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TENSILE PROPERTIES OF GLASS/EPOXY COMPOSITES WITH DIFFERENT ORIENTATIONS OF FIBERS

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ABSTRACT
This paper collects very important mechanical properties of laminate composites for industry of laminate structures. We found very important results for various stacking sequences of glass/epoxy laminate composites.
On the other hand, we determined the properties of the materials during manufacturing process in the company, which produced mechanical parts in railway industry. Our results can help to designer how to optimally design mechanical parts of railway components.
Keywords: tensile properties, laminate composites, and railway industry.

1. INTRODUCTION
Relevant facts and engineering properties of some man-made reinforced material, which are becoming common in structural applications, are noted in this work. These composites involve combinations of reinforcement and matrix constituents. As such, the material becomes mechanically anisotropic (orthotropic E_{11}, E_{22}, V_{12}, G_{12}), giving rise to orientational dependence of strength and stiffness, thermal, optical and electrical properties. [1]
The mechanical anisotropy presents the subsequent need to pursue anisotropic elasticity. That employed composites are frequently bonded laminates of individual plies necessitates the need to study lamination theory for structural analysis. For design and analysis purposes, and because composites are directionally dependent and stacked laminates, strength theories (or failure criteria) take on added complexity. Similarly, the anisotropy and heterogeneity of composites complicates the picture with respect to fatigue and fracture. The high dependence of gross composite response on individual constituents and the reinforcement-matrix interface necessitates attention be paid to the micro-mechanics of the situation. [2,3]
Even once a basic family of matrix and reinforcement constituents are chosen, the mechanical, physical and structure response of a composite can be highly dependent upon factors such as the following:
• relative reinforcement size (length, cross-section),
• mechanical and physical properties of matrix,
• mechanical and physical properties of reinforcement,
• interface and bonding of the reinforcement-matrix,
• shape of reinforcement,

• relative volume content of the reinforcement,
• fabrication procedures,
• environmental conditions such as temperature, humidity, radiation, residual stresses,
• relative spacing and location array of reinforcement ingredients,
• internal voids, defects, local variations in reinforcement packing, alignment, delaminations, etc. [4]

2. EXPERIMENTAL PART

We investigated glass-epoxy laminate composites, because they are commonly employed structural composites. Popular applications include aerospace hardware, sporting and recreational items, transportation vehicles, pressure vessels and liquid containers, water and sewer pipes, and domestic items. Glass-epoxy composites are available as unidirectional reinforced plies (bundles or roving), chopped reinforced epoxy (usually reasonably isotropic in the plane) or twisted yarns may be cross woven to produce a fabric. Glass-epoxy materials are commercially available as

• unidirectional prepreg tape
• cross-woven prepreg fabric
• spools of roving material for winding
• continuous filament for filament winding
• cured laminates
• chopped fibres

One can purchase a particular glass filament, roving, yarn or fabric and have it prepregged with a particular resin at a specified fiber content, etc.

Many different types of composite materials are available. To make the exercise manageable, consideration was limited to continuous-fibre-reinforced thermosetting plastics. Taking into consideration the availability of suitably extensive experimental data for laminates, important and widely used class of fibre are E-glass and one group of resin systems (epoxy resins) were selected for the exercise.

At the firs step we did tensile test on four type of different laminate composite with various stacking sequences. We measured width and thickness on every sample on three parts, and then we calculated average values.

Determination of tensile properties was doing according to EN ISO 527-4, Part 4: Test condition for isotropic and orthotropic fibre-reinforced plastic composites.

Investigated specimens was deformed by constant speed along the main axis to breaking, or stress or deformation do not achieve predetermine value. During test we measured stress sample and strain.

Fig. 1 describe devil HOUNSFIELD W-SERIES with part to plot on curve stress-strain.

The four types of laminate lay-ups selected were analysed under of loading conditions. Table 1 summarises laminate type, material type the investigated samples. Fig. 2 shows stress-strain curves for four different stacking sequences with epoxy resin. Tables 2, 3 describe experimental results of mechanical properties of investigated laminate samples. Figure 3 depicts the shape of area after tensile test.

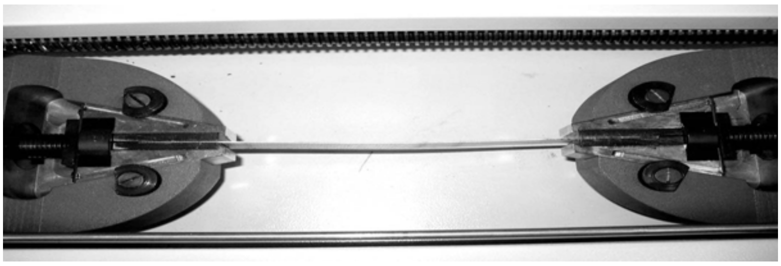

Figure 1. Devil with sample.

Table 1. Description of laminate composite samples with different stacking.

Sample	**Type of composites**	**Kind of fabric**	**Resin**	**Stacking sequences**	**Direction of strain**
1C	*glass/epoxy*	*220g/m^2-Interglass 92145 - unidirectional*	*Epoxy resin L285 MGS*	*(0º/90º)6x*	*45°*
1D	*glass/epoxy*	*220g/m^2- Interglass 92145 - unidirectional*	*Epoxy resin L285 MGS*	*3x0º/3x90º*	*45°*
1E	*glass/epoxy*	*220g/m^2-fabric*	*Epoxy resin L285 MGS*	*0/90 (fabric)6x*	*90°*
1G	*glass/epoxy*	*220g/m^2-Interglass 92145 - unidirectional*	*Epoxy resin L285 MGS*	*6x0º*	*90°*

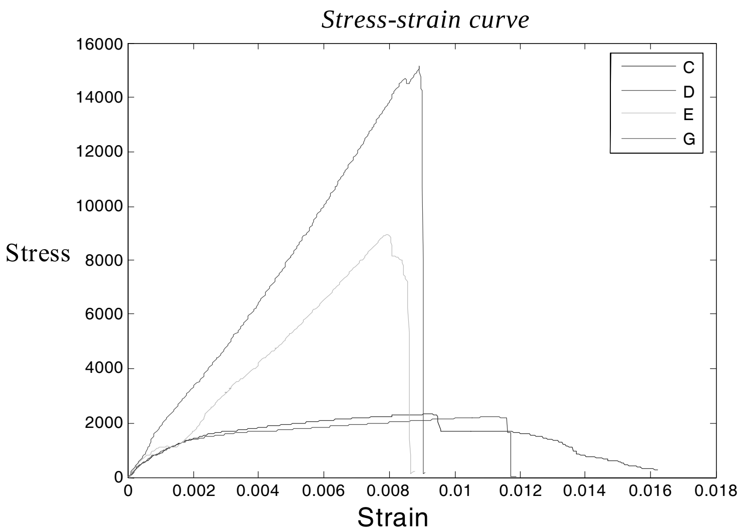

Figure 2. Stress-strain curves.

Table 2. Description of strength and strain for sample C.

Stacking sequences	**Tensile strength δ [MPa]**	**Tensile strain ε [%]**	**Direction of strain**
6x(0°/90)	$\overline{\sigma} = 93,05$	$\overline{\varepsilon} = 9,41$	45°

Table 3. Results from measurement.

Sample	**Thickness [mm]**	**Width [mm]**	**Gauge length L_0 [mm]**	**Strength F_m [N]**	**Tensile strength δ [MPa]**	**Tensile strain ε [%]**
1C	*1,23*	*25,03*	*170*	*2863,74*	*93,07*	*9,41*
1D	*1,07*	*24,87*	*170*	*2073,73*	*78,37*	*6,27*
1E	*1,26*	*25,03*	*170*	*11727,32*	*371,08*	*5,48*
1G	*1,07*	*24,78*	*170*	*13836,4*	*519,34*	*5,17*

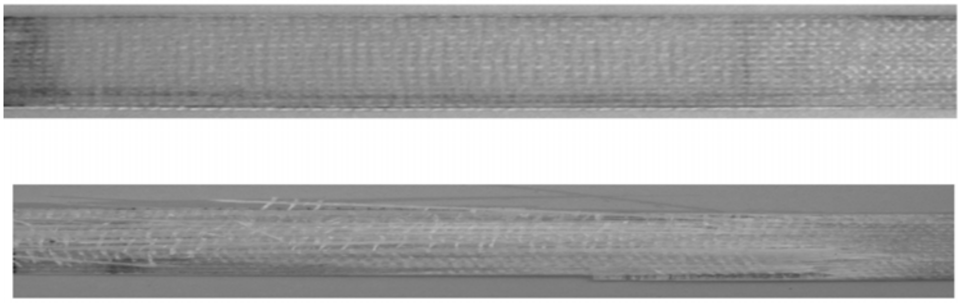

Figure 3. Description of shape of sample C before and after tensile test.

3. CONCLUSION AND DISCUSSION OF RESULTS

In this paper we present lamina properties, lay-up configurations and loading conditions for a range of fibre-reinforced composite laminates. The results obtained from tensile test are very important for designer of structural part in railway and car industry. During laminate process we can very easy change the kind of resin, type of reinforcement, stacking sequence of laminate, thickness and another properties to obtain very important mechanical properties. In our measurement we achieved increasing of tensile strength from value 93,07 MPa to value 519,34 MPa. This is very dramatically increasing of tensile strength. In the conclusion we can confirm, that the stacking sequence, kind of fabric, orientation of fabric have significant part to mechanical properties.

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