EXPERIMENTAL STUDY ON POLYESTER BASED CONCRETES FILLED WITH GLASS FIBRE REINFORCED PLASTIC RECYCLATES -A CONTRIBUTION TO COMPOSITE MATERIALS SUSTAINABILITY-

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Introduction

The development and applications of thermoset polymeric composites, namely fibre reinforced plastics (FRP), have shifted in the last decades more and more into the mass market [1]. Despite of all advantages associated to FRP based products, the increasing production and consume also lead to an increasing amount of FRP wastes, either end-of-lifecycle products, or scrap and by-products generated by the manufacturing process itself. Whereas thermoplastic FRPs can be easily recycled, by remelting and remoulding, recyclability of thermosetting FRPs constitutes a more difficult task due to cross-linked nature of resin matrix. To date, most of the thermoset based FRP waste is being incinerated or landfilled, leading to negative environmental impacts and supplementary added costs to FRP producers and suppliers. This actual framework is putting increasing pressure on the industry to address the options available for FRP waste management, being an important driver for applied research undertaken cost efficient recycling methods. [1-2]. In spite of this, research on recycling solutions for thermoset composites is still at an elementary stage. Thermal and/or chemical recycling processes, with partial fibre recovering, have been investigated mostly for carbon fibre reinforced plastics (CFRP) due to inherent value of carbon fibre reinforcement; whereas for glass fibre reinforced plastics (GFRP), mechanical recycling, by means of milling and grinding processes, has been considered a more viable recycling method [1-2]. Though, at the moment, few solutions in the reuse of mechanically-recycled GFRP composites into value-added products are being explored.
Aiming filling this gap, in this study, a new waste management solution for thermoset GFRP based products was assessed. The mechanical recycling approach, with reduction of GFRP waste to powdered and fibrous materials was applied, and the potential added value of obtained recyclates was experimentally investigated as raw material for polyester based mortars. The use of a cementless concrete as host material for GFRP recyclates, instead of a conventional Portland cement based concrete, presents an important asset in avoiding the eventual incompatibility problems arisen from alkalis silica reaction between glass fibres and cementious binder matrix. Additionally, due to hermetic nature of resin binder, polymer based concretes present greater ability for incorporating recycled waste products [3].
Under this scope, different GFRP waste admixed polymer mortar (PM) formulations were analyzed varying the size grading and content of GFRP powder and fibre mix waste. Added value of potential recycling solution was assessed by means of flexural and compressive loading capacities of modified mortars with regard to waste-free polymer mortars.

Experimental Program

PM specimens were prepared by mixing an unsaturated polyester resin -Aropol FS3992- (20% w/w), with different sand aggregates/GFRP waste ratios. Siliceous foundry sand, with rather uniform particle size and an average diameter of 245 µm, was used as sand aggregate. Applied GFRP waste material was supplied by a local pultrusion manufacturing company, and it was proceeding from the shredding of the leftovers resultant from the cutting and assembly processes of pultrusion profiles. GFRP waste was further processed by milling on a heavy-duty cutting mill laboratory unit, using bottom sieves with different perforation sizes inside the grinding chamber. Obtained recycled products, hereinafter designated by coarse (CW) and fine (FW) pultrusion wastes are illustrated in Fig. 1.

Fig. 1. Coarse (CW) and fine (FW) pultrusion waste.

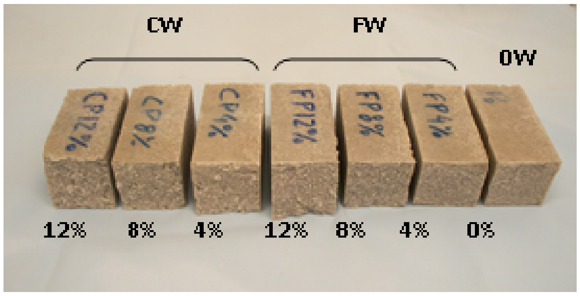

Fig. 2. . Test PM specimens: broken specimens in bending of each formulation in study.

Six different PM formulations were investigated, as shown in Fig. 2, varying the GFRP waste type (CW and FW recyclates) and content (4%, 8% and 12% of total mass). For each formulation, including reference formulation (waste-free PM), six standard prismatic (40x40x160 mm^3) specimens were casted. After curing (24h at 23ºC plus 8h at 80ºC), PM specimens were tested in three-point bending up to failure, and afterwards, each broken piece in bending was tested in compression, following the procedures described, respectively, in RILEM CPT PCM-8 and UNE 83821:1992 test standards.

Results and Main Findings

Mechanical test results, in terms of average flexural and compressive strengths, are presented in Table 1. Relative increase of mechanical properties of GFRP waste admixed mortars over unmodified mortars, can be observed in graphs of Fig. 3, for each type of waste admixture (CW and FW), and accounting for the average global effect of GFRP waste addition (CW/FW).

Table 1. Flexural and compressive test results.

Trial Formulation		Flex. Strength [MPa]	Comp. Strength [MPa]
Reference -0%		25.2 ± 1.3	76.3 ± 3.3
FW	4%	26.2 ± 1.5	78.0 ± 2.7
	8%	27.8 ± 1.6	84.7 ± 1.9
	12%	27.1 ± 1.5	81.0 ± 1.2
CW	4%	27.5 ± 0.6	83.4 ± 2.6
	8%	26.8 ± 1.4	86.2 ± 2.7
	12%	26.2 ± 1.1	82.0 ± 4.3

The partial replacement of sand aggregates by GFRP waste materials has an incremental effect on both flexural and compressive strengths of modified mortars, regardless of the GFRP waste type and content. However, two distinct trends were observed for the effect of waste admixture according to waste addition content: up to 8% content, the turning point value, and above that value.
For the same waste content, coarse GFRP waste admixed mortars present, in general, improved mechanical behavior over PMs modified with fine GFRP waste. Basically, taking into account the distinct geometric characteristics of FW and CW recyclates, (respectively, mainly powdered or fibrous material), it can be stated that whereas FW acts more like a filler extension for sand aggregates of modified mortars, leading to a less void-volume of resultant material; CW acts mainly as reinforcing material, conducting to improved mechanical strength and less brittle material.

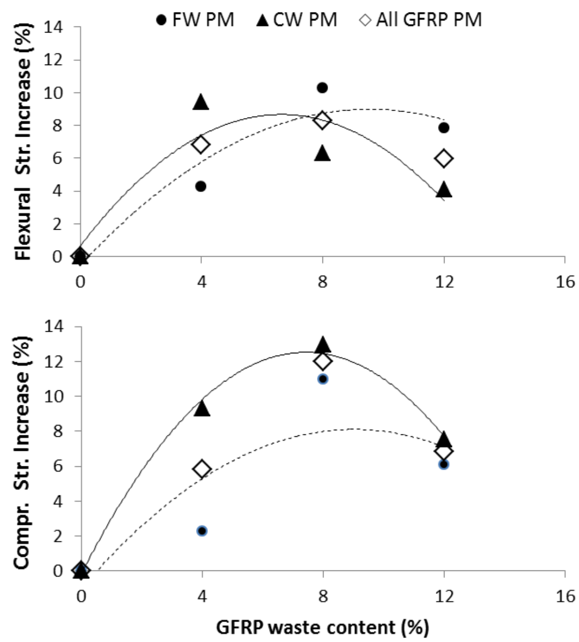

Fig. 3. Relative flexural and compressive strength increases of GFRP waste admixed mortars over plain mortars –Trend curves-.

The key findings of this study showed a viable technological option for improving the quality of polyester based mortars, and highlight a potential cost-effective waste management solution for thermoset composite materials in the production of sustainable concrete-polymer based products.

Ackowledgements

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