Use of Nano Powders in Cement-based Mortar Production

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Abstract:

In order to improve the properties of cement mortars, it is possible to accelerate the nucleation that occurs in hydration reactions by adding nanoparticles instead of cement in the mixtures. Preferred methods to accelerate hydration are the use of particles such as Nano SiO2, nano Al2O3, nano TiO2, nano Fe2O3, nano carbon tubes, nano graphene powder and graphene oxide. While nanoparticles create very large reactive surface areas, they enable the formation of many nucleation points in the environment and nucleation reactions start quickly at these points. Since nanoparticles have a high potential to react with the components of cement paste, they form additional nuclei, hydration is accelerated and large increases in strength are achieved. Under normal conditions, there is no need for nucleation reactions that cause time loss for crystal development, and the dead phase of cement hydration is shortened. Although nanomaterials have been researched in industrial products for a long time, there are few studies on cement mortars containing nanocarbon tubes. Since the acceleration of the hydration process is related to the reactions occurring on the reactive surfaces of nanoparticles, the surface areas or sizes of these particles are important in terms of cement hydration kinetics. With the method that attempts to improve the hydration kinetics by adding nanoparticles, the nuclei of hydration products are formed not only on the cement grains, but also on these nanoparticles and between the cement grains. Cement hydration products are formed by the crystal growth mechanism thanks to these nuclei. Hydration products begin to form between the cement grains, resulting in the formation of a much more void-free internal structure in a short time compared to a reference mixture that does not contain nanoparticles. In this way, it is possible to obtain cement-based materials with more voids and high compressive strength at an early age. Many studies have been carried out to increase the mechanical properties of cement-based products by using admixtures, fibers, complements and nanomaterials. Strengthening cement with the help of nanomaterials has been investigated for a long time to prevent crack formation and increase its durability. Due to their high mechanical properties, low density, and thermal and chemical stability, nano powders offer an alternative to cement-containing composites. In this study, the mechanical properties of cement mortars containing nano powders was investigated. Mortars produced by using carbon nanotube, graphene nanoplatelet and nano TiO2 at the rates of 0%, 0.5%, 1% 1.5% and 2% instead of cement. CEN standard sand and CEM I 42.5R cement was used in the mixtures. Mortars specimens at the size of 40x40x160 mm prepared with a constant water/cement ratio and binder content were cured for 7 and 28 days and their flexural and compressive strengths were determined. The 28-day compressive strength values of control mortars, which were 45 MPa, increased by approximately 20% and reached 55 MPa with the substitution of 0.5% graphene nanoplatelet. The 28-day compressive strength values of control mortars, which were 45 MPa, increased by approximately 10% and reached 50 MPa with the substitution of 0.5% carbon nanotube. Substitution of graphene nanoplatelet and carbon nanotube instead of cement caused agglomeration during mixing. Therefore, agglomeration was reduced by using a magnetic stirrer. However, it was predicted that mixing carbon nanotube or graphene nanoplatelet into cement mortar by sonicating it with water would provide higher

homogeneity. The amounts of chemicals used in the production of carbon nanotube or graphene nanoplatelets, mixing times and speeds used in experiments change the product properties of the synthesized graphene, such as average surface roughness and crystal size. Therefore, mortars with different properties can be produced with graphene nanoplatelet or carbon nanotube with different properties. Improvements in strength could be achieved by using low amounts of carbon nanotube or graphene nanoplatelets.

Keywords:

Carbon Nanotube, Cement, Graphene Nanoplatelet, Mechanical Properties, Mortar, Nano TiO2.