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WASTE CLAY MATERIALS AS POZZOLANIC ADDITIONS

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Abstract

The building materials industries have made improvements in manufacturing processes. However, with the implementation of quality systems, more compliance, with new standard more restrictive, and especially by the competition between products, it is inevitable that industries deemed a rejection of material unsuitable for marketing or materials waste. The wastes from the ceramic industry (ceramic waste) may have characteristics suitable for use as pozzolanic materials, as it is known that the first materials used as pozzolans were heat-treated clays, material like clay products.

Keywords: clay, Ceramic waste, pozzolanic activity, building.

INTRODUCTION

During 2008 around 20 million tons of ceramic products were produced in Spain, 30% less than in 2006 [1]. This amount decreased due to the economical crisis produced in the building sector. Even so, the number of rejected products for sale, and therefore waste is still important because it is usually about 5% of total production (although the amount of rejected products depends on the manufacture type and product requirements). In principle, this kind of waste can be considered inert, because they have a relatively low power of contamination. However, its visual impact is important, because of the large volume occupied and the low environmental control exercised over the land containing them. Ceramic products are made of natural materials with high clay mineral content. Clay is activated firstly by dehydration, beginning at temperature about 500 ºC, followed by the separation of amorphous and highly active alumina, whose maximum concentration is reached at different temperatures depending on the type of mineral involved. The constituent minerals of ceramic materials would be activated by the high firing temperatures used in their manufacture, resulting in a product with pozzolanic properties. Researches about ceramic waste indicate that these materials are suitable for use in construction, with good performance and durability [2-10].

This work shows some results of investigations conducted by the Research Group Materials Recycling in IETcc.

EXPERIMENTAL

Materials

The rejected ceramic material or ceramic waste, was totally collected without considered the rejected reason, and was crushed and grounded to obtain the fineness suitable for use this waste as pozzolanic material (particle size <45 µm). In this waste chemical and mineralogical studies were carried out.

The reference cement used was a CEM I/42.5 type, according to EN 197-1:2000 Standard [11], with a clinker content greater than or equal to 95% and up to 5% in additional components.

Standard sand was used to make Portland cement mortars according to EN 196-1:2005 standard [12], with silica content up to 98% and a particle size below 2 mm.

Test methodologies

The activity of the pozzolanic materials was evaluated with a quick method based on lime uptake by the material when cured in a saturated lime solution. The lime fixed by the sample (% mol) was found as the difference between the initial concentration of the saturated lime solution and the CaO present in the solution in contact with the sample at different reaction times.

The study was conducted by cement pastes, with replacements of cement by ceramic waste material. The hydrated pastes were subjected to the different attacks according to the Koch-Steinegger test [13].

Cement pastes were prepared at a water-to-mixture ratio of 0.5 and 0% and 20% replacement of cement by ceramic waste. After the pastes were molded into1 cm x 1 cm x 6 cm specimens. After 1 day at 100% relative humidity, the samples were demolded and cured by immersion in deionised water at 20± 1ºC for 21 days. After this curing period, the samples were immersed in different aggressive solutions (NaCl, Na_2SO_4, simulated ocean water [14] and deionised water as a reference) at 20ºC for 14, 56 and 90 days.

The resistance in a specific aggressive medium was evaluated through the changes of flexural strength values compared with those obtained in deionised water.

RESULTS AND DISCUSSION

The samples consisted with a BET specific surface area of 3 m^2/g, show a chemical composition highly acidic with a predominance of silica, aluminium and iron oxide (about 94%). The chemical composition of the calcined clay is very similar to the composition of the other types of industrial waste with pozzolanic properties. Its mineralogical composition is studied by X-ray Diffraction. The main crystalline compounds observed are quartz, muscovite, calcite, microcline and montmorillonite.

The results (Figure 1) show that the calcined clay residues have an acceptable pozzolanic activity, since at the age of 1 day, these residues fixed a 46% of lime, 50% at 3 days and 80% at 90 days. These results show that the calcined temperature of these ceramic materials (by 900ºC) is enough to activate the clays, obtaining pozzolanic properties.

According to the Koch-Steinegger test, the criterion for classifying a material as resistant in a specific aggressive medium is that the corrosion index (relative flexural strength of the samples stored in the aggressive compared with those stored in water) must be higher than 0.7 at 56 days [13].

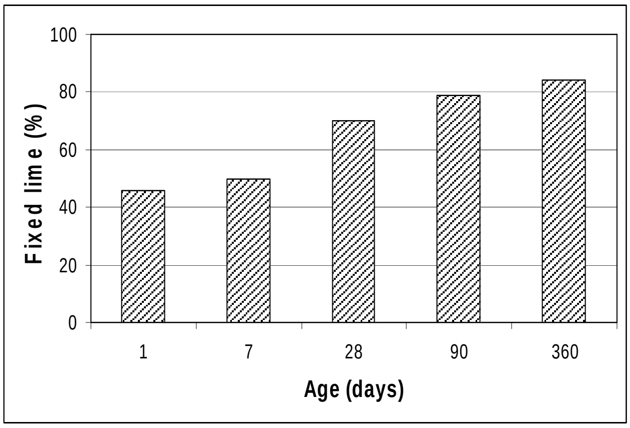

Figure 1.Pozzolanic activity

Pastes containing ceramic wastes improve cement durability respect reference cement pastes, because the obtained index are higher in all cases, except for sea water, that is slightly lower (Figure 2).

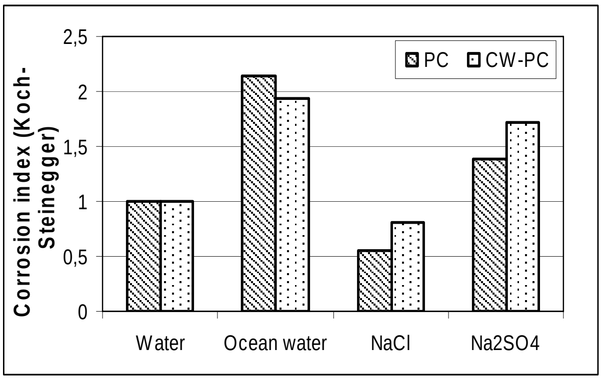

Figure 2. Corrosion index (Koch- Steinegger)

The mortar elaboration and dosage is done according to UNE EN 196-1:2005 standard [12]. The mortar composition was 3/1: sand/cement and W/C was 0.5. The ceramic waste materials used replacing a 15% of cement. The mortars produced are:

M1: Reference Mortar (100% cement)
M2: Mortar with product calcined clay, replacing a 15% of cement

The results of the flexion and compression strength of the 4x4x16 specimens at 24h and 28 days are shown in the Figure 3. The flexion strengths at 24 hours do not vary significantly. At 28 days of curing, the values obtained are slightly lower than reference mortar in all cases.

The compression strength results do not show important changes. For the mortar M2, with a 15% of replacement, the compression strengths decrease slightly compared with the reference mortar, but those are less than the percentage of cement substitution, indicating that these materials act as pozzolanic material improving to the compression strengths.

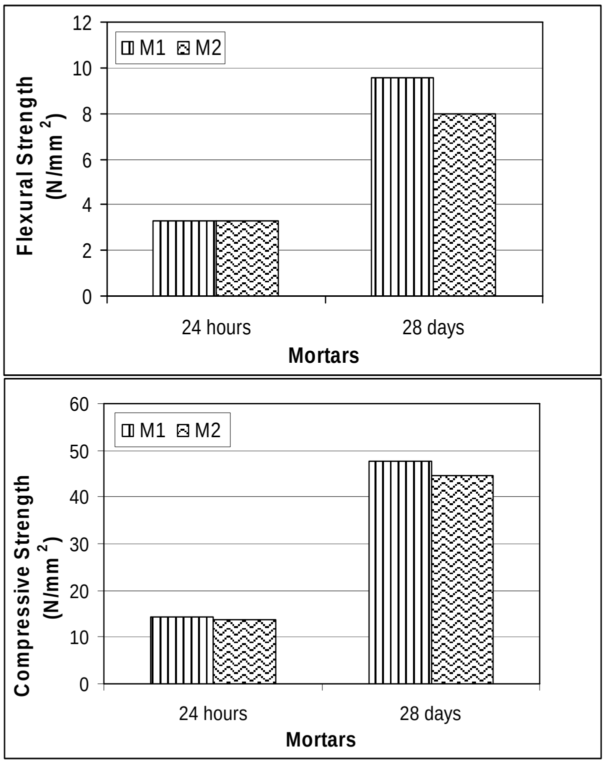

Figure 3. Mortar mechanic strengths

CONCLUSIONS

The studies carried out indicate the feasibility of using these waste materials from calcined clay as pozzolans. These results indicate that the firing temperature of these materials (around 900ºC) is enough to activate the clays, giving them pozzolanic properties. The hydration products are similar to the obtained from fly ashes.

The ceramic waste additions give positive characteristics to blended cements, due to these wastes contribute to the increment of chemical strength against aggressive medium.

The mortars with a 15% of replacement, the compression strengths decrease slightly compared with the reference mortar, but those are less than the percentage of cement substitution, indicating that these materials act as pozzolanic material improving compression strengths.

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