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Abstract 43

REUSE OF LOW-GRADE PLASTIC PACKAGING AS FIBROUS REINFORCEMENT IN CEMENTITIOUS MATERIALS

Academic paper

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Abstract text:
Purpose
In recent years, the use of virgin and recycled plastic macro-fibres as integration in construction and building materials has gained increasing attention from researchers. In particular, recycled fibres have become more attractive due to their large-scale availability, low cost, and sustainability. In this work, we investigate the potential benefits related to the use of recycled plastic macro-fibres, which include blends of polyolefins [1] with good recycling capabilities, obtained from processing disposed plastic food packaging. They are employed as the reinforcement phase in viable and performing Fibre Reinforced Concrete (FRC) [2]. We assess both the mechanical performance and the post-crack behaviour by testing composite prismatic beams in bending, thus establishing a range of possible environment-friendly applications in the field of constructions, and specifically as industrial pavements [3-4].
Originality and value
Plastic pollution has become one of the most alarming environmental issues, strictly related to the increasing production of disposable single-use plastic products. At the same time, the great demand for building materials gives rise to the need of improving the viability in the construction industry. In this work, we try to address both problems by investigating innovative construction materials manufactured by incorporating plastic debris no longer exploitable for the pristine intended use, meeting the requirements of the Circular Economy approach. More specifically, we assess the performance of FRC including fully recycled and partially recycled plastic macro-fibres from low-grade food packaging, with the main goals of establishing novel sustainable applications in the civil engineering field.
Design and methodology
We analyse the mechanical response of cementitious conglomerates reinforced with randomly dispersed plastic macro-fibres consisting of blends of polyethylene (PE) and polyethylene terephthalate (PET). These polymeric mixtures are retrieved from processing disposed food packaging, then milled, and eventually extruded as cylindrical-shaped draw-wired filaments (diameter: 0.7 mm). More specifically, the performance of FRC including PE-PET fully recycled fibres (referred to as RP) are compared with those of conglomerates reinforced with both virgin polypropylene (PP) and partially recycled PE-PET-PP fibres (referred to as RP-PP).
Mechanical characterisation of the FRC beams is performed according to the UNI 1015:2007 [5] methods, intended for cement and lime hardened mortars for structural purposes. 40mm x 40mm x 160mm prismatic beams reinforced with 1-cm-long fibres are manufactured by following the procedure hereafter summarised.
First, by means of a low speed mechanical stirrer, a fixed amount of fibres is homogeneously incorporated and dispersed in a commercially available pre-mixed ordinary Portland cementitious (OPC) mortar. Then, the binder+aggregates powder is properly hydrated. The fresh mortar is further stirred, cast into accurately lubricated formworks, and then thoroughly vibrated to prevent the stagnation of air bubbles. The specimens are then covered with tight PP foils (7 days at 100\% RH) and finally left to cure in climatic chamber (21 days at 20° and 70\% RH), until complete hardening.

We perform mid-span displacement-controlled bending tests (load cell 30 kN- displacement rate 1 mm/min) by means of an Instron 5567 universal testing machine (UTM).

Results and findings

We compare the mechanical performance of each specimen in terms of stress-strain curves, as illustrated in Fig.1(a). More specifically, we discuss the results by focusing on the measured ultimate load and the energy dissipated at failure. The last quantity is computed as the area under each strength curve. The presence of fully recycled (RP) and partially recycled (RP-PP) fibres within the cementitious matrix does not affect the ultimate load, whose value remains close to the reference curve (PP) for both groups. Therefore, the resisting matrix cross-section is not affected by the discontinuities between the matrix and the reinforcement fibres. On the other hand, the energy dissipated at failure reduces in both RP and RP-PP curves, with a more significant decrease for RP-PP specimen, as reported in Fig.1(b).

This trend may be ascribed to the better crack-bridging effect deployed by the virgin fibres, which exhibit a remarkable axial and bending stiffness. Consequently, the post-peak branch for PP samples is more pronounced, with an initial hardening phenomenon [6].

Limitation and implication

The preliminary analyses here illustrated show that PE-PET recycled fibres included in cementitious composites represent a promising opportunity to provide recycled plastic with a new life, with several innovative applications in the civil engineering field. Indeed, the mechanical response is comparable to the one of the well-established FRC technique with virgin PP macro-fibres. This experimental activity paves the way to further investigations aimed at filling the performance gap currently existing between recycled and virgin reinforcements.

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