HIGH PERFORMANCE CONCRETE COMPRISING NANO AND MICRO SILICA WITH FLY ASH

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ABSTRACT

Concrete is the single most widely used material and the second most consumed commodity after water in the world. Cement industry is responsible for about 5% of all man-made CO_2 emissions. Obviously, cement and concrete's impact to the environment is enormous. Development of new concrete additives could produce a stronger, more workable and durable material whilst reducing the amount cement required and the resulting low CO_2 emissions.

Use of supplementary cementitious materials (SCMs) goes back to centuries. SCMs are commonly used in concrete mixtures as a replacement of a portion of clinker in cement or as a replacement of a portion of cement in concrete. Most widely used SCMs in cement and concrete are; blast furnace slag, siliceous or calcareous fly ash, natural or natural calcined pozzolana, burnt shale, limestone and silica fume.

This study examines in detail the influence of amorphous nano silica (NS) and micro silica (MS) with fly ash (FA) as SCMs on fresh properties, mechanical properties, heat of hydration and durability of concrete. As many researchers focus on single blend of nano silica on concrete performance, the study extends its effort to see binary effects (nano silica + micro silica/ fly ash) and ternary effects (nano silica + micro silica + fly ash) on fresh and hardened properties of concrete. Under this, concrete and mortar performances are tested in both fresh & hardened states to cover properties such as consistency and setting time, heat of hydration, workability, compressive strength,

splitting tensile strength, static modulus of elasticity, poison's ratio, scanning electron microscopic (SEM) analysis and thermo gravimetric analysis (TGA).

Results show that NS helps to enhance concrete performance in numerous ways in combination with micro silica and fly ash. The optimum percentages of nano silica differ for different applications. NS reduces setting time when compared to MS and FA blends and help for faster construction practices. Similarly, NS increases early strength of concrete significantly, while MS and FA reduce. NS accelerates the hydration process and reacts with Calcium Hydroxide (CH) generated in the primary reaction to create more Calcium Silicate Hydrate (CSH) in the secondary pozollanic reaction, in concrete mixes in very early age. NS reduces CH gathers at interface and increase interface bond between aggregates. It could be observed that the CSH gel formations around NS particles are very effective and NS creates more nucleuses for CSH bonds.

On durability, either single blend of NS, MS, FA and binary and ternary blends can give required durability. Heat of hydration of NS and MS are completely different; NS accelerate and MS retards the hydration process. For high strength, high performance concrete, binary blend (NS+FA) or (MS+FA) and ternary blends (NS+MS+FA) provide better performance than single blends.