Alkali-activated electric arc furnace slag as a concrete binder and aggregate

Summary

The objective of this PhD is to ascertain the potential of using electric arc furnace slag (EAFS) to fully replace cement and/or aggregates in the production of alkali-activated concrete. The EAFS used is a by-product of steel manufacturing and provided by HARSCO from the beneficiated output at Siderurgia Nacional, Portugal. Given its extensive particle size distribution, milling and sieving will be required to obtain cement-like sized powder before it can be used in the alkali activation process. The work plan will be divided into four main stages. The first stage will include the optimization of the alkaline activator in EAFS mortars. In this stage, mortar mixes will be produced by varying the concentration of alkaline activator based on sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). Optimization of the alkali activator (i.e. Na_2O/binder and SiO_2/Na_2O ratios) will be based on the maximized mechanical performance of the alkali-activated EAFS mortars.

In the second stage, using the optimum concentration from the previous campaign, the EAFS will then be used as a binder for concrete production. Some of the mixes will contain unprocessed EAFS as complete aggregate replacement. The tests performed on the alkali-activated EAFS concrete specimens will include: slump; air content; fresh state density; hardened state density; ultrasound; splitting tensile strength; compressive strength; water absorption by immersion; water absorption by capillary action; creep; shrinkage; chloride ion penetration; and resistance to carbonation.

The objective of the third stage will be to evaluate the performance enhancement of concrete specimens exposed to a CO_2-rich environment, using an optimum concentration from previous stages. Variations based on CO_2 concentration and pressure will be tried. The analysis of the specimens, apart from their mechanical and durability-related performances, will also be based on the changes to the mineralogy and internal morphology using thermogravimetric, nuclear magnetic resonance, scanning electron microscopy and X-ray diffraction analyses.

Finally, a life cycle assessment of the raw materials is also expected at a later stage as the complete replacement of cement and/or aggregates with alkali-activated aluminosilicate wastes may translate into significant reductions in cost and environmental impacts, especially with the incorporation of a forced carbon curing stage using industrial CO_2-rich flue gases.

Keywords

Mortar, concrete, alkali-activated materials, electric arc furnace slag, binder, aggregate, life cycle assessment, sodium hydroxide, sodium silicate, carbonation.

Electric arc furnace slag (EAFS).

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