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# Durability Studies of Self-Compacting Concrete containing Electric Arc-Furnace Slag Aggregate

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## 1 Introduction

The steelmaking industry is of great importance to the global economy. There are different types of furnaces for manufacturing steel. Each type of furnace will generate a different type of residue. In the electric arc-furnace procedure, Ladle Furnace Slag (LFS) and Electric Arc Furnace Slag (EAFS) are generated. Various possible uses for those by-products have been analyzed. The use of EAFS in hydraulic mixes has been widely studied.

The result obtained from various studies show that EAFS aggregate is a reliable material, both in terms of its mechanical behavior and durability (Arribas, Vegas, San-José, and Manso, 2014; Faleschini *et al*,. 2015).

One of the disadvantages that has been found is the poorer workability of the concrete mixes manufactured with this type of aggregate. In this study, the feasibility of the correct design of self-compacting concrete mixes containing EAFS as aggregate is demonstrated. Its mechanical behavior, internal structure and durability is evaluated, paying special attention to the durability of EAFS self-compacting concrete samples in highly saline marine environments.

## 2 Mixes

Three different mixes were designed with this purpose:

- A reference mix, labeled NATI, (Portland cement type I and limestone aggregates)
- A mix labeled EAFSI, in which Portland cement-type I was used, the EAFS was used in partial substitution by volume of the limestone aggregates.. The higher density and the rougher surface of the EAFS particles require higher proportions of fines, to manufacture mixes with this type of aggregate (Santamaría *et al*., 2017).
- An EAFSIV mix, with exactly the same design as the EAFSI mix, except that Portland cement-type IV, rather than Portland cement type I, was used.

## 3 Results

All the mixes met the requirement for self-compacting mixes.

As may be expected from the results of previous works, the density of the mixes manufactured with EAFS slag was higher, due to the higher density of the slag particles.

Concrete strength was tested at 7, 28, 90 and 180 days. The strength of mix EAFSI was quite high when compared with the reference mix. The mix manufactured with cement-type IV had the lowest strength, as was expected. At 180 days the difference in strength between the mixes manufactured with cement type I and EAFSIV was less than the difference at 90 days, a difference that will probably be even less at 365 days. The strength gain of this mix was slow and the maximum strength was obtained after about one year.

The capillarity water absorption of the mixes was also evaluated. The results showed similar capillarity water absorption rates of mixes EAFSI and NATI, while mix EAFSIV was of lower permeability. The result also pointed to higher total pore volumes of EAFSI than NATI, which can be explained by the higher porosity of the slag, compared with natural aggregates. The porosity of EAFSIV was higher. The results for mix EAFSIV showed that it had a high number of single, unconnected spherical pores.

The freezing-thawing and the wetting-drying tests were performed to evaluate the durability of the mixes. The behavior of all specimens was similar in both tests. The development of the mechanical properties, during the durability tests, of mixes NATI and EAFSI was similar

The behavior of mix EAFSIV differed in so far as it showed strength gains, rather than loss of strength, due to the aggressive cycles. The presence of fly ash with long-term pozzolanic reactions help to explain the results.

The specimens were placed in cages, hanging from a dock wall in an intertidal area of Pasaia Port, to evaluate the durability of the Self-compacting EAFS concretes in marine environments. After one year of exposure, the chemical composition was analyzed, especially chlorine and sulfur ion penetration of the first 50mm. The results showed that EAFSIV had greater resistance to the penetration of chlorine ions while the resistance of NATI and EAFSI was similar

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## 4 Conclusion

- The use of electric arc-furnace slag as a concrete aggregate was not detrimental to the durability of the concrete. The great similarity, with no major differences between the natural and the EAFS aggregates was confirmed by the test results.

**References**

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