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Mechanical Properties and Photocatalytic Reactions of Zinc Oxide Nanoparticles in the Cement Environment

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ABSTRACT: In order to evaluate the performance of zinc oxide nanoparticles on the microstructure and mechanical properties of cement-based materials, compressive strength test, reaction with calcium hydroxide, shrinkage test, x-ray diffraction and infrared spectroscopy analyses were carried out. The results indicated that zinc oxide nanoparticles have significant influences on the mechanical properties of cement based surfaces. It has also been shown that a good reaction with calcium hydroxide occurs and significant reduction in shrinkage of cement mortars was observed. Moreover, the nano zinc oxide incorporated surfaces had high capability in removing the contaminants and provide photocatalytic characteristics for the surfaces.

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1- Introduction

It is clear that clean air is a vital component of a healthy environment; however, air pollution in many regions of the world is reaching the critical point. This event causes acidic raining, reducing the operational life of exterior facades of buildings and aesthetic elements of cities and eventually leads to spreading of disease that could threaten the living organisms [1-3]. Investigations reveal that photocatalytic Oxidation-Reduction reaction compared to conventional methods of removing contaminants is more efficient, which is activated easily by sunlight and could decompose a wide range of organic pollution as a product of fossil fuel combustion and chemical materials [4-6]. Thus, it seems that concrete surfaces of streets and exterior surfaces of buildings which are widely in contact with pollutants are suitable locations for the use of photocatalytic materials. In the current study, the influence of zinc oxide nanoparticles on the self-cleaning characteristics and engineering properties of cement mortars has been investigated. For this purpose, the nanoparticles of zinc oxide were synthesized and their influences have been characterized by different tests.

2- Results and Discussion

2- 1- ZnO Nano Particles

The properties of the produced nanoparticles were determined using SEM and XRD tests. Produced nanoparticles have quite sharp and crystallized peaks compared to the original patterns using the x'pert software. According to the SEM photo (Figure 1) mean nanoparticles size is about 48 nm.

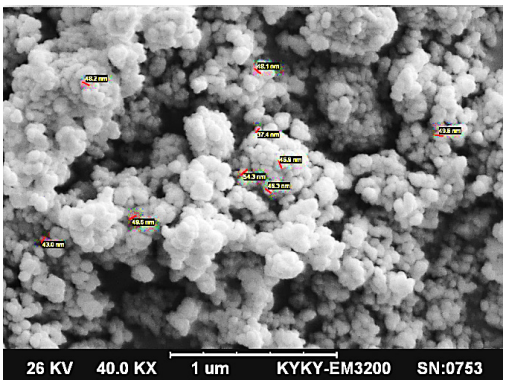

Figure 1. SEM image of zinc oxide nanoparticles

2- 2- The Results of Compressive Strength

Based on the obtained results, it can be understood that with increasing the content of zinc oxide nanoparticles on cement mortar the process of strength gain in lower ages becomes slower and this amount increases with age. The maximum obtained compressive strength in mortars also relates to the mixture with cement replacement level of 0.75% by zinc nano-oxide at 90 days.

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2- 3- Determining the Reactivity Rate with Calcium Hydroxide

This experiment was carried out according to references [7, 8] and was conducted in order to determine the rate of zinc oxide nanoparticles reactivity in comparison with other pozzolans, like silica fume, copper slag, and silica powder. The obtained results showed that the zinc oxide nanoparticles has suitable reactivity with calcium hydroxide in comparison with three investigated pozzolans, so that its favorable reaction capability can be used to enhance the engineering characteristics of cement-based materials.

2- 4- Infrared Spectroscopy of Fourier Transform

Generally, the investigations about FTIR spectrum shows that using zinc oxide nanoparticles in the cement based materials increases the units of polymerization of C-S-H. Accordingly, in the cement based surfaces which include zinc oxide nanoparticles, improving the mechanical properties and durability of cement surfaces can be expected [9, 10].

2- 5- X-Ray Diffraction (XRD)

The investigations using x-ray diffraction on the observed phases in the cementitious matrix which included 3% zinc oxide nanoparticles after 7 days curing shows the new compound of zinc calcium hydroxide.

2- 6- Investigating the Performance of Cement-Based Material in Industrial Pollutants Removal

The results of experiments show the effective performance of these surfaces to remove the color of methylene blue solution. For instance, after 100 minutes in the matrix which included 0.1% zinc oxide nanoparticles, methylene blue was completely removed from the environment and the color of the solution was converted to natural water color.

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