**Nanocomposites and nanomaterials**

**Effects of nanocrystalline calcium silicate hydrates and nanosilica on the hardening of Portland composite cements**

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Concrete is a composite material with a multiscale structure in four size ranges: macroscale, mesoscale, microscale, and nanoscale. At submicron length scale the main component of hardened concrete is C-S-H, formed by the reaction of Portland cement clinker, mineral additives and water. The hydrated cement paste acts as a binding matrix for the other components and is responsible for the compressive strength of concrete. The crystalline phases of hydrated Alite and Belite minerals are nanocrystalline calcium silicate hydrates (C-S-H) and well-formed crystals of calcium hydroxide (CH), larger than 500 nm. Calcium silicate hydrates of the type C-S-H (I) with a lower C/S, having a developed structure, which is provided by strong covalent chemical bonds, gives cement paste higher strength.

The aim of this study is to evaluate effects of different types of nanocrystalline calcium silicate hydrate (C-S-H) and silica nanoparticles (NS) on formation of structure and strength properties of Portland composite cement (PCC). In addition, the effects of alkaline activators and polycarboxylate ether additives on hardening of the nanomodified PCC was investigated.

The study showed that addition of nanosilica (NS) into the cement paste improves the composite cements microstructure and leaching of calcium ions became significantly lower, because NS particles react with calcium hydroxide resulting in the formation of a denser C-S-H (I) gel at the early stage of hardening. The addition of C-S-H-nanoparticles caused the formation of hydration products in the porous space between the cement grains, which leads to a more uniform distribution of hydrates with the creation of a denser microstructure and hence provides a possibility of obtaining high-strength PCCs. Nanocrystalline C-S-H particles modified by specific PCE molecules exhibited a huge surface area which produced an extremely strong seeding effect during the hydration of alite, thus a significant acceleration of strength development has been observed.