



MUNICIPAL SOLID WASTE INCINERATION FLY ASH STABILIZATION AND IMMOBILIZATION INTO SULFOALUMINATE CEMENT MORTARS MATRIX: PHYSICAL/MECHANICAL BEHAVIOUR.

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1 Introduction. The first objective of the research aims to transform the waste formed mainly by calcium hydroxide and calcium hydroxychloride into another limy-type material (calcium carbonate material). This is achieved by transforming the high soluble heavy metals chlorides into low soluble carbonates.

The second objective focuses on the stabilization and use of this MSWI fly ash as part of the aggregates used in the production of cement mortars. Previous studies emphasize [1-3] that the mechanical strength of mortars elaborated with Portland cements and the incorporation of fly ash as a partial substitute for the aggregate were significantly affected when compared to the reference mortars. On the contrary, the use of sulfoaluminate cements (CSA) has been demonstrated [4] to be a highly effective way to safely encapsulate hazardous materials without affecting mechanical strength. In addition, CSA was also chosen due to the perception that sulphur content would make the precipitation of heavy metals in the form of sulphides easier.

2. Methods. A search of the possible reagents has been carried out to use them in the stabilization process of fly ash. In this way, considering previous researches aiming to stabilize heavy metals [5-6] and, at the same time to eliminate part of chlorides of fly ash through washing, an alternative method using NaHCO_3 is established. An appropriate combination of this will exercise a buffer function and maintain pH at an optimum value, for which the heavy metals content in the leachate will be minimal. Likewise, the addition of Na^+ ion in equivalent quantities to chloride ions, in the fly ash washing process, will facilitate the removal of a large amount of chlorides in the form of sodium chloride. In addition, NaHCO_3 is a cheap and safe stabilizing agent and does not alter the pH of cementitious materials.

The stabilizing procedure began by washing the original ashes, with a proportion of deionized water/fly ash of 10:1. This mixture was manually stirred by mechanical means, while the calculated amount of NaHCO_3 was added. The recovered paste was dried and grinded to obtain a greyish powder, mostly calcite, which is easily combinable with the selected aggregates for the mortars implementation.

3. Results and discussion. Analytical data shows a high content of heavy metals in original fly ashes, mainly regarding Zn and Pb content and also high levels of chlorides. The problem arising from Cl^- ion excess in cementations mixtures is the one derived from corrosion. Two goals are achieved through the treatment with the NaHCO_3 solution. Firstly, the soluble heavy metal ions existing in the original ashes, due to chloride presence, are transformed into poor soluble solid carbonate or hydroxide precipitates. Secondly, the content of chlorides has been drastically reduced in almost 99% but, despite this, their use is not recommended with steel reinforcing rods [7].

FA XRD analysis of original fly ash (FA) shows broad and low intensity diffraction peaks, characteristic of a poor crystallized material. Two crystalline phases have been clearly identified: Ca(OH)_2 and Ca(OH)Cl . XRD analysis of treated fly ash (TFA) shows one crystalline phase clearly identified: Calcite (CaCO_3).

With regard to dimensional stability, deformation in mortars made with CSA are particularly positive. Not only does the trend mark a conservation of dimensional stability, unlike reference mortars, but also the values offered at 28 days are the best ones obtained with this type of mortars and of all the ones tested. Nevertheless, a greater specific mass loss is observed with values below those offered by the reference mortar.



As a supplementary analysis to the one on dimensional stability, in the density results of the dry mortar samples studied a gradual material lightening occurs when TFA. For those performed with CSA, lightening is reduced by 4.5% for 1/1 proportion, and by 6.5 per cent for the 1/3 proportion.

CSA mortars present much higher rates of natural carbonation compared with both Portland and CAC cements [8]. For CSA mortars with proportion 1/3, as well as for TFA mortars of proportion 1/1, a singular feature is observed: i.e. the carbonation front does not start on the surface, but gets in gradually. In this case, an area of surface protection, which is not carbonated, can be seen; this area is much more pronounced in the reference mortar. This fact may be due to the characteristics of the used cement. This cement is produced in a similar process to that of Portland cement but with less energy consumption, different configuration phases and similar or higher mechanical properties than that other cement. CSA cements present a rapid hydration, which can generate a very heterogeneous distribution of pores and therefore, a higher carbonation, which in turn, has been accelerated with the addition of TFA resulting in a total carbonation of the studied surfaces.

Reference mortars behaviour regarding compression of CSA mortars show high initial strengths –although with a gradual strength loss at 28 and 60 days-- two proportions, 1/1 and 1/3, made with TFA reverse this trend and present moderate initial strength but with a clear upward trend; in the case of the 1/1 proportion of TFA showing even more than 1% higher values than those offered by the reference mortar. As a consequence, CSA present certain benefits in comparison with ordinary Portland cements [9]. As it is a cement type with high initial strength, when used in combination with MSWI fly ash it promotes its stabilization/solidification in the mortar matrixes. Likewise, as previously said, the used ashes are rich in chlorides and sulfates, which may easily react with the calcium sulfoaluminate in the hydration process and take advantage of the new phases of this hydration to encapsulate heavy metals. Similarly, the sulfide included in its initial formulation, will facilitate the precipitation of heavy metals contained in TFA in the form of sulfates.

CSA mortars suffer higher carbonation rates. Aggregates, together with the evaporation of the mixing water lead to the development of a system of pores promoting CO₂ diffusion. This fact, far from being negative, reduces shrinkage and cracking of the samples during drying and they can give rise to subsequent puzzolanic reactions favoring the increase of compressive strengths.

Conclusions.

- The mean data obtained on a sample period of 22 weeks indicates that the MSWI ashes have a high content of heavy metals, at least with regard to Zn and Pb, and also high levels of chlorides and sulfates, making them to be treated as special waste.
- The washing method of the MSWI ashes with the appropriate NaHCO₃ proportion shows a reduction of almost 99% of soluble chlorides. The addition of the Na⁺ cation produces the elimination of these chlorides in the form of sodium chloride. The studied solution exerts the buffer function and maintains pH environment at the optimum values so that the concentration of heavy metals in the leachate is the minimum possible.
- CSA cement mortars with partial replacement of 10% of the aggregate with TFA, present much better behavior than reference mortars, both in compressive strength and dimensional stability.
- The results show that the workability period of mortars made with CSA cements and the inclusion of TFA is much shorter than those offered by the two types of ordinary Portland cement tested.
- In all analyzed mortars the inclusion of TFA implies a carbonation increase of the resulting mortar and therefore, an increase in porosity. However, this does not seem to negatively affect final compressive strengths of the mortars made with CSA.



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