate an application to the extent that they are now the preferred material rather than one of several possible candidates (e.g., small boat production).
The properties of GRP should be considered and understood in relation to the types or classes of materials arising from different processing routes and conditions, together with choices of constituents, their format, and weight/volume fractions. These aspects have a direct influence on the material response and behavior as characterized by the measured property data. In addition, the wider context of the measurement methods used and the data uncertainty must be considered.
There are several types of glass fibers available for use in reinforcing polymeric matrices. They are manufactured by drawing filaments from a molten bath of glass held in a heated platinum crucible. The different types of glass fibers are designated normally by alphabetical codes such as E, S/R, and ECR/AR. The main fibers used are E glass fibers, which amount to 90% of the market. Although E-glass fibers standing for electrical grade with a lime-alumina-borosilicate composition are well recognized, there is no agreed standard composition. The S and R fibers are high strength grades. AR glass was developed as an alkali resistant grade, with ECR as an alkali-resistant glass.
In discussing the properties of GRPs it is important to ensure that industry recognized test methods are used, preferably available as international or national standards, and that the material tested is fully characterized.

The properties of GRPs are anisotropic to varying degrees depending on the type and amount of fiber present. The material axes of continuous or discontinuous unidirectional composites are defined by a set of three mutually perpendicular directions parallel and perpendicular (transverse) to the fiber direction. The material axes are also known as either the symmetry axes or principal axes. For in-plane properties, the direction parallel to the fibers is known as the longitudinal or 1-direction and the direction perpendicular to the fibers is known as the transverse or 2-direction (Figure 1). The through-thickness (out-of-plane) direction perpendicular to the fibers is the 3-direction.

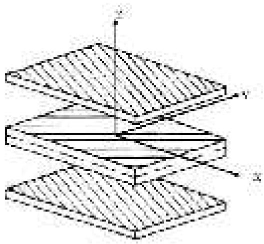

Figure 1 (a) Axes of symmetry for a unidirectional reinforced laminate, (b) axes of symmetry for a multidirectional reinforced laminate.

It is important when quoting property data that the material is fully characterized for fiber volume fraction, fiber format and orientation, void fraction, etc., as they control not only the properties in the absolute sense but also through the balance of properties, the failure mechanisms, and the final failure mode. This knowledge is also needed to ensure that the appropriate test methods are used as in some cases, the specimen size etc. depends on the material format and properties (e.g., ISO 527 Parts 4 and 5; ISO 14 125). Several aspects of the characterization of GRPs are covered by international test methods. Starting from the test panel, a traveler coupon, or a section cut from the product itself, there are several measurements that should be undertaken to characterize the material, as detailed in Table 8, prior to further evaluation.
These characteristic data should be recorded with input material codes, specifications etc., together with information or data obtained in the testing program.
The following table lists physical and mechanical property values for representative ply and core materials widely used in bar reinforced composite laminates. Ply properties are taken from F.P.Gerstle, \Composites," Encyclopedia of Polymer Science and Engineering, Wiley, New York, 1991, which should be consulted for data from a wider range of materials. See also G. Lubin, Handbook of Composites, Van Nostrand, New York, 1982.

Table 1: Mechanical properties

	S glass/ epoxy	Kevlar/ epoxy	HM Graphite/ epoxy	Pine	Rohacell 51 rigid foam
Elastic Properties:					
E_1, GPa	55	80	230	13.4	0.07
E_2, GPa	16	5.5	6.6	0.55	0.07
G_{12}, GPa	7.6	2.1	4.8	0.83	0.021
ν_{12}	0.26	0.31	0.25	0.30	
Tensile Strengths:					
σ_1, MPa	1800	2000	1100	78	1.9
σ_2, Mpa	40	20	21	2.1	1.9
σ_{12}, MPa	80	40	65	6.2	0.8
Compressive Strengths:					
σ_1, MPa	690	280	620	33	0.9
σ_2, MPa	140	140	170	3.0	0.9
Physical Properties:					
α_1, 10^{-6}/°C	2.1	−4.0	−0.7		33
α_2, 10^{-6}/°C	6.3	60	28		33
Volume fraction	0.7	0.54	0.7		
Thickness, mm	0.15	0.13	0.13		
Density, Mg/m^3	2.0	1.38	1.63	0.55	0.05

3. TEST RESULTS OF FLEXURAL STRESS

To see what is the positive influence in material properties named MAT-roving, have tested specimens made from roving RT800 with 4 layers, with the same technology. In figure 2 are presented the specimens from composite material named Roving RT800 warp, and in figure 3 Roving RT800 weft.

Figure 2 Specimens Roving 4 layers on warp

Figure 3 Specimens Roving 4 layers on weft

Table 2: Valorile de încărcare a parametrilor epruvetei din Roving

	E U1	E U2	E U3	E U4	E U5	E B1	E B2	E B3	E B4	E B5
Cali-brated part length *mm*	60	60	60	60	60	60	60	60	60	60
Load speed *mm / min*	5	5	5	5	5	5	5	5	5	5
Test-piece width *mm*	10,4	10,8	11	10,5	10,6	10,5	10,8	10,5	10,4	10,6
Test-piece thick-ness *mm*	4	4,2	4,2	4,1	4,5	4,5	4,4	4,5	4,4	4,4
Area mm^2	41,6	45,36	46,2	43,05	47,7	47,25	47,52	47,25	45,76	46,64

Table 2: Medium values of mechanical characteristic subjected on bendind

Proprietăţile mecanice la încovoiere pentru Roving	**Valorile medii pentru Roving pe urzeală**	**Valorile medii pentru Roving pe bătătură**
Stiffness *N/m*	207560	247850
Young's modulus *MPa*	11397	10404
Flexural Rigidity Nm^2	0,69286	0,82738
Maximum Bending Stress at Maximum Load *MPa*	288,02	285,86
Maximum Bending Strain at Maximum Load	0,031726	0,030984
Work to Maximum Extension *Nmm*	4967	5652
Load at Minimum Extension *kN*	0,97834	1,1098
Maximum Bending Stress at Break *MPa*	261,39	258,36
Elongation at Fracture *mm*	0,040164	0,040205

In figure 4 is presented the stifness value of the 5 specimens made from Roving. Will observ that the minimum value of stifness 225182.554 *N/m* has the specimen 5, and the maximum value of stifness 259284.65 *N/m*, has the specimen 1 and the medium value is 242700 *N/m*.

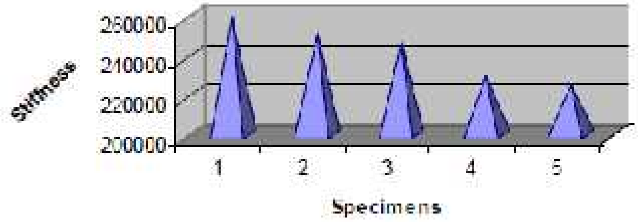

Figure 4: Flexural rigidity for specimens made from Roving

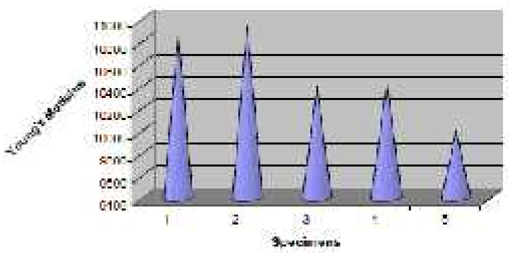

Figure5: Diagram of 5 specimens Young's Modulus for Roving

In figure 5 is presented the Young Modulus of the 5 specimens made from Roving. Will observ that the minimum value is 9990 *MPa* for specimen 5, and the maximum value 10932 *MPa*, for specimen 2 and the medium value is 10512 *MPa*.

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3. CONCLUSION

If in fiber-reinforced composite materials are internal stresses higher than the allowable values, then when in use, even a small task can irreversibly damage the composite.

We cannot match a composite material with a regular one, it is much more resistant, elastic, easier to manufacture, cheaper, lighter and keeps its properties in time.

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