



0.- Abstract.

The possibility of producing concrete in which the percentage of cement could be considerably reduced would bring major economic and environmental benefits. Replacing large volumes of Portland cement with fly ash is known to significantly improve the properties of the concrete which contains it and its use leads to ecological, economic and technical improvements. Ecological improvements are due to two reasons: on the one hand, there is a reduction in greenhouse gas emissions produced by the manufacture of clinker and the use of raw materials; on the other hand, it allows a by-product of the industry to be reused which would otherwise have to be collected and stored in a rubbish tip with no further use whatsoever. There are economic benefits because a residual material is used, meaning lower costs than if cement were used. And finally, there are technical improvements because in the long term, the use of fly ash such as pozzolana can improve some aspects of durability and resistance. However, the use of pozzolanic additives in high proportions could affect the pH of the cementitious matrix and the portlandite generated in the hydration of the calcium silicate of the Portland cement will be reduced due to the effect of dilution. In addition, some of this portlandite reacts with the pozzolana. Thus, this aspect must be considered in the case of reinforced concrete, given that these conditions could contribute to the process of corrosion. This study proposes the use of an extra part of calcium hydroxide (CH) in matrices in which high volumes of Portland cement have been replaced with fly ash (FA) in order to analyse whether such an addition has a positive influence on the mechanical properties and the durability of the material.

The first phase (pastes) involved the analysis of the cement systems, cement with 50% of the cement replaced with fly ash and finally the effect of adding 10%

calcium hydroxide to the paste which contained fly ash. These pastes were characterised by thermal analysis and mechanical resistance. From the tests carried out, it was concluded that the addition of powdered CH improved the alkaline reserve in the long term and that there was a negative effect on the mechanical performance of these systems.

A deeper study was carried out on aspects related to the durability of these systems through the analysis of reinforced mortar with the addition of different percentages of CH. Their durability was analysed in the face of attacks from CO₂ and chlorides: these systems were characterised by thermal analysis, X-ray diffraction and their mechanical properties were analysed. Likewise, the speed of carbonation and the corrosion process of the reinforcements were evaluated. In both attacks, the addition of calcium hydroxide to the cement-fly ash system represented a substantial improvement over the system in which fly ash was used as a replacement. Even the performance was very similar to that of the control mortar made only of cement.

After identifying the loss of resistance obtained when using powdered CH, two means of improving the dispersion of lime in the cementitious matrix were proposed. To that end, the powdered CH was treated previously in two ways: by mechanical agitation in water and by sonication in an aqueous suspension. This meant a greater reduction in the average particle size compared to the powdered material. The pastes were then analysed again by means of thermal analysis, observing improvements in the percentages of lime fixation by the fly ash with regard to the pastes produced using untreated powdered lime.

The figures for pressure resistance and mercury intrusion porosimetry showed a slight improvement in the mortars which contained sonicated CH compared to those which contained agitated CH. The mercury porosimetry tests showed that the matrix with sonicated lime was much more compact and intricate than that obtained by means of the other treatment. It was concluded that the treatment of lime by

sonication can offer better performance and for that reason the study continued exclusively with that processed material.

The following stage of the study of the durability of these systems was the analysis of the transport of chlorides through pastes, demonstrating once again that the addition of sonicated CH helps to structure a denser and more compact matrix.

Analysis of the durability of the mortars in the face of attacks by sulphates of varying degrees of aggressiveness (sodium, magnesium and ammonium), showed that despite adding calcium hydroxide (which could appear to be a weak point faced with such attacks), these mortars performed better than those in which CH was not added, maintaining a greater alkaline reserve in the long term and greater volume stability.

Another of the aspects analysed focused on the beginning and end of the setting process of the matrices in this study, highlighting the fact that sonication of the carbon hydroxide reduced the setting time in relation to the rest of the matrices studied.

As a final part of the study, a characterisation of high resistance concrete was carried out in terms of its mechanical properties and durability. This final section once again confirmed the positive aspects mentioned above with regard to the use of additional sonicated calcium hydroxide.

In short, the results obtained demonstrate that the addition of CH in mixtures in which large volumes of Portland cement have been replaced with fly ash creates a denser and more compact microstructure with a greater alkaline reserve which also improves its mechanical properties and durability. It can also be concluded that the process of prior sonication of aqueous suspensions of CH significantly improves the properties of mortars and concrete comprising Portland cement / fly ash.