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STUDY OF THE PHYSICO-MECHANICAL PROPERTIES OF SOME NANO-CEMENT SAMPLES

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ABSTRACT

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ABSTRACT

The addition of a material, such as micro- silica and nano-clay (Na-Ca-montmorillonite) to the ordinary Portland cement (OPC) can be considered as a new trend in the production of a new complex cement paste, due to the ultra fine size of nano-particles, which show unique physical and chemical properties different from those of the conventional materials, due to the chemical composition of the additive materials. The complex cement matrix has been gaining increasing attention to fabricate new cement materials with concentration function of the additive materials (micro silica and nano-clay).

The additive materials are used in the OPC to get new physical properties, and also on an additive to reduce the cement content. This is leads to a decrease the amount of CO_2 emission during the production of the OPC. The effects arise due to pozzolanic and size parameter and their morphology and microstructure of the cement matrix, together with the concentration of the ions mobility in the pore system. Therefore, they influence the physico-mechanical properties of the blended complex cement under different concentration of the additive materials. This influence is reflected in the changes occurring in the electrical, mechanical, thermal measurements and the pore microstructure analysis for the fresh and hardened blended cement pastes. These changes are closely linked and related to the level of hydration inside the complex cement pastes.

From the above mentioned reasons and the selected parameters, which are required to produce a new complex cement paste , that can be used in the field of construction building, it is necessary to known the changes of the physico-mechanical properties of different blended cement samples . This will be covered comprehensibly in this work.

The mixed samples cement paste, were prepared by replacing the OPC with 10٪ till 7٪ of micro silica and 0٪ up to 3٪ of nano –clay (Na-Ca montmorilloneit) by weight. These specimens were investigated at W/C =0.3 ratios and relative humidity 100% and different concentration of additives materials in the plank ordinary cement paste (OPC) with the curing hydration time.

The hydration mechanism of these samples (M_0, M_{01}, M_{02}, M_{03} and M_{04} systems) were investigated by the electrical conductivity and dielectric constant(σ, ε) thermal (DSC) and mechanical (compressive strength) measurements, as well as the morphology and microstructure of the different systems characterized by the X-ray diffraction and scanning electron microscopy(SEM and EDAX) techniques .

The OPC containing these materials (micro-silica and nano-clay) have been found to have lower permeability than those without these additives. This is because the additive materials especially the micro-silica react with the calcium hydrated CH phase in the cement pastes resulted in more calcium silicate hydrate CSH gel phase , that precipitate in the available pore system (packing effect). The mechanism, the concentration of the additive materials and its chemical composition were being also investigated.

The critical condition for the changes of the hydration process inside the matrix of mortar cement systems (M_0, M_{01}, M_{02}, M_{03} and M_{04}) occurs at the concentrations 0.8٪ and 0.9٪ for the micro-silica and 0.1٪ up to 0.2٪ for nano-clay (Na-Ca montmorillonite). The changes obtained from the electrical properties (σ, Є) at the setting time, the mechanical measurements (macrostructure changes), the DSC measurements and the morphology microstructure analysis of the hydrated CSH and CH phases through the Ca/Si molar ratio.

Microstructure changes are attributed to the rate of physical pozzolanic effect, not to the chemical effect of the concentration of the additive materials and the important role of the nano-clay (Na-Ca montmorillinte) through the swelling effect (crystalline and macroscopic) in the matrix cement system, that are clearly observed in the two M_{02} and M_{03} cement matrix system .

The degree of hydration in blended cement paste (M_{01} system) can be linked to the changes in the microstructure, due to the pozzolanic effect of microsilica inside the matrix M_0 system, and through the transformation of mortar into solid. This leads to less macroscopic capillary pores (i.e.) an increase in the packing density (due to the specific surface area) and a decrease in the air content. These effects lead to a change and improvement in the microstructure (increase the mechanical properties) of M_{01} system and this contributes changes in cement matrix physical parameters. The addition of the nano-clay (Na-Ca montmorillonite), have a negative effect on the rate of hydromechansim and on the microsturcture on the cement matrix system M_{01}. This is clearly observed through the decreases of the mechanical properties of the different M_{02}, M_{03} and M_{04} systems. This negative effect is mainly attributed to the amount absorbed water observed by the nano-clay (Na-Ca montmorillonite), in the mixed water inside the matrix cement system (swelling effect). The Ca- montmorillonite in the nano-clay produces a crystalline swelling which is easier to separate and this increases the hydration reaction of cement paste. However the Na-montmorillonite results in a macroscopic swelling and that is the most difficult to separate inside the matrix cement system, due to the large decrease in the rate of hydration and an increase in the capillary pore system. Here, the microscopic swelling effect is larger than the crystalline effect leading to a decrease of the mechanical properties (which creates a weak zone in the form of voids) and a change in the density of the

microstructure of the hydration products which are dependent on the diffusion of the nano- particles inside the matrix cement system. That is clearly observed in the M_{04} system, a result that is supported by other measurements. From the above mentioned consideration, the variation in the dense of microstructure and the degree of stability of each system depends on the concentration of both micro-silica and Na-Ca montmorillonite. From these it, can be concluded that the addition of micro-silica and nano-clay to the M_0 matrix system depends upon the intended use and required of performances, e.g. resulted mechanical properties, durability….etc, which can be employed in the construction building fields.