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The Use Of Aluminum Oxide Nanoparticles In Improving Some Mechanical Properties And Increasing The Abrasion Resistance Of Concrete

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ABSTRACT: Today, with the development of nanotechnology, the application of this material is very important in achieving some desired properties in construction materials, especially concrete. In this regard, the use of nano aluminum oxide can cause changes in some physical characteristics and mechanical properties of concrete. Due to the high hardness of aluminum, it is expected to increase the abrasion resistance of concrete with the help of this nanoscale material. In this research, by examining the effect of nano aluminum oxide on the characteristics of concrete, while optimizing the amount of use of these materials, the possibility of using them in special applications, especially concrete coatings and flooring, has been evaluated. The amounts of nano oxide aluminum used in the concrete mixing plan of this research, in weight ratios of 0.25, 0.5 and 0.75%, replace part of the cement. Also, with the aim of reducing the cost and making it easier to implement, the spraying of a diluted nano-aluminum oxide solution in one to four layers on the concrete surface was also tested. The results of this research showed that the addition of 0.5% aluminum oxide nanopowder in concrete can increase the abrasion resistance of concrete up to 77% while partially improving some of the tested mechanical properties. Also, the results of the abrasion test showed that creating a layer of nano-aluminum oxide on the surface of the concrete, despite the improvement of effectiveness by increasing the number of coating layers, is less effective compared to the mixed design.

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1- Introduction

Abrasion of the concrete surface is one of the most common causes of deterioration of the concrete surface. Abrasion often occurs on the surface of the concrete as a result of friction between hard objects [1]. Hardened cement in concrete has little resistance to wear, especially under the effect of alternating loads. Also, due to the continuous passage of vehicles and people in workshops and factories, concrete floors are exposed to wear. Conventional concretes are very weak due to high porosity and low resistance to wear. One of the new methods of increasing the durability and resistance of concrete against wear is the use of nanomaterials in the design of concrete mix [1-2].

In recent years, due to the development of nanotechnology and the use of nanomaterials in concrete technology and due to the properties that these materials can create in concrete, the use of nanomaterials in concrete production has increased. Among the reasons for using nanomaterials in concrete, we can mention environmental issues, quality improvement and the need for special concretes for special conditions. Some of these nanomaterials are being used due to their positive effects, and the effect of some others on the behavior of concrete types is still being discussed [3].

According to the background of the subject, it can be seen that mainly the dosage of aluminum nano oxide in concrete is very variable and in some references, the dosage is above 1% and most of the researches have recommended a weight ratio of less than 1%. Therefore, it is better to use the type and amount of this material in concrete based on the testing or recommendation of the manufacturer, because according to the type and characteristics of the product, the manufacturing method, the level of purity and its chemical base, its effectiveness can be changed. Also, the newness and expensiveness of using this technology are always one of the challenges that must be answered before entering the industry. On the other hand, the effectiveness of this material in concrete over a long period of time (past several years) is always one of the ambiguities of using this material, for which no answer has been found so far. Therefore, in this research, with the aim of optimizing the use of nano aluminum oxide and its effect on concrete characteristics, especially abrasion resistance, this study has been carried out for use in concrete coating and flooring. Also, in order to reduce the construction cost and make this project economical, the coating of diluted aluminum oxide nanolayer has been tested on concrete in different layers and its results have been compared. The use

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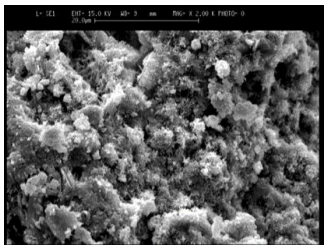

Fig. 1. SEM image of the control concrete sample

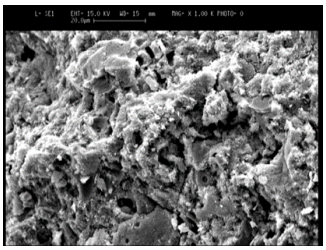

Fig. 2. SEM image of concrete sample with 0.25% nano

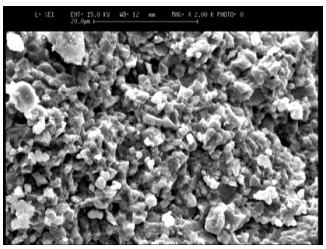

Fig. 3. SEM image of concrete sample with 0.5% nano

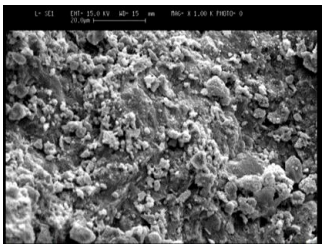

Fig. 4. SEM image of concrete sample with 0.75% nano

of different percentages of nano aluminum oxide to optimize the construction of concrete (before construction) and to investigate the effect of using diluted nano oxide aluminum coating to repair the surface of concrete floors (after construction) is an innovative aspect of this research. . Also, so far, nano aluminum oxide has not been used for coating on concrete. Therefore, the comparison between the mixed design with multi-layer coatings can be useful and effective in choosing and making decisions for use in industries.

2- Materials and Method

The laboratory program for making concrete includes making 6 samples of sand and cement mortar and 56 samples of concrete. At first, in order to obtain the optimal amount of aluminum nano oxide in concrete, sand and cement mortar were made with silica sand in a 10×10×10 cm^3 cube mold. The mixture plan used to make cement sand mortar is 1:6 ratio, and silica sand with a maximum size of 2 mm is used. The amount of aluminum oxide nano in the sand and cement mortar in different weight ratios of 0.5, 1, 1.5, 2 and 3% were substituted for part of the cement. After 7 days of processing and testing the compressive strength of the samples, it was determined that the optimum amount of nano oxide aluminum is in the range of 0.5% by weight instead of cement. Also, the results obtained from other researches conducted in a similar situation will confirm this [7, 5, 2]. Thus, the laboratory program of this research was considered based on the percentages of 0.25, 0.5 and 0.75 by weight of cement.

In the continuation of this research process, in order to reduce the cost and use of nano aluminum oxide in concrete and to examine the economic plan of increasing its durability, concrete samples were made with molds of dimensions 2.5×9×18 cm^3. Then, after 7 and 28 days of treatment, the samples were coated with diluted aluminum nano oxide in one to four layers. The aluminum nano oxide coating layer was diluted with super lubricant in a volume ratio of 3:4 (75% aluminum nano oxide, 25% super lubricant) and mixed for 3 minutes to obtain a homogeneous solution. Then this solution was sprayed on the concrete surface and spread evenly and exposed to the open air for 24 hours until the solution was completely dry and adhered to the concrete surface.

The mix design used for making concrete in this research is based on the weight standard of ACI-211, which is optimized by trial and error based on the type and type of materials. The maximum nominal size of the coarse grain was 19 mm and the ratio of water to cement was 0.4. Also, due to the high water absorption of nano-aluminum oxide in concrete [1] and the need to maintain the efficiency of concrete, carboxylate-based super-lubricant was used at the rate of 0.6% by weight of cement.

3- Result

According to the results obtained from the tests, it was also determined that the use of aluminum oxide nanopowder in concrete increases the resistance and durability of concrete against wear. Also, due to the condensation created by nanomaterials, the amount of water absorption and permeability of concrete decreases. The optimum percentage of using nano aluminum oxide powder additive in concrete mix design was found to be 0.5% by weight of cement. The results of the tests showed that using more than this amount will cause no noticeable change in concrete results or in some cases will cause weakness in concrete. Therefore, from an economic point of view, considering the price and cost of preparing and buying nanomaterials, it is not economical. Also, from the results obtained from the wear test on the samples containing one to four layers of nanomaterial coating, it can be acknowledged that the creation of a coating layer will not have much effect on increasing the wear durability of concrete, and the main reason for this is the lack of proper adhesion of this layer to the concrete surface. But with the increase in thickness and the number of layers, the wear durability also increased. The result of some previous researches on the use of aluminum nano oxide in concrete showed that it will not have much effect on increasing the compressive strength of concrete and it is only used to improve the modulus of elasticity of concrete [1,3,4]. But in this research, it was also proven that adding 0.5% of aluminum oxide nanopowder to the aforementioned concrete mixture will increase the 28-day compressive strength by a maximum of 33%. . Based on the SEM images, it was found that the use of an optimal amount of nanomaterials in concrete causes diffusion and compaction and improves the boundary transition zone in order to prevent the spread of fine and capillary cracks in concrete.

4- Conclusion

1- The results obtained in this research showed that the addition of 0.5% nanopowder in the concrete mix design can increase the 28-day compressive strength of concrete by 33% compared to the control sample. Also, this

additive increases the tensile strength by 21%, which is the highest resistance among all the mixtures studied in this research.

2- The amount of final water absorption in 72 hours of samples with 0.25%, 0.5% and 0.75% is equal to 2.5%, 1.5% and 0.9%, respectively, which is due to the condensation of the space The capillarity of concrete is by nano-materials and it makes the penetration of water in the concrete flow less.

3- The results obtained from the water penetration test in concrete showed that the concrete with 0.25%, 0.5% and 0.75% nano additives can increase the water penetration in concrete by 33%, 41% and 45%. reduce that this is important because of the reduction of concrete porosity due to the addition of nanomaterials.

4- The results of concrete abrasion resistance show that the final abrasion resistance of the 28-day plan with 0.25% nano powder increases by 47%. Also, the design with 0.5% nano powder increased up to 77% and finally, the design with 0.75% nanopowder showed a 64% increase in wear resistance compared to the control sample. Increasing the wear resistance of concrete with the combination of 0.5% nano in the composition of the concrete mix design has the best results, so that by increasing the amount of nanomaterials in the mix of concrete, it will also reduce the adhesion between concrete particles and as a result, it will cause a decrease in the wear resistance of concrete.

5- The amount of abrasion resistance of the design with one and two layers of nanopowder coating has increased by 5.5% compared to the control sample at the age of 28 days. Also, the design with three layers of nano-coating increases by 28% and finally the design with four layers of nanomaterial coating increases the wear resistance by 39% compared to the control sample.

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