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Abstract

Development and Characterization of Composite Mortar from Non-Metallic Fractions Recovered from Printed Circuit Boards under Thermal Fatigue †

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Concrete is undoubtedly one of the best-known composites in the world. However, there is constant search for materials that can replace the natural materials used in its production. The consumption of materials to manufacture concrete are becoming scarce. Therefore, opportunities arise to recycle or reuse materials, for example, electronic waste. According to the UN's Global E-waste Monitor 2020, a record 53.6 million metric tonnes (Mt) of electronic waste was generated worldwide in 2019, up 21 per cent in just five years. Despite this, only 17.4 per cent of 2019's e-waste was collected and recycled.

Electrical and electronic equipment (EEE) includes a wide range of commercial products, such as electrical circuits or components, for example, cell phones, laptops, PCs, and others. The huge quantity of waste from electrical and electronic equipment (WEEE) or electronic waste (e-waste) now produced creates opportunities to reuse some components for other purposes. Such waste can also be used as secondary materials or raw materials.

In this study, non-metallic fractions recycled from waste printed circuit boards (WPCBs) were used to modify the mechanical properties as well as superficial or morphological characteristics of fillers in cement.

The development of lightweight construction materials with good mechanical properties can reduce the dead weight of current structures, reducing transport and erection costs, especially when prefabricated structural components are made in the factory. Meanwhile, the use of lightweight aggregates is one of the best-known ways to make lightweight building materials. However, the use of only lightweight concrete is not a definitive solution because of temperature differences between countries and different months of the year. Frost damage can be assessed by subjecting concrete specimens to freeze-thaw cycles.

When thawing occurs, water enters the pores of concrete and can cause its disintegration. This effect occurs due to an increase in water within the concrete and the action of freezing and thaw cycles within the concrete, resulting in its area expansion and cracks. Thus, there are two factors that affect concrete damage due to the freeze-thaw action. One is temperatures below zero and the other is the number of freeze-thaw cycles. To solve this problem, many studies have been undertaken to simulate freeze-thaw cycles in the context of different concrete formulations, materials, and parameters. Additionally, in other studies [1–3], polymeric resins were used in formulations and, as a result, better results in terms of freeze-thaw cycles were obtained. Perhaps the greatest advantage of such polymeric concretes is the reduction in porosity, with a consequent reduction in free paths for crack propagation and an increase in the final mechanical strength.

Different formulations were tested in polymeric concretes under severe conditions, i.e., exposure to freeze-thaw cycles. Mechanical properties tests (flexural strength, compression strength, stiffness, and impact properties) were also carried out, as were water absorption ratio measurements. Such efforts to accelerate the deterioration of polymer cements and mortars and characterize their best formulations and performance is common in the evaluation of the durability and service life of construction materials. The recycling process for non-metallic fractions was established during previous stages by Sousa et al. in 2022 [4]. The recovered fibers in question are a coarse aggregate approximately 1.52:0.81:0.48 mm in size. To evaluate the effect of the size of the aggregate, the recovered fibers were turned into a fine aggregate.

The goal of this work was an optimized route for the processing of polymer mortars with non-metallic waste from WPCBs and the definition of an optimized methodology for their long-term characterization and the testing of three different formulations in terms of flexural, compression, and impact strength, and thermal fatigue.

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