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NEW MATERIALS FROM WASTE GLASS FIBRE

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ABSTRACT. The authors propose a new material obtained from waste composites reinforced with glass fibres, sand, and polyester. Composite plates which contain in the structure waste glass fibre were developed. The obtained material was characterized by compression tests and microstructure analysis by SEM-EDX.

Keywords: *composite materials plates, fibre glass waste, recycling*

INTRODUCTION

Composite materials consist of reinforcement material (glass fibre, carbon fibre, Kevlar, etc.) and a matrix (polyester resin, epoxy resin, and so on). A composite material may contain, in the structure, some auxiliary materials (catalysts, accelerators, coupling agents, pigments, etc.) with the role to give high properties or low price [1, 5].

One problem that we are facing is the storage and recovery of waste composite materials. Composite waste resulting from production processes and composite parts out of use occupy significant space for storage. A solution for recycling such composite materials has been to grind these materials and create new composite products. [6 - 9].

Mixtures of concrete with sand and fiberglass waste are known [10, 11]. Howeve, with the known technical solutions these materials have lower mechanical properties, higher density, and they degrade in time under the influence of external factors: moisture, sunlight, UV radiation.

Dang et al. [12] proposed a chemical recycling protocol for glass fibre reinforced epoxy resin cured with amine using nitric acid. Giraldi et al. [13] recycled PET reinforced with glass fibre, while Bartl et al. [14] investigated the recycling of fibres obtained from tyres. Composite materials obtained from wood fibres were analysed by Nemes et al. [3] and Augier et al. [15].

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In this paper composite plates based on waste fibre glass (Figure 2) are described. Specimens were carried out to determine the physical and mechanical characteristics. The composite plates provide higher mechanical properties, lower costs and reduce waste materials in the environment.

RESULTS AND DISCUSSION

Wastes from composite materials shown in Figure 1 are due to accumulation in time and a poor interest to find solutions for recycling or recovering. By grinding composite waste, one can obtain a material rich in glass fibre (Figure 2) that forms a very valuable reinforcement to be embedded in other materials or to be used for obtaining reinforced composite materials.

Figure 1. Waste composite materials

Figure 2. Ground glass fibre

A manual lay-up technology was used in the manufacturing process for the composite materials as previously described [17]. Cubic specimens were made from the obtained composite material for compression testing. Following the compression load of cubic specimens, the constituent of composite material remains bonded through the filaments of reinforcement material. This paper highlights a new composite material with higher mechanical properties and different possible applications.

Microscopy study in the case of waste materials

The microstructure of fracture samples from waste glass fibres/sand/ polyester matrix composites was analysed using a metallographic microscope type Optika XDS-3 MET [16]. The sand was used as a low-cost reinforcement material in the form of particles with transparent aspect. The morphological analysis of the sand is shown in Figure 3. The sand grains contain in the structure over 90% silica (SiO_2). The glass fibres are made from silica sand, which melts at 1720 ºC.

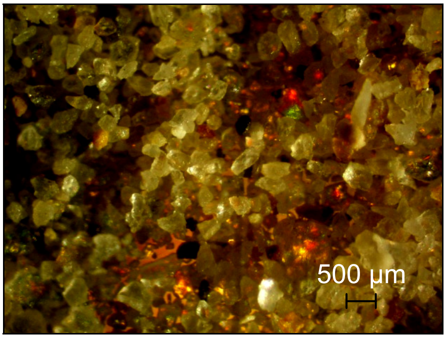

Figure 3. Sand grains

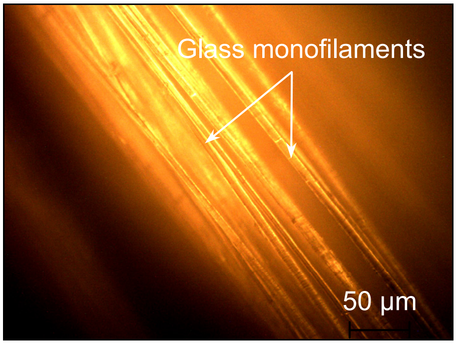

Figure 4. Non-impregnated glass fibre monofilaments

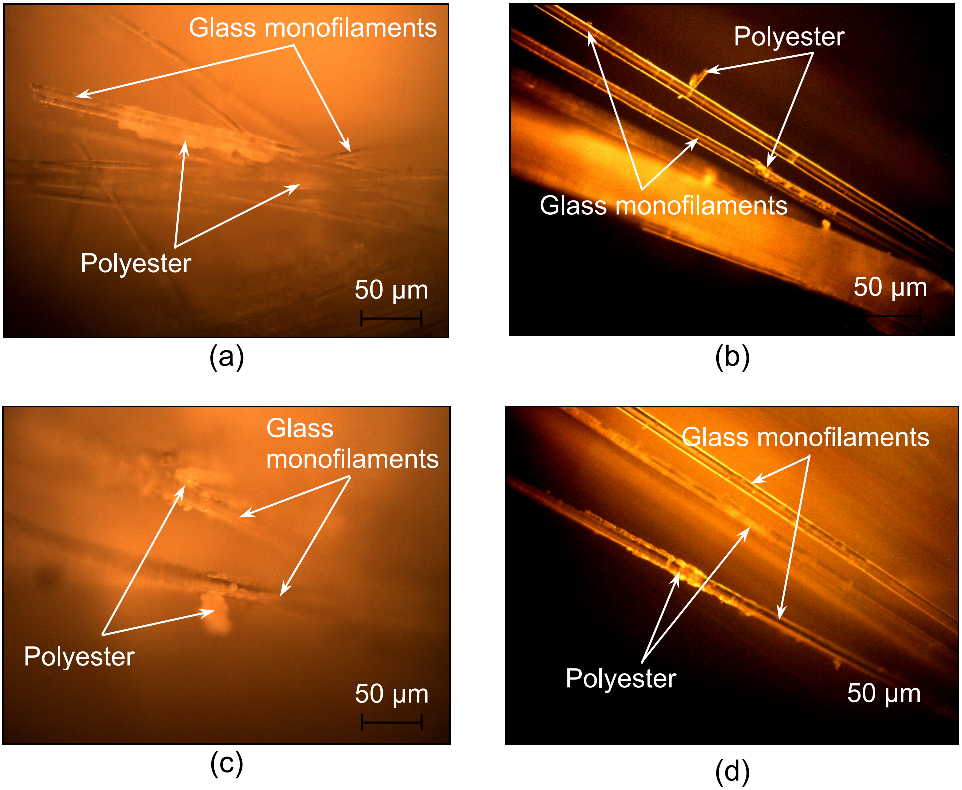

Figure 5. Waste glass fibre monofilaments impregnated with resin.

The non-impregnated glass fibre monofilaments have a glossy and smooth surface, specific to the glass. The glass fibres surface is treated with silane, which favors good adhesion at the interface between fibres and matrix. The non-impregnated glass fibre was also analysed using optical microscopy, cf. Figure 4.

Figure 5 (a-d) illustrates the adhesion between glass fibre monofilaments and polyester resin. The morphological analysis of the fracture area indicates glass fibre monofilaments and sand grains well impregnated with resin, cf. Figure 6. One may nota a good impregnation of the matrix and a good compatibility between filaments, sand and resin.

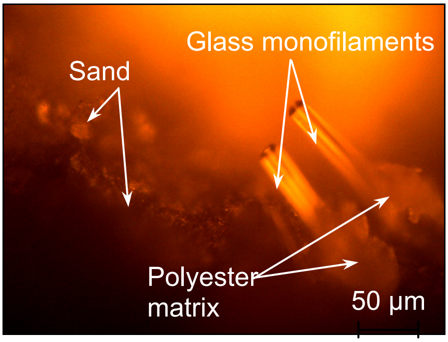

Figure 6. The fracture zone of waste fibre glass/sand/polyester resin plate.

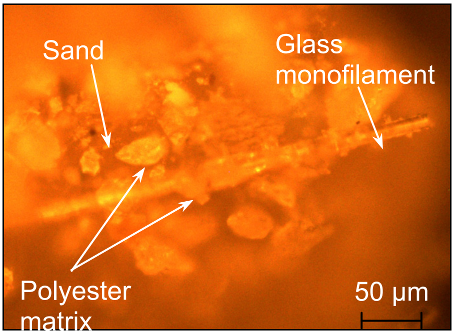

Figure 7. Sand and glass monofilaments in polyester resin.

The particles of polyester resin and sand glued on the glass monofilament indicate that connection between glass fibres, sand and polyester matrix was achieved, cf. Figure 7. One has thus obtained a composite material with high mechanical properties and low density. These materials allow one to reuse waste glass fibre. Using these materials at low temperatures increases their mechanical characteristics.

EDX analysis

Elemental analysis of the waste fibre glass and polyester resin was performed using the energy dispersive x-ray spectroscopy (EDX). Elemental percentages are based on the total weight of the elements detected. Figure 8 shows the elemental EDX analysis of the waste glass fibre, revealing the predominance of silicon and aluminium. Minor amounts of calcium, oxygen, carbon, magnesium and sodium are also detected. Data are expressed as both weight (Wt.%) and atomic per cents (At.%). The weight and the atomic percentages for the contained elements are: Si with 28.19Wt%, 21.12At.%;

Al with 18.50Wt.%, 14.43At.%; Ca with 16.50Wt.%, 8.66At.%; O with 18.34Wt.%, 24.12At.%; C with 17.67Wt.%, 30.96At.%; Mg with 0.43Wt.%, 0.38At.% and Na with 0.37Wt.%, 0.34At.%. Table 1 gives the elements on the surface of a waste glass fibre.

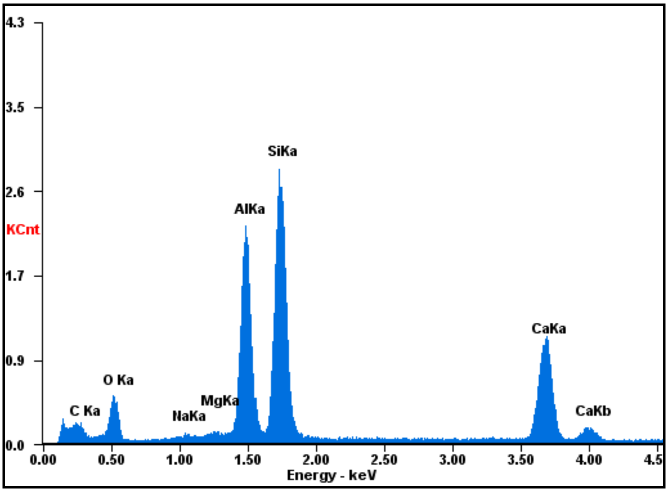

Figure 8. Elemental EDX analysis of the waste glass fibre

Table 1. EDX analysis of the waste glass fibre

Element	*Wt%*	*At%*
C	17.67	30.96
O	18.34	24.12
Na	00.37	00.34
Mg	00.43	00.38
Al	18.50	14.43
Si	28.19	21.12
Ca	16.50	08.66

Figure 9 shows the elemental EDX analysis of the polyester resin. These microanalyses reveal the predominance of carbon, oxygen and silicon. Minor amount of calcium, aluminium and sodium have also been detected. The weight and the atomic percentages for the contained elements of the polyester matrix are: C with 62.18Wt.%, 74.80At.%; O with 17.69Wt.%, 15.97At.%; Si with 9.30Wt.%, 4.78At.%; Ca with 7.98Wt.%, 2.87At.%; Al with 2.39Wt.%, 1.28At.% and Na with 0.47Wt.%, 0.29At.%.

Elemental quantitative analyses presented in Table 2 gives the elements on the surface of polyester matrix.

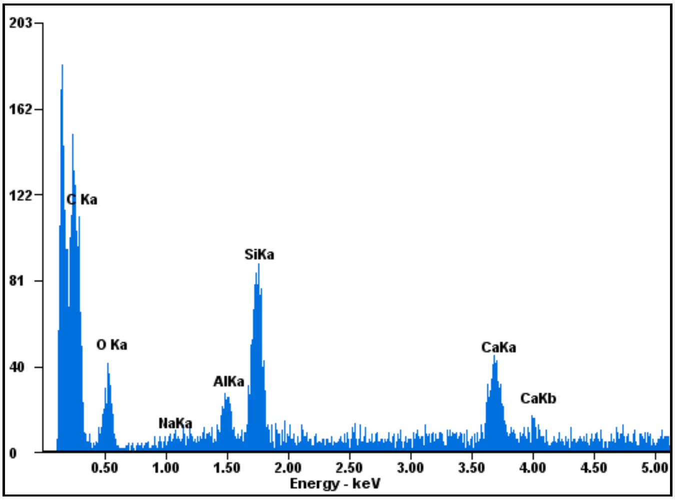

Figure 9. Elemental analysis of the polyester matrix

Table 2. EDX analysis of polyester matrix

Element	***Wt%***	***At%***
C	62.18	74.80
O	17.69	15.97
Na	00.47	00.29
Al	02.39	01.28
Si	09.30	04.78
Ca	07.98	02.87

Table 3 shows data following the compressive stress of cubic specimens, the constituent composite material remains bonded through filaments of reinforcement material.

Table 3. Compressive tests results

No.	Force [KN]	Average force [KN]	Average compressive breaking strength [MPa]	Density [Kg/m^3]
1.	185.8	189.96	78.27	1380
2.	191.2			
3.	193.2			
4.	187.3			
5.	192.3			

CONCLUSIONS

This study characterizes a new composite material obtained from recovered materials, with a complete recovery of waste glass fibres.

The experimental data shows that the new materials have good mechanical properties and they can be successfully used in the dimensioning and verification process of composite structures resistance.

The microstructure of fracture samples from waste glass fibres/sand/ polyester resin composites was microscopically analysed, noting a good impregnation of the matrix and a good compatibility between filaments, sand and resin. The fracture area indicates monofilaments of glass fibre well wetted by the resin.

The new composite material contained crushed waste glass fibre, sand and polyester matrix all mixed together. After polymerization of the resin we obtain a composite material reinforced with glass fibres which has superior mechanical properties. This can be used in various applications such as: polyester reinforced concrete, strengthening composite parts (ornamental composites plates, ornamental garden stones, garden furniture, additive materials and so on).

EXPERIMENTAL SECTION

The materials used in this study are waste glass fibres, polyester resin, sand of 0.3 mm granulation and gel coat. The polyester resin is type Norpol 440-M750 which is ortophthalic with low styrene emission, tixotropized and pre-accelerated. The technical characteristics of the resin are: Brookfield viscosity: 250 - 350 mPa.s; Density at 25 ºC: 1350 kg/m^3; Gel time: 2% MEC (methyl-ethyl-ketone): 8 - 15 min; Exothermic peak: 160 - 190 ºC; Exothermic peak time: 15 - 23 min; Colour: Transparent blue. The gel coat type Norpol is an isophtalic polyester resin designed to have excellent application properties, good mechanical properties, excellent curing properties, easy to sand and repair. The composite material waste, after grinding, was mixed with the sand and polyester matrix. The quantities of components were as follows: 50% sand, 30% waste glass fibre, 15% polyester matrix and 5% gel coat. From this material cubic specimens were made with the dimensions 50x50x50 mm, according to EN 12320-3 standard.

The composite plates that contain in the structure waste glass fibre were prepared by hand lay-up and compression. To determine the mechanical properties of composite plates experimental testing at compressive load was performed.

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