FIBER-REINFORCED POLYMER CONCRETE: MECHANICAL IMPROVEMENT BY GAMMA RADIATION

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Introduction

Polymer concrete (PC) is a particulate composite where thermoset resins binds inorganic aggregates instead of the water and cement binder typically used in Portland cement concrete (PCC). We thus have a polymeric matrix and dispersed particles of strengthening phases. Polyesters or epoxy resins have been used for the purpose, with polyester resins the most common due to low prices and corrosion resistance [1, 2]. PC shows a longer maintenance-free service life than PCC, because of this durability and physical properties superior to those of PCC, fast setting times (curing within 1 or 2 h) and low permeability. Moreover, improved mechanical strength (compressive and flexure) and chemical resistance are also advantages of PC in comparison to ordinary PCC.

It well known that the gamma radiation causes structural modifications of polymers via three main processes: scission, crosslinking and grafting of chains involving generation of free radicals [3, 4].

In polyester resins irradiated with gamma rays there is a monotonous increment in the conversion percentage up to about 8 kGy. At this stage a gel fraction and the styrene monomer are present. Although the glass-rubber transition is below the reaction temperature up to doses of about 8 kGy, the samples behave as fairly elastic gels from about 3 kGy. Moreover, there is no significant difference in thermal decomposition for both kind of resin (un- or irradiated) at higher decomposition temperatures, up to 500 ^{o}C.

We expect that the ionizing energy can improve compatibility between polyester resin (matrix) and the $CaCO_3$ and silica sand (aggregates) by means of the structural and surface modification of both components. Thus improvement of the mechanical properties of PC can be obtained.

In this work we report on gamma radiation effects on Polyester-PC systems, focusing on the mechanical improvement. On this basis, we propose a novel technology for manufacturing polymer concrete, at different than of costly and time consuming current procedures such as chemical attack or thermal treatment.

Experimental

For preparing the polymer concrete specimens, silica sand and calcium carbonate was used, as well as a commercial unsaturated pre-accelerated polyester resin (orthophtalic). Moreover, polyester fibers were added; whose diameters vary from 30 to 40 µm and 20 mm of average length. Five different polymer concrete lots identified by A, B, C, D, and E were prepared, each one a different day.

The polymer concrete was exposed to varying gamma radiation doses using a ^{60}Co source. The experiments were performed in air at the room temperature; the dosages were 5, 10, 50 and 100 kGy at the dose rate of 2.48 kGy/h.

The compressive tests of the polymer concrete cubic specimens were carried out in a Universal Testing Machine (Controls^{TM}).

Results and Discussion

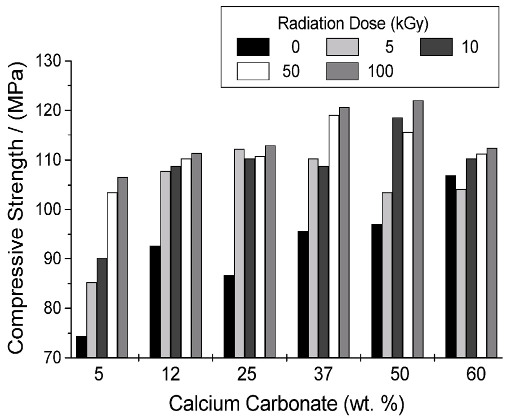

Fig. 1 Compressive strength of PCs for a number of $CaCO_3$ concentrations

In Figure 1 we see that for non-irradiated PC the compressive strength values increase with increasing $CaCO_3$ concentration, namely from 74 to 107 MPa. For irradiated PCs, show values varying from 85 to 122 MPa; the highest value of 122 MPa is achieved for PC containing 50 wt. % of $CaCO_3$ and irradiated at 100 kGy. This result constitutes an improvement of 63.9 % with respect to the minimum value obtained for non-irradiated PC with 5 % of $CaCO_3$.

We find in Figure 2 that the compressive strength values are lower than for PCs without fibers. Nevertheless, all values for the fiber-containing PCs are higher than those reported in the literature for standard polyester-based PC (80 MPa) [5]. For 0.1 vol. % of fiber, the compressive strength values increase along with increasing applied radiation dose. For 0.3 and 0.5 %, three well-defined stages are seen.

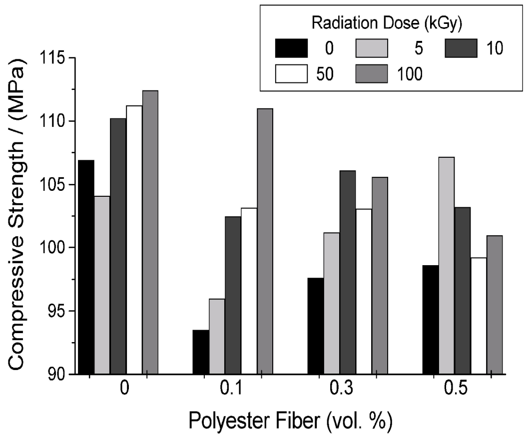

Fig. 2 Compressive strength of fiber-reinforced PCs with varying polyester fiber concentrations.

Changes on surfaces of irradiated polyester fibers were observed by SEM (Figure 3). For non-irradiated fibers smooth and homogeneous surfaces are seen (Figure 3a). For 10 kGy several "particles" are observed on the fiber surface (Figure 3b); they contribute to improvement of compressive strength values by increasing the interface areas. At the high dose of 100 kGy SEM reveals more particles (Figure 3c), and thus more improvement of the compressive strength seen above in Figure 2.

Conclusion

As expected, mechanical features depend on two mean parameters: the component concentrations ($CaCO_3$, silica sand and polyester fibers) and the applied dose.

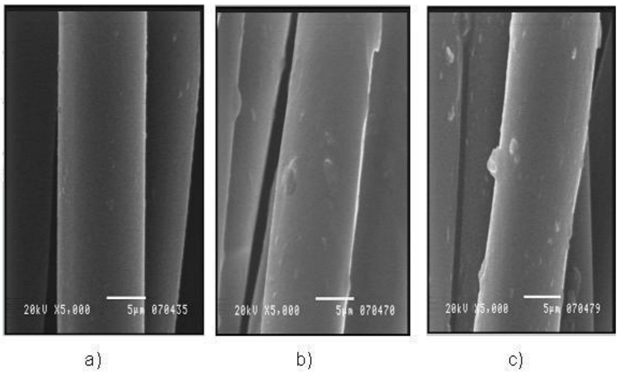

Fig. 3 SEM Micrographs of polyester fibers: non-irradiated (a), irradiated at 10 kGy (b), and irradiated at 100 kGy (c).

Acknowledgements

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