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Mortar with pet—Preliminary results

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Abstract

The objective of this work is to evaluate the performance and feasibility of the use of coating mortars with the incorporation of ground polyethylene terephthalate (PET) waste.

It was studied the performance of 1: 4 mortars in weight with partial replacement of the aggregate by PET residuals in different percentages (0%, 5% and 10%).

Obtained results showed a decrease of the mechanical resistance of mortars in the inverse proportion of the use of PET residues of the mixture, an increase in resistance to water absorption by capillary action and a decrease in thermal conductivity.

These results support the potential use of PET waste in coating mortars, thereby contributing to reduce the environmental impact caused by plastic waste. However, in order to be considered energy efficient, this new material needs further improvements.

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Keywords: Mortars; PET waste; Plastic aggregates and thermal conductivity

1. Introduction

Sustainability in construction industry and circular economy are a concern of the vast majority of countries.

Currently, the scarce disposal of plastic waste is a concern in all countries and, in the case of non-biodegradable waste, its non-reuse increases the concern as it contributes to its accumulation in landfills or its spread in the oceans. On the other hand, the construction sector is one of the main responsible for the consumption of extracted natural resources.

Thus, and, aware of the importance of the environmental issue strongly linked to waste management, solutions that could promote reduction, reuse, recovery and recycling of materials and energy, new applications for plastic waste in the production of mortars and concrete for construction have been investigated.

The main objective of the present work is to evaluate the performance and feasibility of the use of coating mortars with the incorporation of ground polyethylene terephthalate (PET) waste and to conclude about the usefulness of this solution regarding the urgent reduction of environmental impact caused by plastic waste.

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In the last two decades, several studies have been carried out by several authors with the aim of analyzing the feasibility of using PET waste as a partial substitute for sand in mortars at different replacement rates, with traces in weight ranging from 1:2 to 1:4.

Mortars with PET main properties were investigated by some researchers. In terms of workability, the higher the percentage of aggregate replacement per PET the higher the scattering diameter [1–3]. In relation to density in the fresh state, it was reported that it decreases with the increase of PET, due to the lower density of the PET [1,2,4–7]. As for compressive strength, regardless of the percentage of substitution of natural aggregate by PET, a decrease in the compressive strength occurs [4,5]. The modulus of elasticity decreases as the substitution rate increases [5,8]. The lower the density the greater the water absorption by capillarity [3,7,8]. Finally, the addition of PET reduces the thermal conductivity of mortars [9–11].

2. Experimental program

The tests carried out in this experimental work have as objectives the identification of the PET residues and the characterization of mortars in the fresh and in the hardened states.

Mortars were produced with partial replacement of sand by PET and a non-PET control mortar (CA) was performed. For each mortar the following properties were evaluated: workability; bulk density in the hardened state; resistance to bending and compression; water absorption by capillarity and thermal conductivity.

2.1. Characterization of sand and PET

The PET waste used were supplied by DANIEL MORAIS S.A., having an irregular and angular shape (Fig. 1(a)) but due to display 45% of its diameter larger than 4 mm had to be ground with the aid of a blade mill until reaching a particle size similar to sand (Figs. 1(b) and 2), presenting a bulk density 320 kg/m^3. Sand was supplied by EUROMODAL S.A., whose bulk density of 1585 kg/m^3 and granulometry is shown in Fig. 2.

a b

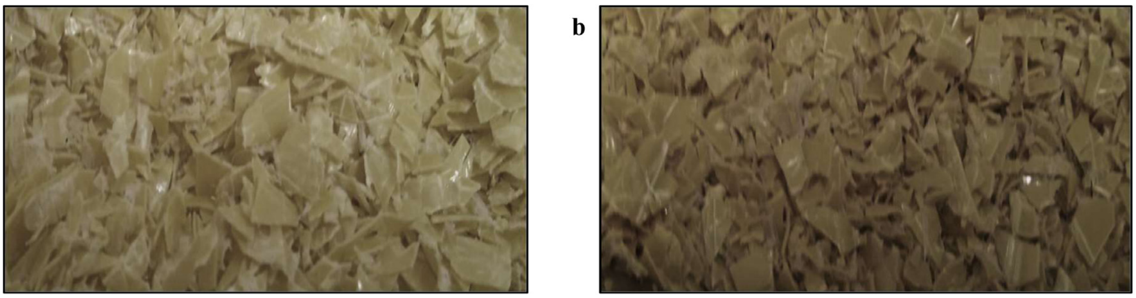

Fig. 1. (a) Pet with D $\geq$ 5.6 mm; (b) Pet ground with D $\leq$ 4.0 mm picture.

2.2. Mortar production

The mortars were prepared according to NP EN 196–1, with the dash by weight of 1:4, made with partial sand replacement of 0%, 5%, 10%, labeled as AC, A5P, A10P. An additional mortar was prepared as delivered by the company, labeled as A5PG, containing PET particles larger than 4 mm. The binder applied was Portland cement CEM I 42.5 R according to standard NP EN 197–1 supplied by the company SECIL S.A., with a density of 3.11 g/cm^3. No adjuvant was used (Table 1). The workability was measured by spreading table test according to procedures described in standard EN 1015–3.

2.3. Results and discussion

For each type of mortar, standard prismatic specimens (40 × 40 × 160 mm) and square plates with 250 mm of edge and 40 mm thickness were made according to the tests to be performed. Flexural strength and compression

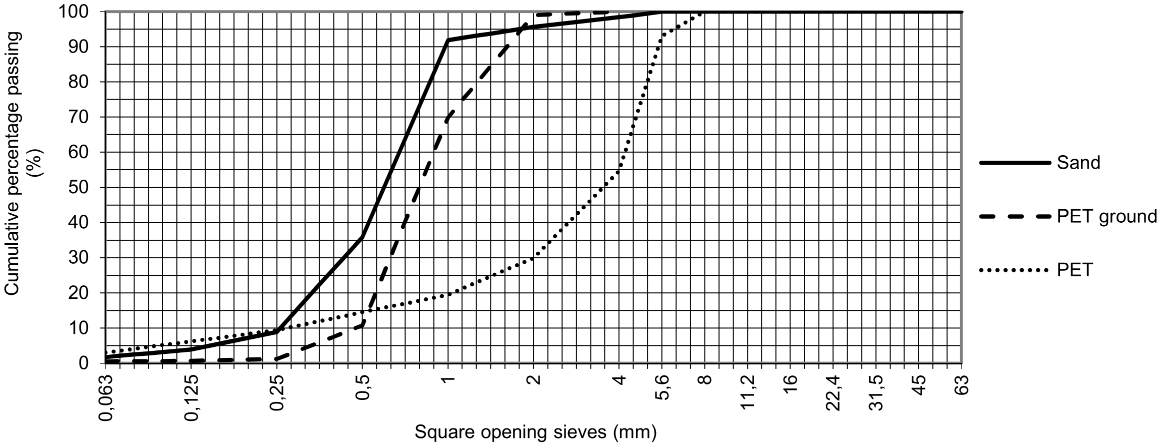

Fig. 2. Granulometric results for sand and PET waste.

Table 1. Composition of mortars.

Mortars	AC	A5P	A10P	A5PG
Cement (g)	400	400	400	400
Sand (g)	1600	1520	1440	1520
PET ground (g)	0	80	160	0
PET (g)	0	0	0	80
Water (ml)	300	300	300	300

tests were also performed according to EN 1015–11. As for absorption by capillary, the wicking surface on mortar was evaluated according to the procedures described in the RILEM recommendation TC116 - PCD and EN 1015–18 (2002). The thermal conductivity coefficient was determined using a PHYWE thermal insulation chamber, whose walls were replaceable, a heat source in the interior of the chamber and a set of EasyLog USB thermocouples with amplitude from −30 °C to 100 °C, to record the differences in surface temperature inside and outside the specimens. The results obtained are shown in Table 2.

Table 2. Results of Properties determined in control mortar (AC) and mortars with 5% and 10% sand replacement by PET, as well as the percentage improvement of each property of each mortar with PET in relation to the control mortar (AC).

Property	AC	A5P	A10P	A5PG
Spreading diameter, d, [mm]	184	170	174	150
Percentage improvement in the spreading diameter, d, [%]	0	−8	−5	−18
density, ρ [kg/m^3]	1703	1435	1159	1618
Percentage improvement of the density, ρ, [%]	0	−16	−32	−5
Flexural strength, σf28d, [MPa]	6,16	4,78	3,73	3,64
Compressive strength, σc28d, [MPa]	30	20	16	33,1
Percentage improvement of σf28d [%]	0	−22	−39	−41
Percentage improvement of σc28d [%]	0	−33	−47	10
Absorption coefficient, S, [mg/[mm$^2 \times \sqrt{\text{min}}$]]	0,442	0,418	0,472	0,023
Percent improvement of absorption coefficients, S, [%]	0	5	−7	95
Coefficient of thermal conductivity, λ [W/[m °C]]	0,571	0,242	0,312	0,526
Percentual improvement of thermal conductivity, λ, [%]	0	57	45	8

Compressive strength and flexural strength decrease with increased litter replacement rate for PET, however in the mortar with 5% PET ground (A5PG) there is a 10% increase in resistance to compression. Moreover, during the test flexion observed that the specimens containing PET is not completely smashed, remaining attached by plastic particles, and test compression, in turn, it was noted that PET particles do not adhere to cementations slurry. This behavior may be due to the hydrophobic characteristics of the plastic.

The greater the surface temperature difference between the inside and the outside, the lower the thermal conductivity coefficient and the greater the insulation capacity of the study material

According to the results achieved, the grinding PET residue afforded an increased thermal insulation of A5P and A10P mortar.

2.4. Conclusions

PET containing mortars have different properties than cementitious matrix mortars. In this investigation, the properties and thermal performance of composite mortar composites with PET addition performed better than cement mortars. However, this decrease in thermal conductivity of the sample tends to get worse as the percentage of PET increases, verifying that the best value rushes to the lowest percentage of PET and with diameter less than 4 mm. In fact, the percentual improvement of thermal conductivity, has increased up to 57% in mortars with sand replacement by PET. According to these results, we conclude that the reuse of PET waste into new composite mortars could contribute to reducing the negative environmental impact caused by plastic waste. However, in order to be considered energy efficient, this new material needs further improvements.

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