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PERFORMANCE OF CONCRETE BY INCORPORATING NANO-SIZED PARTICLES

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ABSTRACT

Concrete can be nano-engineered by incorporating nano-sized particles to modify its properties and provide concrete with superior performance. The nanoparticle is the elementary building block in nanotechnology and is comprised of up to thousands of atoms combined into a cluster of 1-100 nm. Reduction in the size provides an exceptional surface area-to-volume ratio thereby changing its basic properties and reactivity. Nano-silica (silicon dioxide nanoparticles), for example, has been shown to improve workability and strength in concrete. Nano-alumina (aluminum trioxide nanoparticles) and Nano-titanium (titanium dioxide nanoparticles) has shown better performance towards durability of concrete. In the present work concrete of M40 grade induced with both nano-silica (NS) and nano-alumina (NA), nano-silica and nano-titanium (NT) are to be tested for fresh and hard properties of concrete including durability. Also to report the optimum dosage of combination of nano materials as a percentage weight of cement for better performance of concrete.

Keywords: *Concrete; Nano-silica; Nano-alumina; Nano-Titanium; Optimum dosage*

I. INTRODUCTION

During the recent years, Nano technology is developing with noticeable rate. Due to the new potential uses of Nano particles there is a global interest in investigation of the influence of Nano-particles in construction materials especially in cement mortar and concrete. Many of the available studies have focused on the effect of Nano-SiO2 on properties of hardened cement paste, cement mortar and/or concrete.

II. MATERIALS AND MIXING PROCEDURE

The quality of concrete can be achieved by selection of suitable materials, admixtures, and the choice of mix proportions, w/c ratio and use of proper methods of placements and curing. All these aspects depend upon materials and admixtures.

The properties of cement used: -
Normal consistency – 32%
Initial Setting time – 29.3 mins
Fineness – 3.67%
Specific Gravity – 3.15

Admixtures used in the study are fly ash, ground granulated blast furnace slag (GGBS), Nano Silica (NS), Nano Alumina (NA), Nano Titanium (NT). Crushed rock fines are also used as replacement for fine aggregates. CONPLAST is used as super plasticizer.

III. CEMENT AND CONCRETE MIXING

When it comes to improvements in concrete properties, mixing technology is as important as concrete composition. Mixing is an essential step in the production of uniform, high quality concrete. It is decisive, that water, cement and admixtures are evenly dispersed and distributed down to a fine scale and that agglomerates are sufficiently dispersed.

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Wet mixing is preferred than dry mixing for uniform dispersion of nanomaterials. The nanomaterials are mixed in water and blended using blender to make it lumps free and then added to concrete mix. Conplast is used for better workability when concrete is mixed with nanomaterials. Percentage of conplast used is 1.5% weight of cement.

IV. METHODOLOGY

Three different specimens of M40 mix - control concrete, 25% fly ash and 25% GGBS as percentage weight of cement, CRF as full replacement of fine aggregate.

Table 1.Mix proportions and quantities

	1:1.702:2.426
W/C	0.45

Water	197.55 kg/m3
Cement	439 kg/m^3
Fine Aggregate	747.2 kg/m3
Coarse Aggregate	1065.4 kg/m3

- Repeating the three mixes adding 3% nano-silica and testing for compressive, split tensile and flexural strength for the age of 28 days.
- Durability of these mixes is measured by evaluating loss in strength and weight after acid attack and sulphate attack for 28 days.
- Testing specimens with combination of nanoparticles i.e., NS and NA, NS and NT for compressive strength and durability.
- 3% of nanoparticle by weight of cement is used per mix.

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Table 2. Different Proportions of Nanomaterials used

Mix	Nano Silica Percentage	Nano Alumina Percentage	Nano Titania Percentage
1	-	-	-
2	3	-	-
3	2	1	-
4	1.5	1.5	-
5	1	2	-
6	-	3	-
7	2	-	1
8	1.5	-	1.5
9	1	-	2
10	-	-	3

Fig. 1Cubes with 0%NS and 3%NA

Fig .2 Cubes with 2%NS and 1%NA

V. RESULTS

Mechanical Properties of samples

Table.3. Results of sample with fly ash, CRF and Nano silica

	Description	Replacement % wt of	NDT UPV	Compressive Strength	Split Tensile Strength	Flexural Strength
			m/sec	N/mm^2	N/mm^2	N/mm^2
Control Mix			4702	45.33	10.63	10.26

Mix 1	25% FA 25% GGBS	Cement	4237	42.05	10.4	7.53
Mix 2	100% CRF	FA	4630	44.36	11.23	9.2
Mix 3	3% NS	Cement	3245	34.22	7.54	3.03
Mix 4	25% FA 25% GGBS 3% NS	Cement	3654	38.26	7.89	4.26
Mix 5	100% CRF 3%NS	FA andCement	3788	39.21	8.24	5.1

Table.4 .Results of sample with NS, NA and their combination

	Description	Notation	Replacement % wt of	NDT UPVm/sec	Compressive StrengthN/mm^2
Mix 3*	3%NS	H	Cement	4523	54.66
Mix 6	2% NS 1% NA	Q	Cement	4615	58.69
Mix 7	1% NS 2% NA	T	Cement	4587	56.9
Mix 8	3% NA	X	Cement	4464	50.36
Mix 9	1.5% NS 1.5% NA	V	Cement	4598	57.28
Mix 10	Control with SP	U		4302	45.21

Table 5. Results of sample with NS, NT and their combination

	Description	Notation	Replacement % wt of	NDT UPV	Compressive Strength
				m/sec	N/mm^2
Mix 3*	3%NS	H	Cement	4523	54.66
Mix 11	2% NS 1% NT	E	Cement	4658	59.14
Mix 12	1% NS 2% NT	Z	Cement	4515	55.45
Mix 13	3% NT	L	Cement	4432	47.42
Mix 14	1.5% NS 1.5% NT	B	Cement	4607	57.08
Mix 10	Control with SP	U		4302	45.21

Table 6. Durability Results of sample with NS, NA and their combination

	Description	Replacement % wt of	Compressive Strength after acid attack	Compressive Strength after sulphate attack
			N/mm^2	N/mm^2
Mix 3*	3%NS	Cement	48.07	50.23
Mix 6	2% NS 1% NA	Cement	52.69	55.02

Mix 7	1% NS 2% NA	Cement	50.55	52.65
Mix 8	3% NA	Cement	48.36	49.1
Mix 9	1.5% NS 1.5% NA	Cement	51.48	52.4
Mix 10	Control with SP		41.8	41.86

VI. DISCUSSION AND CONSLUSION

- Concrete with nano materials does not form a workable mix, there is no use of increasing the water content as there is no gain in strength. The reason being nano materials with water formed colloidal solution which is thicker therefore reducing the workability.
- Fly ash and GGBS as together with 50% replacement of cement has no gain in strength of concrete due to decrease in required cementitious materials.
- Crush rock fines neither improve nor decrease the mechanical properties of concrete. Therefore, they can be used as full replacement of sand if readily available.
- Out of the three nano materials used nano silica is best among improving the compressive strength of concrete by 21%.
- Combination of nano materials also has been showed to improve the strength of concrete by greater percentage than usage of single nano particles, reason being nano particles are forming integral bulk when used together.
- Optimum dosage of combination of nano silica and nano alumina is 2%, 1% respectively.
- Similarly, for nano silica and nano titanium also it is 2%,1% respectively.

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