World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:12, No:02, 2018

Developing a High Performance Cement Based Material: The Influence of Silica Fume and Organosilane

Authors : Andrea Cretu, Calin Cadar, Maria Miclaus, Lucian Barbu-Tudoran, Siegfried Stapf, Ioan Ardelean

Abstract : Additives and mineral admixtures have become an integral part of cement-based materials. It is common practice to add silica fume to cement based mixes in order to produce high-performance concrete. There is still a lack of scientific understanding regarding the effects that silica fume has on the microstructure of hydrated cement paste. The aim of the current study is to develop high-performance materials with low permeability and high resistance to flexural stress using silica fume and an organosilane. Organosilane bonds with cement grains and silica fume, influencing both the workability and the final properties of the mix, especially the pore size distributions and pore connectivity. Silica fume is a known pozzolanic agent which reacts with the calcium hydroxide in hydrated cement paste, producing more C-S-H and improving the mechanical properties of the mix. It is believed that particles of silica fume act as capillary pore fillers and nucleation centers for C-S-H and other hydration products. In order to be able to design cement-based materials with added silica fume and organosilane, it is necessary first to understand the formation of the porous network during hydration and to observe the distribution of pores and their connectivity. Nuclear magnetic resonance (NMR) methods in low-fields are non-destructive and allow the study of cement-based materials from the standpoint of their porous structure. Other methods, such as XRD and SEM-EDS, help create a comprehensive picture of the samples, along with the classic mechanical tests (compressive and flexural strength measurements). The transverse relaxation time (T_2) was measured during the hydration of 16 samples prepared with two water/cement ratios (0.3 and 0.4) and different concentrations or organosilane (APTES, up to 2% by mass of cement) and silica fume (up to 6%). After their hydration, the pore size distribution was assessed using the same NMR approach on the samples filled with cyclohexane. The SEM-EDS and XRD measurements were applied on pieces and powders prepared from the samples that were used in mechanical testing, which were kept under water for 28 days. Adding silica fume does not influence the hydration dynamics of cement paste, while the addition of organosilane extends the dormancy stage up to 10 hours. The size distribution of the capillary pores is not influenced by the addition of silica fume or organosilane, while the connectivity of capillary pores is decreased only when there is organosilane in the mix. No filling effect is observed even at the highest concentration of silica fume. There is an apparent increase in flexural strength of samples prepared only with silica fume and a decrease for those prepared with organosilane, with a few exceptions. XRD reveals that the pozzolanic reactivity of silica fume can only be observed when there is no organosilane present and the SEM-EDS method reveals the pore distribution, as well as hydration products and the presence or absence of calcium hydroxide. The current work was funded by the Romanian National Authority for Scientific Research, CNCS – UEFISCDI, through project PN-III-P2-2.1-PED-2016-0719.
Keywords : cement hydration, concrete admixtures, NMR, organosilane, porosity, silica fume
Conference Title : ICCC 2018 : International Conference on Cement and Concrete
Conference Location : London, United Kingdom
Conference Dates : February 15-16, 2018