

COMMERCIAL AND WASTE CARBON BASED NANO/MICRO FILLERS FOR THE DEVELOPMENT OF INNOVATIVE AND MULTIFUNCTIONAL MORTARS

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Introduction: Recently, the introduction of fillers/nanofillers in the formulation of mortars has gained a growing interest due to an increase in the mechanical performance and durability, with consequent reduction of maintenance costs, thanks to a microstructure refinement.

In particular, carbon-based fillers, thanks to their high electrical conductivity, can improve also the electromagnetic shielding effectiveness of mortars and concretes.

However, carbon based commercial fillers, such as carbon nanotubes, graphene and its oxides, are very expensive. Therefore in this work, for the benefit of the process sustainability, the effect of the addition of commercial carbon-based fillers on the mechanical performances and electrical conductivity of a binder paste, was compared with that of carbonaceous fillers with zero embodied energy, obtained from different industrial by-products.

Materials and Methods: Pastes were manufactured with hydraulic lime (NHL 5) at water/binder ratio equal to 0.32 by weight (stiff consistency), a naphthalene sulphonate based superplasticizer (SP) (1% by binder weight) and different amount of carbon based fillers (0.25%, 0.50% and 1.00% on binder weight). As commercial fillers, graphene nanoplatelet (GNP) (thick = 7 nm, width < 5 μm) and activated carbon (AC) (mean particle size = 20 μm) were used. As waste carbon based fillers, char (CH) and the finer fraction of a used foundry sand (FS) (particle size < 75 μm for both) were used. CH and FS particles are industrial by-products obtained by biomasses gasification and ferrous and non-ferrous metal casting industries, respectively. As a reference, a paste without filler addition (R) was manufactured.

Water was previously mixed with SP, then fillers were added and dispersed with an ultrasonic sonicator for 10 minutes until lime addition. The obtained paste was poured in different molds and cured at 20 °C and RH = 100% for 7 days, then at RH = 50% until testing.

Specimens were subjected to compression and tensile splitting tests at 2, 7 and 28 days of curing. Electrical resistivity was determined by electrochemical impedance measurements through two AISI 316 electrodes at 7, 14, 21 and 28 days of curing.

Results: At 28 days of curing, R tensile strength was 0.82 MPa; 1% of GNP enhanced it of 40% but also with the less expensive AC it increased of 25%. The other additions do not affect significantly the results.

Under compression, not only GNP but also all other additions improved mechanical behavior of about 30% with respect to the reference (11MPa), regardless of the type and amount of filler.

During time, the electrical resistivity of pastes increased, becoming extremely high for R (over $2 \cdot 10^4 \Omega \cdot \text{cm}$). However, all additions decreased it: GNP and AC of about 55% and 50%, respectively, but CH and FS at 1% of about 65%.

Discussion: Based on these preliminary experimental results, it can be said that the investigated waste carbon based fillers, highly cost effective with respect to commercial carbonaceous fillers as graphene, can comparably enhance the mechanical properties and electrical conductivity. These preliminary data are encouraging in developing mixtures to be tested also in terms of electromagnetic shielding effectiveness.