

Mechanical and Environmental Behavior of Cement Mortars Containing Ladle Furnace Slag

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1 Introduction

Steel slag is waste that to date has no integral solution, since its properties depend on the raw materials, Steel manufacturing process and the recovery processes carried out. Slags from steel manufacturing can be either from melting or refining processes. The first ones have been subject to more research, as well as regulation. This is because, in 2016, more than 18 Mt of slag (black and white) was generated in the European Union, but they were mostly black slag.

To date, different studies have been carried out on the possibility of the use of refining slag (white slag) in civil works. Some of the topics studied are: ladle slag as a filler in self-compacting concretes, ladle slag as a cementitious agent in concretes and mortars, ladle slag as a binder in soil stabilization and ladle slag as a filler in asphalt mixtures. In the studies mentioned above, the durability problems due to the expansion of white slag are present, and it is an aspect that does not have an easy resolution. Therefore, more research is still necessary to clarify the effect of ladle furnace slag when used in cement-based materials, due to its expansive behavior and its problems with the release of contaminant elements. In this context, the main goal of this study is to analyze the incorporation of fine ladle furnace slag in mortars in different rates (0, 25, 50, and 75%), and its influence in mechanical properties, expansion behavior and environmental impact (leaching test).

2 Material and Testing Methods

The materials used for the experimental campaign are basically: (i) CEM I 52.5R Portland Cement, (ii) slag from the refining process of an electric arc furnace Steel plant, and (iii) limestone sand with a particle size between 0 to 5mm. Potable water is used for the manufacture of mortars, and MiliQ water is used for all leaching tests.

The mortars are manufactured in accordance with standard UNE EN 196-1, with a water to cement ratio of 0.5 in all cases. At the ages of 7 and 28 days of curing, compressive strength is determined. A length comparator is used to measure the expansion/shrinkage of the mortars over time. Finally, for the environmental impact tests, standard UNE EN 12457-2 is used for all mortars at the age of 28 days, as well as for white slag. The results of this test are compared with the Decree on waste acceptance criteria in landfills (Council Decision 2003/33/EC of 19 December 2000) to classify mortars as an inert, non-hazardous, or dangerous material.

3 Results

Slag and cement basically contain Calcium, Silica, Aluminium, and Iron. White slag has high magnesium content. It should be mentioned that the used slag contains a part of amorphous material, together with crystalline phases, such as: calcium silicates (α -C₂S, β -C₂S), calcium aluminate (C₃A), gehlenite (Ca₂Al(AlSi)O₇), wustite (FeO), and periclase (MgO). In addition, calcite (CaCO₃) and in low proportion portlandite (Ca(OH)₂) and lime (CaO) have been identified. Figure 1 shows the effect of incorporating slag into mortars and curing time (7 and 28 days) in compressive strength. It can be seen that as the amount of slag increases, the strength decreases, and this decrease is almost proportional.

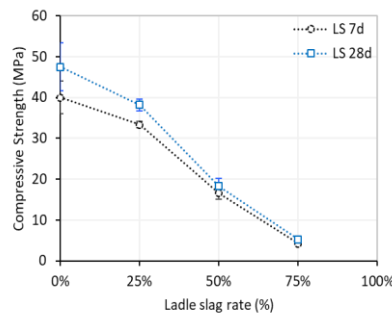


Figure 1. Compressive strength of mortar with different rates of ladle slag.

Figure 2 shows the behavior for the different types of mortars. For the control mortar, a linear increase can be observed up to 100 days, and then the behavior is constant up to 0.02% linear expansion. For mortars containing slag, it can be seen that after 100 days, linear expansion continues to increase over time, possibly with greater expansion as the slag content increases.

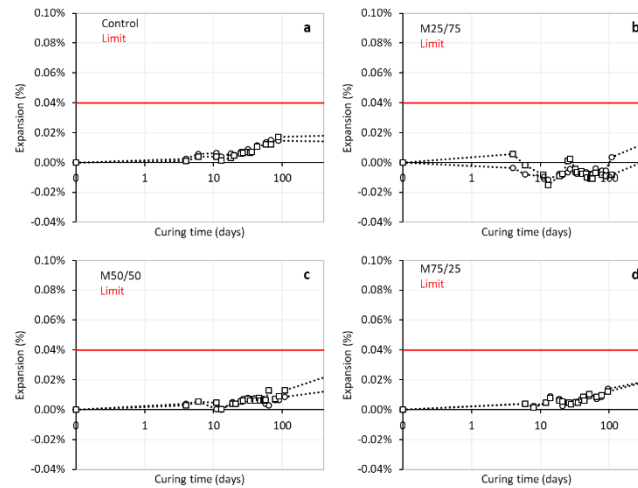


Figure 2. Expansion for control mortars (a), 25% L.S. Mortars (b), 50% L.S. Mortars (c) 75% L.S. mortars (d).

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