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Research Article

The Effect of Nano-Al_2O_3 on the Fiber-reinforced Concrete

Seyyed Mahmoud Sheikhaleslamzadeh and Masoud Raofi
Department of Civil Engineering, Islamic Azad University, Shabestar Branch,
East Azerbaijan, Shabestar-Iran

Abstract: In this study, we studied the effects of Nano-Al_2O_3 with different contents on the compressive strength of fiber reinforced concrete, for this purpose we used cubic samples of 10cm with four different contents (0, 1, 2 and 4%) of cement by weight. The cement content of the concrete (including 300 kg/m^3) and fiber (Polypropylene) volume fractions 0.2% of cement by weight were considered. The water to binder (sum of the cement and Nano particles) ratio used for all mixtures is 0.45.The influence of the Nano-Al_2O_3 on the concrete strength was assessed by measuring the compressive strength at 7 and 28 days. The results showed that the use of Nano-Al_2O_3 particles produces concrete with improved strength and significantly effected on the compressive strength of the Fiber-reinforced concrete.

Keywords: Compressive strength, fiber-reinforced concrete, nano-Al_2O_3, Polypropylene fibers

INTRODUCTION

Nano science in the production of concrete initiatives for the twenty-first century plays an important role. Nano science enables scientists to work at the molecular level and to develop new materials atom by atom essentially creating new physical and chemical properties (Lu and Young, 1992). The use of Nano particles in construction materials is increasing and the dramatic impact of these particles on concrete strength has led us to research more about Nano particles. The final goal of the study materials at the Nano scale is finding a new class of materials with high performance that they can be referred to as multi-functional materials. The multipurpose performance an cause to creation of new special and different material properties than usual (Li *et al*., 2004).

In recent years, many researches have been done on adding Nano particles to cement, the Nano particles that added to cement can be from cement's particles (Iron Oxide or AluminaOxide and etc.) Or not. Cement paste made of Nano-sized particles ready in less time and in comparison with paste that prepared from ordinary cement have more strength, density and greater compactness. One of nanoparticles that can we have special attention about it is Nano-Alumina, in this study we try to see the effect of Nano Alumina on the compressive strength of fiber's concrete. In general, by reducing the size of particle, the ratio of effective surface-to-volume of the particles increases, As a result, the reactivity of materials on the Nano scale are higher than the larger size particles so we expect significant impacts on the concrete that we used alumina Nano particles in it (Lu and Young, 1992).

Alumina particles can be react with the crystals of calcium hydroxide in the transition zone between the two procedures hardened cement paste and aggregate (Kuo *et al*., 2006). This reaction creates hydrated calcium silicate's gel, so,the size and amount of calcium hydroxide crystals considerably decreases and initial resistance of hardened cement paste and concrete increases (Qing *et al*., 2007).

AluminaNano particles are used in Fiber-reinforced concrete cause the filling of very fine cavities and pores in the cement paste and can increase the density of particles in concrete (Lu and Young, 1992).

On the other hand, can cause changes in the hydration process that improves the compressive strength of Fiber-reinforced concrete (Toutanji, 1999).

In this study, we tried to check and compared concrete compressive strength fibers with different percentages of alumina particles to achieved fit percent and optimal use of Nano alumina fibers in concrete. In this study due to the following reason we used powder of Nano-alumina:

- Uncertainty amount of the alumina particles in solution.

Corresponding Author: Seyyed Mahmoud Sheikhaleslamzadeh, Department of Civil Engineering, Islamic Azad University, Shabestar Branch, East Azerbaijan, Shabestar-Iran, Tel.: +989143151364

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

%	Al_2O_3	CaO	SiO_2	SO_3	FeO_3	K_2O	Na_2O	MgO
Cement	5.12	58.02	21.45	2.87	3.10	0.82	0.14	4.47

Table 2: Specifications of aggregate

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

Table 3: Concrete weights in a 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-Al_2O_3 (%)	Cement (Kg/m^3)	The amount of Nano Al_2O_3(kg/m^3)
S0	0	300	0
S1	1	297	3
S2	2	294	6
S4	4	288	12

Table 5: Concrete compressive strength (in 7 and 28 days)

Name of sample	Percent Nano-Al_2O_3 (%)	7 Days (MPa)	28 Days (MPa)
S0	0	21.8	33.6
S1	1	26.6	38.7
S2	2	28.2	41.2
S4	4	26.9	38.9

- Due to the rapid deterioration of Nano-alumina solution.
- Lubricant or super plasticizer used in Nano alumina solution can effect to Nano alumina particles.

MATERIALS AND METHODS

When and where the study was conducted: University of Shabestar Labratorys about 3-4 years ago.

Cement: Cement specifications were chosen in Table 1.

Nano-Al_2O_3: All the Nano alumina that used in samples are powder, they have spherical, crystalline structures with purity of 99% and average of particles size are 60 nm.

Aggregate: Aggregate specifications were chosen in Table 2.

Polypropylene fiber: Polypropylene fibers have been used have length of about 6 mm with a density of 0.9 that are completely random and scattered in different directions.

Super lubricants: Super Lubricants have been used have Density of 1.11 kilograms per liter and used 1.5% by weight of cement.

Mix design: The purpose of a mixing ratio is obtained the required performance concrete mix with the possible lowest cost.

To get the best mix design we selected 20 samples from different mix design and after testing, mix design was chosen (Table 3).

4 samples by replacing the alumina particles (0, 1, 2 and 4%) considered, 3 samples were prepared from each state to consider the average results mix design specifications shown in the Table 4.

In all cases lubricant is 1.5%, polypropylene fiber is 0.2% by weight of cement is used, water-cement ratio is 0.45 and Cement content of 300 kg per cubic meter is fixed.

RESULTS AND DISCUSSION

Concrete compressive strength: The results for different ages are in the Table 5.

In Table 5 is specified, compressive strength of samples containing alumina particles in all ages, especially at the age of 7 days, are more than the compressive strength of samples without alumina particles (0%) And by increasing the amount of alumina particles the compressive strength increases. In the sample containing 2% alumina particles show better results, by increasing the amount of alumina particles to 4% the effect of alumina particles on improving Fiber-reinforced concrete compressive strength decreases but still, compressive strength is greater than the control sample (0% Nano-Al_2O_3).

Because of its very high surface area alumina particles have a lot of activities and can react quickly with the large number of crystals of calcium hydroxide (result of the hydration reaction between water and cement) and produce hydrated calcium silicate gel and helping in reducing amount of the crystals. If calcium hydroxide staying in the concrete over time as sediment

washed out of Fiber-reinforced concrete and will remove and replaced with air vents and pores.

The Nano particles also improve density of the cement mix.

The reasons why we are encouraging the use of Nano-Alumina:

- Alumina Nano particles are well dispersed and Increases the viscosity of the liquid phase and helps in suspending of the cement grains it causes Improving Strength and system performance.
- Alumina Nano particles fill the space between the grains of cement and cause inactivity or stagnation of released water.
- Alumina Nano particles that spread fine acts like crystal or crystalline hydrates centers Thus it is helping in hydrating.
- Alumina Nano particles has a strong tendency to make uniform clusters and small size of hydrated calcium silicate gel.
- Nano-alumina helps in reactions that lead to the use of crystals of calcium hydroxide and making additional calcium silicate hydrate gel.
- Nanoparticles of alumina improve type of aggregation, surface structure that causes better connection between aggregation and adhesion of cement.
- Avoid cracking and joining slip planes provided by Nanoparticles and improves tolerance Endurance, ordering, elasticity and strength of cement.

CONCLUSION

- The results of the pressure tests and the percentage of samples containing particles, show, due to the high activity of Nano-alumina, the most effect of Nano-alumina is during the first days so Compressive strength increase more in the age of 7 days than 28 days.
- Adding Nano-alumina is increases the compressive strength of Fiber-reinforced concrete and by increasing amount of Alumina Nano particles the compressive strength become better but 2% Nano-alumina (by weight of cement) have the best effect on the compressive strength of Fiber-reinforced concrete.
- Due to the appearance of the samples after the break it is believed alumina particles reacts with calcium hydroxide in the cement paste and hydrated calcium silicate gel produces, this leads concrete to higher density and thus increase the strength of the samples.
- Nano alumina is too small so tend to aggregate heavily in the mix, Alumina particles that become aggregate due to make poor sections in the concrete so compressive strength of concrete is reduced thus overuse of alumina particles (more than 2% by weight of cement) is even reduced the compressive strength of Fiber-reinforced concrete.

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