INHIBITION OF ASR AND DEF: EVALUATION OF THE MICROSTRUCTURE OF CONCRETE MIXES WITH POZZOLANIC ADDITIONS

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The use of pozzolanic mineral additions is a known method to inhibit the expansive chemical reactions in concrete, like the alkali-silica reaction (ASR) or the delayed ettringite formation (DEF).

The ASR is a chemical reaction that occurs between certain types of minerals present in aggregates and alkali and hydroxyl ions present in the interstitial solution of cement paste in concrete. These reactions, involve the dissolution of amorphous or poorly crystallized forms, of silica, in alkaline medium, with the formation of an alkaline hygroscopic gel that absorbs water and expands, creating internal stresses in the concrete with cracking. The DEF is a pathology related with the formation of ettringite inside the hardened material, due to an excessive heating of the concrete during the cure that induces swellings, cracking and decrease of the mechanical properties.

This paper presents the results of SEM/EDS analysis of concrete mixes with different pozzolanic materials, like metakaolin, biomass fly ash, natural pozzolan and mine sludge from a tungsten mine. The microstructural evaluation is discussed and correlated with the expansion data of each concrete mix.

The results obtained in this study points out the existence of a relationship between the mineral addition type and the inhibition of IER, being only the type II additions effective in this purpose. This efficiency is related to the chemical composition and pozzolanic activity of the addition.

According our results the mitigation effect of the mineral additions in ASR seems mainly due to the pozzolanic activity, CaO and alkalis content of the mineral additions. The materials studied that show the best ASR inhibition effects are: MK > FA > TMS > GGBS. Due to their high CaO and alkalis content the biomass fly ashes could be effective in ASR mitigation by incorporating a small amount of metakaolin (e.g. ~10%). The microscopic observations confirmed the presence of ASR products in all blended mortars, however in the mortars that have less expanded during test these expansive products are mainly located in voids with no evidence of distress in the specimens.

In terms of DEF inhibition their efficiency is mainly related to the Al_2O_3 content and also pozzolanic activity. Although the occurrence of ettringite their formation in some of the blended concretes was not accompanied by expansion. By microscopy we have observed that the concretes that more expanded during immersion storage the monosulfoaluminate was replaced by ettringite, this did not happen in the blended concretes with sufficient Al_2O_3-bearing mineral addition. The use of a non pozzolanic mineral addition in blended concretes, e.g. limestone filler, could be worse than only Portland cement. This seems occur due to a refinement of the cement microstructure, reducing the porosity, which is not more sufficient to accommodate the expansive ettringite.