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SUITABLE MATERIAL FOR STUDIED TANK

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Abstract: *Composites materials are made by combining two materials where one of the materials is reinforcement (fiber) and the other material is a matrix (resin). The combination of the fiber and matrix provide characteristics superior to either of the materials alone. Some examples of composite materials are plywood, reinforced concrete, fiberglass & polyester resin, and graphite & epoxy resin. The glass fibers used in reinforcing thermo-plastic thermo-rigid resins are obtained from the so called textile glass consisting of yarn and ply. 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, especially due to the accentuated dependence of the polymeric composite materials of some influences like temperature, test duration.*
Keywords: *Young's module, mat, roving, bending*

1. INTRODUCTION

Composite materials are very versatile and are utilized in a wide variety of applications. The most widely used composite material is fiberglass in polyester resin, which is commonly referred to as just fiberglass. Fiberglass is lightweight, corrosion resistant, and economical, easily processed, has good mechanical properties, and has over 50 years of history. It is the dominant material in industries such as boat building and corrosion equipment, and it plays a major role in industries such as architectural, automotive, medical, recreational, and industrial equipment.
The manufacturing process for glass fibers suitable for reinforcement uses large furnaces to gradually melt the sand/chemical mix to liquid form, then it is extruded through bundles of very small orifices (typically 17–25 micrometers in diameter for E-Glass, 9 micrometers for S-Glass). These filaments are then "sized" with a chemical solution. The individual filaments are now bundled together in large numbers to provide a [roving]. The diameters of the filaments, as well as the number of filaments in the roving determine its "weight". This is typically expressed in yield-yards per pound (how many yards of fiber in one pound of material, thus a smaller number means a heavier roving, example of standard yields are 225yield, 450yield, 675yield) or in tex-grams per km (how many grams 1 km of roving weighs, this is inverted from yield, thus a smaller number means a lighter roving, examples of standard tex are 750tex, 1100tex, 2200tex).

2. MANUFACTURING PROCESS

The most common manufacturing process for fiberglass is the wet lay-up process using an open mold. The shape of the part is determined by the shape of the mold, and the mold surface is typically in contact with the exterior of the part. Mold release is first applied to the mold to prevent the fiberglass part from adhering to the mold. Then gel coat, which is pigmented resin, is applied to the mold to give the part color. Fiberglass and resin are then deposited on to the mold and the fiberglass is compressed by rollers, which evenly distributes the resin and removes air pockets. Multiple layers of fiberglass are deposited until the desired thickness is achieved. When the resin is cured, the part is removed from the mold. Excess material is trimmed off, and the part is ready for paint and assembly. There are also closed mold processes for making fiberglass parts.
These rovings are then either used directly in a composite application such as (pipe), gun roving (automated gun chops the glass into short lengths and drops it into a jet of resin, projected onto the surface of a mold), or used in an intermediary step, to manufacture fabrics such as "chopped strand mat" (CSM) (made of randomly oriented small cut lengths of fiber all bonded together), woven fabrics, knit fabrics or uni - directional fabrics.

A sort of coating, or primer, is used which both helps protect the glass filaments for processing/manipulation as well as ensure proper bonding to the resin matrix, thus allowing for transfer of shear loads from the glass fibers to the thermoset plastic, without this bonding, the fibers can 'slip' in the matrix and localized failure would ensue.
An individual structural glass fiber is both stiff and strong in tension and compression—that is, along its axis. Although it might be assumed that the fiber is weak in compression, it is actually only the long aspect ratio of the fiber which makes it seem so; i.e., because a typical fiber is long and narrow, it buckles easily. On the other hand, the glass fiber is unstiff and unstrong in shear—that is, across its axis. Therefore if a collection of fibers can be arranged permanently in a preferred direction within a material, and if the fibers can be prevented from buckling in compression, then that material will become preferentially strong in that direction.

Table 1: Mechanical properties

Material	Specific gravity	Tensile strength (MPa)	Compressive strength (MPa)
Polyester resin (unreinforced)	1.28	55	140
Polyester and Chopped Strand Mat Laminate 30% E-glass	1.4	100	150
Polyester and Woven Rovings Laminate 45% E-glass	1.6	250	150
Polyester and Satin Weave Cloth Laminate 55% E-glass	1.7	300	250
Polyester and Continuous Rovings Laminate 70% E-glass	1.9	800	350
E-Glass Epoxy composite	1.99	1,770 (257 ksi)	
S-Glass Epoxy composite	1.95	2,358 (342 ksi)	

Furthermore, by laying multiple layers of fiber on top of one another, with each layer oriented in various preferred directions, the stiffness and strength properties of the overall material can be controlled in an efficient manner. In the case of fiberglass, it is the plastic matrix which permanently constrains the structural glass fibers to directions chosen by the designer. With chopped strand mat, this directionality is essentially an entire two dimensional plane; with woven fabrics or unidirectional layers, directionality of stiffness and strength can be more precisely controlled within the plane. A fiberglass component is typically of a thin "shell" construction, sometimes filled on the inside with structural foam, as in the case of surfboards. The component may be of nearly arbitrary shape, limited only by the complexity and tolerances of the mold used for manufacturing the shell.

3. TEST RESULTS OF FLEXURAL STRESS

In this paper we will present the study of a tank made of MAT -Roving composite material.
First materials used:
• MAT 600 - fiberglass composite (short wires) in the matrix of epoxy resin with specific weight 2x600g / m2, 2-2, 6 mm thick;
• RT 800 - fiberglass composite (fabric) in the matrix of epoxy resin with specific weight of 4x 800g / m2, thickness 3,2- 3,6 mm;
• MAT 450 - fiberglass composite (short wires) in the matrix of epoxy resin with specific weight 2x450g / m2, 1.6-2mm thick.
The 2th composite material used:
• RT 800 - fiberglass composite (fabric) in the matrix of epoxy resin with specific weight of 4x 800g / m2, thickness 4,5 mm;
The 3th composite material used:
• MAT 450 - fiberglass composite (short wires) in the matrix of epoxy resin with specific weight 4x450g / m2, 1.6-2mm Thick:
The 4th composite material used:
• MAT 600 - fiberglass composite (short wires) in the matrix of epoxy resin with specific weight 1x600g / m2, 2-2, 6 mm thick;
• RT 800 - fiberglass composite (fabric) in the matrix of epoxy resin with specific weight of 3x 800g / m2, thickness 3,2- 3,6 mm;
• MAT 450 - fiberglass composite (short wires) in the matrix of epoxy resin with specific weight 1x450g / m2, 1.6-2mm thick.

Fiberglass is an immensely versatile material which combines its light weight with an inherent strength to provide a weather resistant finish, with a variety of surface textures.
As a general consideration, the most experimental methods applicable to isotropic materials may be adjusted to the study of polymeric composite materials. Most of these are based upon the specific measurements of deformations. The

application of these procedures assumes in some cases the use of some modeling methodologies, for others using even the prototype testing.
In order to determine the unit loadings σ in the structure of the composite material, we used 120 Ω strain gauges, applied on the studied structure.
These strain measuring tests were performed by help of a HBM KOMPENSATOR MK device, from Hottinger Baldwin Messtechnic.
The unit loading $\sigma = E \cdot \varepsilon$ daN/mm^2 or Kg/mm^2, where: ε – specific length $\varepsilon = \Delta l/l$; σ – unit loading; E – Young's elastic modulus, the constant for the fiber has values between $(0,06 \div 0,10)10^6$.
After we determined static zero for each measuring point, we started filling the tank with water in three stages, each stage representing 1/3 of the recipient volume, determining by help of the MK device, the structures stress for each of the three fillings.
In Table 2 we presented the stress in the material during the filling, after taking static zero out.

Table 2: Stress in the material during the filling in 3 stages, for 3 TER

Filling stages	ε for gauge no.1	ε for gauge no.2	ε for gauge no.3
1/3 from tank	-0.0118	-0.0139	-0.0247
2/3 from tank	-0.0168	-0.0233	-0.0243
Full tank	-0.0163	-0.0180	-0.0214

In Table 3 we presented the stress in the material during emptying the tank after taking zero static out.

Table 3: stress in the material during emptying the tank in 3 stages, for 3 TER

Emptying stages	ε for gauge no.1	ε for gauge no.2	ε for gauge no.3
1/3 from tank	-0.0007	-0.0091	-0.0069
2/3 from tank	-0.0009	-0.0127	-0.0049
Empty tank	-0.0020	-0.0090	-0.0025

The value obtained from the difference between zero static strain gauge and axle load value is the specific strain (ε), which is dimensionless.

3. CONCLUSION

Measuring by strain gauges analysis brings a significant contribution to the experimental researches results that determined the mechanical properties of the composite materials and to the finite element modeling by emphasizing the maximum stress in certain material areas.
In our case we find that the tank is not subjected to great strain, meaning it is oversized. It might be made of less layers, with smaller thickness, fact that leads to lower fibers and resin consumption and as a follow, lower costs.
We performed a comparison between the strains in this material using several methods:
- Using strain gauges;
- Experimental tests upon samples made of the same material as the studied tank.

The compared results lead us to the conclusion that this material, for the stated dimensions will in fact resist to a 40 times greater stress than those to which it was statically subjected.
Based on the obtained results we may draw some interesting conclusions concerning the shape and size optimization methods for the designed elements, considering the stress and strain magnitude and distribution, the vibration own modes and frequencies.

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REFERENCES

[1] Bârsănescu, P.D., (1997), Creşterea preciziei în tensometria electrică rezistivă, Oficiul de informare documentare pentru industria construcţiilor de maşini.

[2] Cotoros, D., Stanciu, A. E., Baritz, M., (2010), Experimental Research Concerning Mechanical Properties of Materials for Biomedical Use, Proceedings of the World Congress on Engineering, WCE 2010, June 30 - July 2, London, U.K,1113-1116.
[3] Gheorghiu, H., Hadăr, A., Constantin,N., (1998), Analiza structurilor de materiale izotrope şi anizotrope. Editura Printech , Bucureşti.
[4] Teodorescu, H., (2001), Contribuţii privind creşterea capacităţii de încărcare a tuburilor din materiale compozite armate cu fibre, prin introducerea de tensiuni interne suplimentare, Teză de doctorat. Universitatea Transilvania Braşov.
[5] Stanciu, A. E., Cotoros D., (2009), Study Concerning the Mechanical Tests of Mat&Roving Fiber Reinforced Laminated Composites, 5th Wseas International Conference on Applied and Theoretical Mechanics (MECHANICS '09) Puerto De La Cruz, Tenerife, Canary Islands, Spain December 14-16.
http://en.wikipedia.org/wiki/Storage_tank#Tank_failures
http://www.performancecomposites.com/fiberglassdesignguide.pdf