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Research Article

The Effect of Nano Fe_2O_3 on the Fiber Reinforced Concrete

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Abstract: In this study, we studied the effect of Nano Fe_2O_3 on the compressive strength of Fiber reinforced concrete, for this purpose, we used cubic samples of 10 Cm with four different by weight of cement contents (0, 1, 2 and 4%, respectively). The cement contents of the concrete (including 300 kg/m^3) and fiber (Polypropylene) volume fraction 0.2% by weight of cement were considered. The water-cement ratio in binder (sum of the cement and nanoparticles) in all mixtures was equal to 0.45. The effect of the Nano Fe_2O_3 on the strength of Fiber reinforced concrete was assessed by measuring the compressive strength after 7 and 28 days. The results showed that Nano Fe_2O_3 particles improve concrete strength and significantly affected on the compressive strength of the Fiber reinforced concrete.

Keywords: Compressive strength, fiber reinforced concrete, nano Fe_2O_3, polypropylene

INTRODUCTION

Nano science plays an important role in production concrete initiatives in the twenty first century. Nano science enables scientists to study at the molecular scale in order to improve physicals and chemical properties of different materials (Li *et al*., 2004).

The use of Nano particles in construction materials is increases day by day and the dramatic impact of these particles on strength of Fiber reinforced concrete has led to further research on Nano particles.

Study of nanoscale materials is conducted to find a new class of materials with high performance that can be called multifunctional materials. The multipurpose performance can lead to new, special and different properties of materials.

In recent years, much research have been done about adding Nano particles to cement, which these particles may be one of these substances or other materials (Iron Oxide or AluminaOxide etc.).For example in recent years Nano Sio_2 uses a lot in the concrete mixture, it make good effect on the concrete and we have many progress in the concrete compressive strength but it has some problem in the workability of concrete so we need to research more than before about Nano particles like Fe_2o_3 or Al_2o_3 (Lu and Young, 1992)

Cement paste made of Nano sized particles could be ready much more quickly than cement paste without Nanoparticle (Kuo *et al*., 2006). This type of cement has more strength, density and greater compactness in comparison with the cement without any nanoparticles (Qing *et al*., 2007).

Nano Fe_2O_3 is one of these nanoparticles which is very important in new technology of building. In the present study the effect of Nano Fe_2O_3 on the compressive strength of fiber-reinforced concrete was determined.

In general, by reducing the size of particles, the ratio of effective surface to volume of the particles increases, As a result, these materials has more potential of reaction with other substances than the ordinary ones, so that these kinds of cement are supposed to have much more stability and impact than cements without any Nano Fe_2O_3 (Toutanji, 1999).

As we know, crystals of calcium hydroxide are formed in the cement paste and its particles hardening process. Nano-Fe2O3 particles can react with these crystals very quickly (Lu and Young, 1992).

This reaction produces hydrated calcium silicate gel and decreases amount of calcium hydroxide crystals. As a result, resistances of cement paste and concrete are increased.

Nano-Fe2O3 particles are used in concrete to fill small cavities and pores in cement paste and they can increase density of particles in concrete (Ji, 2005). Moreover, it can cause changes in hydration process that lead to improve the compressive strength of fiber-reinforced concrete.

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Table 1: Chemical compounds of the cement used in all samples

%	Fe_2O_3	Ca O	$Si O_2$	$S O_3$	$Fe O_3$	K_2O	Na_2O	Mg O
Cement	5.12	58.02	21.45	2.87	3.10	0.82	0.14	4.47

Table 2: Aggregate specifications

Aggregate	Density (gr/cm^3)	The maximum diameter of aggregate (mm)
Gravel	2.86	12.5
Sand	2.51	

Table 3: Concrete weights per mixed cubic (meters per kg)

Polypropylene fiber	Super lubricants	Water	Cement	Sand	Gravel
0.6	4.5	120	300	960	1117

Table 4: Mix design specifications

Name of sample	Percent Nano Fe_2O_3 (%)	Cement (Kg/m^3)	The amount of Nano Fe_2O_3 (kg/m^3)
S0	0	300	0
S1	1	297	3
S2	2	294	6
S4	4	288	12

In this study, compressive strength of concretes with different percentages of Nano Fe_2O_3 particles were compared in order to achieve the suitable percentage and the maximum amount of Nano Fe_2O_3 in fiber-reinforced concrete (Table 1).

MATERIALS AND METHODS

Cement:

Nano Fe_2O_3: All the Nano Fe_2O_3 particles were used as powder; they had spherical, crystalline structures with 99% purity and average particle size of 60 NM.

In this study due to the following reason we used powder of Nano Fe_2O_3:

- Uncertainty amount of the Nano Fe_2O_3 particles in solution.
- Rapid reaction of Nano Fe_2O_3 solution.
- Lubricant or super plasticizers used in Nano Fe_2O_3 solution can affect to Nano Fe_2O_3 particles (Table 2).

Aggregate:

Polypropylene fiber: Polypropylene fibers with a length of about 6 Mm and a density of 0.9 were used and distributed in different directions.

Super lubricants: Super Lubricants with a density of 1.11 kilograms per liter and 1.5% by weight of cement were used.

Mix design: Mixing is done to obtain optimal performance of concrete with the minimum cost.

To get the best mix design, we selected 20 samples from different mix designs. After testing, the best mix design was chosen as follows (Table 3).

Four (4) samples were prepared by replacing Nano Fe_2O_3 particles (0, 1, 2 and 4%), 3 samples were prepared for each rate of Nano Fe_2O_3 particles in order to obtain the average compressive strength. Results obtained from the mix design are shown in Table 4.

In all cases lubricant of 1.5%, polypropylene fiber of 0.2% by weight of cement was used, water cement ratio was 0.45 and cement content of 300 kg/m^3 were constant.

Mix design specifications was chosen as below (Table 4).

RESULTS AND DISCUSSION

Compressive strength of concrete: The results obtained from concrete strength at different ages are shown in Fig. 1.

Figure 1, compressive strengths of samples containing Nano Fe_2O_3 particles at all ages, especially at the age of 7 days, are more than compressive strengths of samples without Nano Fe_2O_3 particles (0%) and by increasing the amount of Nano Fe_2O_3 particles, the compressive strength is increased. The sample containing 2% Nano Fe_2O_3 particles showed better results. By increasing the amount of Nano Fe_2O_3 particles to 4%, effect of Nano Fe_2O_3 particles on improving concrete compressive strength is decreased, but still the compressive strength is greater than the control sample (0% Nano Fe_2O_3).

Due to the wide surface of Nano Fe_2O_3 particles, they can react rapidly with a large number of calcium hydroxide crystals (resulting from hydration reaction between water and cement). This reaction produces hydrated calcium silicate gel that helps to reduce amount of the crystals. If calcium hydroxide remains in the fiber-reinforced concrete, it gradually comes out of the concrete and residues in form of a porous.

In addition, nanoparticles also increase density of the cement mix.

It is recommended to use Nano Fe_2O_3 particles due to the following reasons:

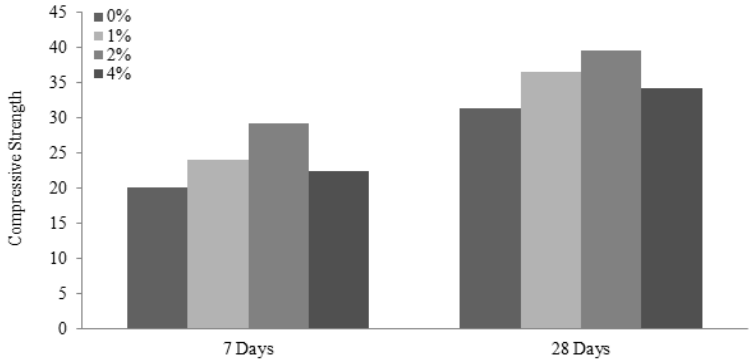

Fig. 1: Compressive strength of concrete (after 7 and 28 days)

- Nano Fe_2O_3 particles are well dispersed; they increase viscosity of the liquid phase and help to suspend the cement grains. As a result, these particles improve strength and performance of the system.
- Nano Fe_2O_3 particles fill the spaces between the cement grains and make the released water position stable.
- Fine spread Nano Fe_2O_3 particles act like crystal or crystalline hydrates. Thus they help hydrating.
- Nano Fe_2O_3 particles have a strong tendency to make uniform clusters and small sizes of hydrated calcium silicate gel.
- Nano Fe_2O_3 plays an important role in long-acting reaction which results in use of calcium hydroxide crystals and leads to produce extra calcium silicate hydrate gel.
- Nanoparticles of Fe_2O_3 increase contact surface, improve type of aggregation and lead to better contact between the aggregates and adhesion of cement.
- Nanoparticles of Fe_2O_3 lead to joint up slip planes to prevent cracking which results in improvement of tolerance, endurance and strength of cement.

CONCLUSION

- The results obtained from the pressure tests and the percentages of samples containing particles, showed that due to the high activity of Nano Fe_2O_3 particles, the maximum effect of Nano Fe_2O_3 particles is seen during the first days. So, the compressive strength was increased after 7 days more than after 28 days.
- Adding Nano Fe_2O_3 particles increases the compressive strength of fiber-reinforced concrete and by increasing amount of Nano Fe_2O_3 particles, the compressive strength becomes better. But 2% Nano Fe_2O_3 (by weight of cement) have the best effect on the compressive strength of fiber-reinforced concrete.
- According to appearance of the samples after the break, it was believed that Nano Fe_2O_3 particles react with calcium hydroxide in the cement paste and hydrated calcium silicate gel is produced. This leads to higher density of concrete and thus increases strength of the samples.
- Because of very small sizes of Nano Fe_2O_3 particles, they tend to mix aggregates. This action produces weak plates in concrete. This reaction occurs at rates more than 2% by weight of cement.

REFERENCES

Ji, T., 2005. Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO_2. Cement Concrete Res., 35(10): 1943-1947.

Kuo, W.T., K.L. Lin, W.C. Chang and H.L. Luo, 2006. Effects of nano-materials on properties of waterworks sludge ash cement paste. J. Ind. Eng. Chem., 12(5): 702-709.

Li, H., H.G. Xiao, J. Yuan and J. Ou, 2004. Microstructure of cement mortar with nano-particles. Compos. Part B-Eng., 35(2): 185-189.

Lu, P. and J.F. Young, 1992. Hot pressed DSP cement paste. Proceeding of Material Research Society Symposium, Vol. 245.

Qing, Y., Z. Zenan, K. Deyu and C. Rongshen, 2007. Influence of Nano-SiO2 addition on properties of hardened cement paste as compared with silica fume. Constr. Build. Mater., 21(3): 539-545.

Toutanji, H.A., 1999. Properties of polypropylene fiber reinforced silica fume expansive-cement concrete. Constr. Build. Mater., 13(4): 171-177.