Effect of the Oxygen Content of Graphene on the Mechanical Properties of Cement-Based Composites.

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Recent research indicates the possibility of using nanomaterials (carbon nanotube, graphene, titanium oxide, nanosilica, and nanoalumina) in civil infrastructure applications; however, costly process and low production of such materials may limit such applications [1]. Introduction of nanomaterials in cement paste reduces the porosity and rate of hydration leading to the development of stronger and more durable products [2]. The high surface area of these materials makes them efficient in controlling the propagation of microcracks in cementitious composite materials. It is demonstrated that graphene and graphene oxide may reduce the brittleness and enhance toughness, tensile and flexural strength of the hydrated cement composite [2].
An improvement of the properties of cement can be achieved only if the graphene is well dispersed in the matrix. Thus, it becomes necessary to disperse graphene in the water used for the preparation of the cement. The dispersion plays a key role in standardizing the properties of graphene-based composites, and has been extensively studied [3,4]. However, in most of the cases graphene is dispersed through the use of an organic surfactant which can create problems at the level of the interface between cement and graphene. Graphene oxide (GO), which have many polar groups on the surface, does not require the surfactant to obtain a good dispersion and also presents a higher interaction with the cement matrix. Indeed, a polar surface improves both the dispersion in water and the interaction between cement and graphene, leading theoretically to better mechanical properties.

In this study, we examine the effect on the mechanical properties of the chemical interaction at the interface between cement and graphene/graphene oxide. This aspect is often underestimated, but the level of chemical compatibility of the graphene surface with the cement can have a significant effect on the mechanical behaviour of the material. Greater interaction with the cementitious matrix creates better adhesion with the cement, and this reflects in improved modulus of rupture. Lower interaction instead causes generally an improvement in toughness.
The prepared cement-based composite were characterized by three-point flexural tests in crack-mouth opening displacement mode. In Figure 1 the case of graphene nanoplatelets (GNPs) is shown. In this case, the surface is almost completely apolar, and the strength is not significantly improved, while a significant enhancement of toughness in function of the GNPs content is evident.

References

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The toughness enhancement can be better observed by separating the first crack toughness and the total toughness contributions, as shown in Fig. 2. It is evident that the first crack toughness increases by up to 50%, showing an effect of the GNPs even in the crack initiation phase. However, since the chemical interaction of GNPs with the matrix is low, most of the toughening effect is observed in the phase after the first crack. The total toughness was in fact more than doubled with a 0.2% GNP content in the cement.

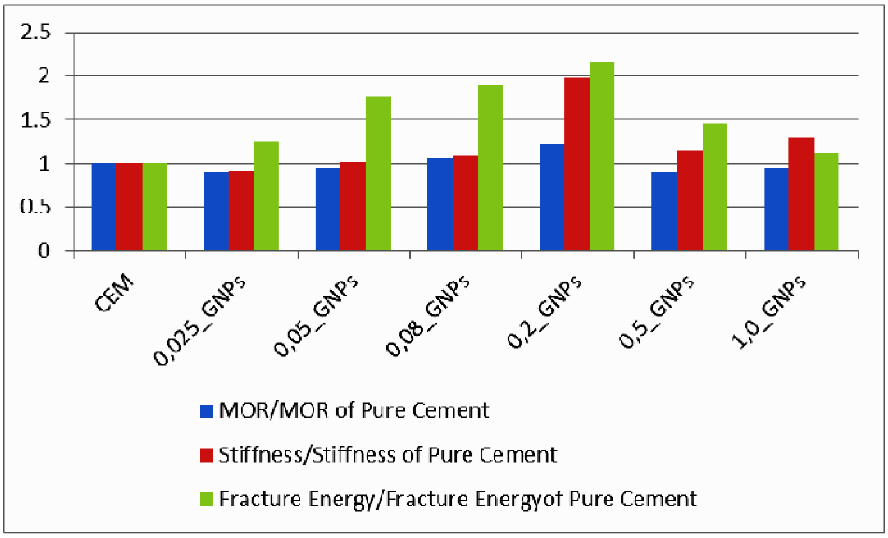

Figure 1: MOR, stiffness and fracture energy of cement with different GNPs percentages.

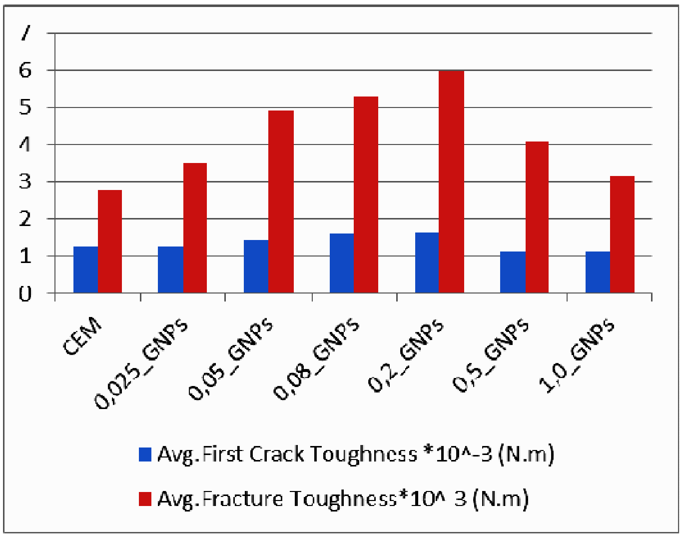

Figure 2: Toughness of cement with different percentages of GNPs.