Local confinement effects in concrete made with EAF slag aggregates

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ABSTRACT

The reuse of Black/Oxidizing Electric Arc Furnace slag (EAF) as coarse aggregate in concrete production is already a sustainable alternative for many countries, with applications in the construction of dikes, reefs and sea walls, in the ground improvement of port and harbour construction, in bank reinforcement, but also for railroad and road applications, thanks to the superior binder adhesion and a high frictional and abrasion resistance of these aggregates, as well as their stable chemical composition and the possibility to reach high strength, maintaining relatively high water/cement ratio [1].

Concrete made with EAF is nowadays a fully characterized material [2, 3]; this work deals with the numerical modelling of this composite at a mesoscale. The novelty of the study stands on the strict comparison between the numerical results and the experimental results from uniaxial tests on companion cubic specimens made of 100% EAF aggregates, with exactly the same aggregate shape and distribution; the study is expected to go towards a full predictability of the mechanical behaviour of concrete made with EAF at any given percentage in the mix design.

The exact reproduction of the solid model out of the real tested sample is made with the aid of industrial computed tomography (CT); the mechanical behaviour of the solid model has been studied numerically with an original FEM model where the cement matrix is characterized as an elastic-plastic material with damage capabilities, calibrated on real homogeneous samples made of pure cement matrix, and the aggregates are conceived to behave elastically, with high-strength characteristics proper of steel slags. In particular, the model catches the local confinement on the cement paste, due to aggregates of different stiffness with respect to the surrounding matrix, under compression loads. The local confinement effect may vary considerably within the concrete sample and it is related to the relative distance between the aggregates, their stiffness with respect to the cement paste and their dimensions. The implemented damage-plasticity model [4] consists in the combination of a non-associated plasticity model [5-6], where the yield surface is described in function of the second and the third deviatoric invariant of the stress tensor, J_2 and J_3, and the scalar isotropic damage model by Mazars [7], and it is formulated in compliance with the plasto-damage combination theory.

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