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EFFECTS OF NANO-SILICA ON PERMEABILITY OF CONCRETE

L.Ranjith Kumar[1], M.V.Vijayaprakash[2], E.Thalapathi[3]

[1]*Assistant Professor Civil Engineering, Panimalar Engineering College, Chennai (India)*

[2&3]*Student Civil Engineering, Panimalar Engineering College, Chennai (India)*

ABSTRACT

In this paper, compressive strength and water absorption of the concretes containing Nano-SiO2 and are investigated in the ages of 7, 14, 28 days. Observations indicate that the concretes produced with Nano-SiO2 show higher degrees of quality in their compressive strength. Specimens with 2% Nano-SiO2 have had less water absorption in comparison with the others.

I. INTRODUCTION

In the recent years, the use of Nano-silica to improve the properties of concrete has opened a vast view to the concrete structures. Materials in the size of Nano have shown a good effect on concrete mixtures because of their higher special surface. In the published reports, researchers have used different Nano materials to test the effect of them on the concrete among which, Nano-silica has attracted more attention due to the Pozzolanic properties. The Pozzolanic activity of Nano-silica is more obvious than that of silica fume. Nano-silica can react with calcium hydroxide Ca(OH)2) crystals, which are arrayed in the interfacial transition zone (ITZ) between hardened cement paste and aggregates, and produce C–S–H gel. Thus, the size and amount of calcium hydroxide crystals are significantly decreased, and the early age strength of the hardened cement paste is increased.

II. MATERIALS AND METHODS

2.1 Materials

Cementitious material used were ordinary Portland cement (OPC), silica fume powder (SF) and Nano-silica particles (NS). Their chemical and physical properties, are given in Table1. The superplasticizer, a Polycarboxylate manufactured by BASF with a relative density of 1.3, was incorporated into all mixes. The coarse aggregates used are the continuous grading crushed gravels, with the maximum particle size of 20 mm. The fine aggregates are river sands, with a fineness modulus of 2.5.

2.2 Mix Proportions:

Details of mix proportions for specimens containing silica fume and Nano-silica are given in Table 2. The water–cement ratio (w/cm) was 0.35, and two contents of Nano-silica particles were 1% and 2% by weight of cement. The compressive strengths and of the concrete specimens with the addition of silica fume were also evaluated at the w/cm ratio of 0.35 to compare with concrete containing Nano-silica particles content of silicafume was 10% by weight of cement. In all mixtures, the amount of superplasticizer is constant.

TABLE 1: COMPOSITION AND PHYSICAL PROPERTIES OF MATERIALS

ITEM	COMPOSITION (%)		
	OPC	SILICA FUME	NANO-SILICA
SiO2	22	95	99.9
Al2O3	6.6	0.9	-
Fe2O3	2.8	0.6	-
CaO	60.1	0.3	-
MgO	3.3	0.9	-
SO3	2.1	0.5	-
Specific Gravity	3.15	2.33	-
Avg. Particle Size	13µm	0.1µm	40nm

Test Procedure

The cement, fine aggregates, coarse aggregates and silica fume were mixed in a rotary mixer for 30 s. The ready-mixed liquid including water, SP and Nano-silica was poured into the rotary mixer slowly. The concrete mixture was mixed for another 1.5 min. The well-mixed concrete mixture was poured into molds to form the cubes of the size 15x 15x15 cm for the compressive strength testing. After being demoulded at the age of one day, all specimens were cured in water at 20 ± 1 °C for 7, 14 and 28 days.

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Compressive Strength

The obtained values of concrete compressive strengthafter 7,14and 28 days according to the different used percentage of Nano-silica are shown in table3. It can be seen that the compressive strength was developed in specimens containing Nano-silica particles in every case higher than that of normal concrete. The difference in the strength development of the specimenscan be attributed to Pozzolanic reaction. As mentioned above, Nano-particles are thought to be more effective in Pozzolanic reaction than silica fume. Also, the Nano-silica would fill pores to increase the specimens strength, as silica fume does. Therefore, it is confirmed that the addition of Nano-silica to concrete specimens improves their strength characteristics. The strength of the concrete specimens was found to increase as the Nano-silica content increased from 1% and 2%. However, it should be noted that using a higher content of Nano-silica must be accompanied by adjustments to the water and superplasticizer dosage in the mix in order to ensure that specimens do not suffer excessive self desiccation and cracking. Otherwise, using this much quantity of Nano-silica could actually lower the strength of composites instead of improving it, although this finding was not observed in this study.

TABLE 3: COMPRESSIVE STRENGTH RESULTS

Item	Compressive Strength		
	7 days	14 days	28 days
NC	**40**	**44.3**	**48.5**
NSC1	**42.4**	**46.5**	**54.3**
NSC2	**48.5**	**50.2**	**56.2**

3.2 Water Absorption

To determine the effects ofNano-silica on permeability of the specimens, water absorption test done at the age of 28-day according to ASTM-C 642. Results of this test are shown in table 4. as it clear from this table, adding Pozzolana (of course with a propitiate percentage) to the NC specimen resulted to decrease water absorption and permeability of the concrete. Of course the effect of Nano-silica in reducing the permeability is more than the effect of silica fume.

TABLE 4: WATER ABSORPTION TEST:

Test	NC	NSC1	NSC2
WAB	6.5	4.26	3.96

3.3 Electrical Resistance:

Electrical resistance is one of the most important parameters which can provides us a lot of useful information about the durability of the concrete. The concrete acts as a capacitor under the electrical field. Changing the frequency of the electric current we can reach to the real resistance of the concrete. On the other hand, using the real resistance of the concrete, the resistivity can obtain. The concretes with the resistivity higher than 20 Kilo Ohm are resistant against the chlorine.

$$\mathbf{P} = \frac{R A}{L}$$

ρ: Resistivity (Ohm – Cm)

R: Real resistance (Ohm)

A: Area of the specimen (

L: Length of the specimen (Cm)

Table 4: Water absorption Test:

Item	Electrical Resistance (Ohm – Cm)	
	14 Days	28 Days
NC	8.32	11.33
NSC1	32.45	44.24
NSC2	49.76	52.16

As it clear from the results, the specimens with Nano-silica have more electrical resistance than the control specimen in both age of 14 and 28 day.

IV. CONCLUSION

The results show that using Nano-silica because of decreasing the amount of pores in concrete will increases the compressive strength and the electrical resistance in the specimens. On the other hand it can decreases the water absorption up to 35%. So using this kind of concrete can dramatically increases the lifetime of offshore structures and reduces the cost of buildings.

The results of electrical resistance of the specimens containing Nano-silica show that Pozzuolana could have a good effect against steel bars reinforcement corrosion. Also using Pozzuolana in concrete mixtures would prove the mechanical properties of the concrete.

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