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Development of High Performance Concrete Using Nano Silica

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Abstract*— Use of high performance concrete in present days is increasing as conventional concrete does not meets the requirement. Hence it is necessary to develop high performance concrete. The high performance concrete is one which has the characteristics like workability, high strength & durability. These characteristics are not found in conventional concrete. From the recent study [1],[2],[4],[6], it is found that the high performance concrete can be developed by using supplementary cementecious materials & high quality superplasticizers. Use of Nano materials is gaining importance due to its vital characteristics, these materials helps in developing high performance concrete[11]. This study aims at developing high performance concrete using Nanosilica. Initially, M60 grade concrete (high strength concrete) is designed and prepared with and without Nano silica. Then it is proposed to make this concrete as high performance concrete by using high quality superplasticizer and a better packing of coarse aggregate(40% 10mm downsize &60% 20mm down size).The test results shows that slump higher than 210mm , strength 68.44 to 75.11MPa and better resistance to water obsorption.

Keywords*— Nano Silica, High performance concrete, Supplimentary cementecious Material (SCM), Durability, Workability.

I. INTRODUCTION

Compressive strength of HPC mix is complex function of water powder ratio & superplasticizer dosage [1]. Acceptable strength and durability characteristics can be achieved by using admixtures [2].Addition of Nano particles makes concrete more sticky hence , suitable plasticizers can be used to achieve required workability [3]. From the results it can be concluded that because of the nucleation effect of the Nano silica , more C-S-H gel can be generated [4].A methodology based on cementing efficiency of fly ash 'k' was successfully used to modify the cement concrete mix[5]., The combined use of fly ash , silica fume & Nano silica reduces the use of silica fume as its availability is reducing in market[6].Nanotechnology remains in its pre exploration stage , it is just emerging from fundamental research to industrial applications. However the tremendous potential of Nanotechnology to improve the performance of conventional materials and process is most promising[7].Use of Nano silica has improved rheological and permeability properties of concrete[8].

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Concrete science is a multidisciplinary area of research where Nanotechnology potentially offers the opportunity to enhance the understanding of concrete behaviour to engineers and its properties to lower the construction cost [9]. In case of packing density method w/c decreases with increase in grade of concrete [10]. This paper discusses about the development of high performance concrete using Nano silica.

II. MATERIALS AND PROPERTIES

1) Cement: Ordinary Portland cement 43 grade confirming to IS: 8112-1989; Specific gravity: 3.15.
Density: 1.45gm/cc

2) Fine aggregate: Locally available natural sand confirming to zone III of IS: 383.
Density: 1.6 gm /cc
Specific gravity: 2.6

3) Coarse aggregate: Locally available crushed angular coarse aggregate of maximum size 20mm, confirming to IS: 383 grade.
10mm Density: 1.65 gm/cc
Specific gravity: 2.91
20mm Density: 1.7 gm/cc
Specific gravity: 2.7

4) Water: Potable water confirming to IS: 456-2000.

5) Nano Silica:
Purity: 99%
Crystallite size: 1nm
BET surface area: 110 m^2/gm
Density: 0.236 gm/cc
Specific gravity: 0.4

6) Superplasticizer:
i) Conplast SP 430
Specific gravity: 1.19
ii) SP111
Specific gravity: 1.19 to1.24

TABLE 1(a): Quantity of materials for 1 cum of high strength concrete

Mix proportion of M60 concrete 1:1.38:1.54 (Without Nano Silica) Superplasticizer (SP111) : 2% of cement				
Cement	Fine aggregate	Coarse aggregate	Water	W/C
579kg	803kg	892kg	156.2kg	0.27

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TABLE 1(b): Quantity of materials for 1 cum of high strength Nano silica concrete

Mix proportion of M60 concrete 1:1.35:1.51 (With Nano Silica) Superplasticizer (SP111) : 2% of binder Nano Silica @ 1.5% of weight of cement

Cement	Nano Silica	Fine aggregate	Coarse aggregate	water	W/b
561 kg	8.54kg	769 kg	860 kg	165.16kg	0.29

III. EXPERIMENTAL PROGRAMME

Initially M60 concrete with & without Nano Silica is prepared as per the mix proportions designed by refering IS guide lines [12]. The specimens were tested for workability, compressive strength and water obsorption. Later the above concrete mix is redesigned & prepared using high quality super plasticizer(Conplast SP 430) and varying the size of coarse aggregate (60% 20mm ,40% 10mm).The dosage of superplasticizer is varied sequancially from 3% to 4.25% (by weight of binder) for better workability. The specimens for each dosage of superplasticizer are prepared and are tested for workability, strength and water obsorption.

IV. METHODOLOGY

To prepare Nano Silica conrete ,initially water reducing agent of suitable proportion is mixed in water thoroughly. Then the required quantity of Nano Silica is added to the mix and stirred for two minuites. Cement ,sand & coarse aggregate are mixed in pan mixer for five minuites. The mixture of water,water reducing agent & Nano Silica is poured into the pan mixer and rotated for ten minuites to achieve homogeneity. Fresh concrete is tested for workability, then concrete is poured into the cube mould and vibrated, The specimens are kept for 24 hours at room temperature. After demoulding, specimens are immersed in the water tank for curing. The cured cubes are dried & immersed again in water tank for water obsorption test. 1 day, 2days & 3 days water obsorption test is carried out.

V. TEST RESULTS

Table 2 (a): Lab Test results of M60 concrete

SP (percentage)	PACKING DENSITY (gm/cc)	SLUMP (mm)	COMPRESSIVE STRENGTH (MPa)		WATER OBSORPTION (Percentage)			
			7 days	28 days	1 Day	2 Days	3 Days	
2	0.613	NIL	48.0	68.44	2.52	4.77	5.65	

Table 2 (b): Lab Test results of M60 Nano Silica concrete

SP (percentage)	PACKING DENSITY (gm/cc)	SLUMP (mm)	COMPRESSIVE STRENGTH (MPa)		WATER OBSORPTION (Percentage)			
			7 days	28 days	1 Day	2 Days	3 Days	
2	0.616	NIL	49.33	68.88	2.19	4.21	4.51	

Table 3: Lab Test results of High Performance Concrete

SP (percentage)	PACKING DENSITY (gm/cc)	SLUMP (mm)	COMPRESSIVE STRENGTH (MPa)		WATER OBSORPTION (Percentage)			
			7 days	28 days	1 Day	2 Days	3 Days	
3.00	0.6344	230	52.00	70.66	1.98	4.07	5.05	
3.25	0.6475	240	57.77	72.88	3.06	3.80	4.90	
3.50	0.6400	210	51.51	69.77	2.50	2.40	4.80	
3.75	0.6270	240	51.11	69.33	3.50	3.70	4.70	
4.00	0.6250	230	50.22	68.88	2.08	3.60	6.00	
4.25	0.6190	240	48.88	68.44	0.69	3.70	4.40	

Table 4: Lab Test results of High Performance Nano Silica Concrete

SP (percentage)	PACKING DENSITY (gm/cc)	SLUMP (mm)	COMPRESSIVE STRENGTH (MPa)		WATER OBSORPTION (Percentage)			
			7 days	28 days	1 Day	2 Days	3 Days	
3.00	0.6436	240	52.88	71.55	1.19	3.40	4.01	

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3.25	0.6547	230	58.60	75.11	2.08	2.30	3.12	
3.50	0.6446	230	53.77	71.55	1.50	1.52	2.25	
3.75	0.6322	240	52.88	70.66	0.62	1.50	2.61	
4.00	0.6295	230	52.00	69.77	0.78	2.10	4.00	
4.25	0.6240	230	51.10	69.33	0.54	2.07	3.08	

V1. DISCUSSION ON TEST RESULTS

Initially there was zero slump for both high strength concrete. By using high quality superplasticizer (Conplast SP 430) and varying the size of coarse aggregate(40% 10mm downsize, 60% 20mm down size) it was possible to achieve a slump up to 240mm and packing density up to 0.6547gm/cc. The maximum packing density & strength achieved is at 3.25% SP dosage for both high performance concrete.High performance Nano silica concrete showed 9% increase in strength and about 35% better durability compared to high strength Nano silica concrete. The variation of packing density with SP dosage is shown in Fig 1(a) & 1(b), similarly the variation of compressive strength with SP dosage is shown in Fig 2(a) & 2(b).

VII. CONCLUSIONS

The addition of Nano Silica and packing of coarse aggregate has resulted in development of high performance concrete. High performance concrete is a function of Supplimentary cementecious material (SCM), cement paste, superplasticizer dosage & aggregate packing. From the results it is found that , the optimum superplasticizer dosage is 3.25% to achieve high performance concrete. A mix proportion with slump up to 240mm, 28 days strength 75.11N/mm^2 and better durability is proposed.

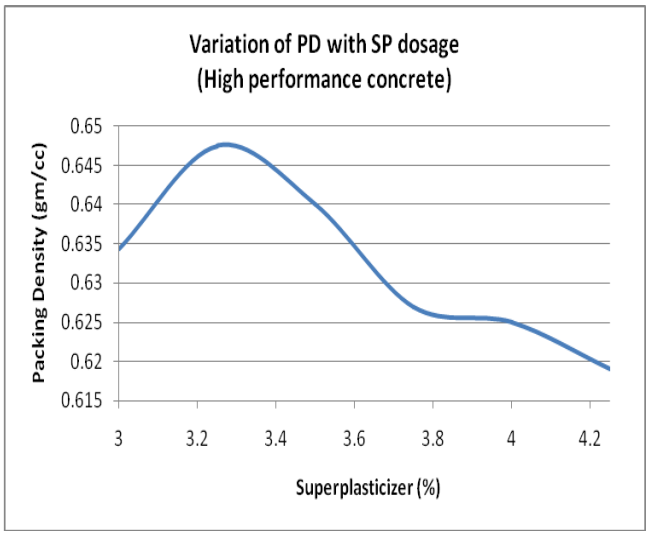

Fig. 1(a)

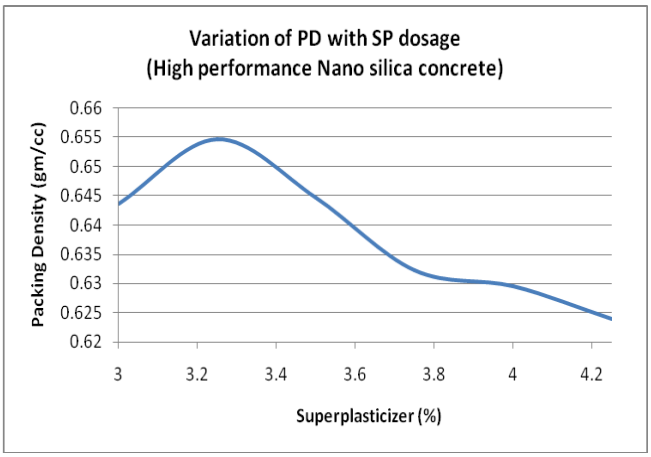

Fig. 1(b)

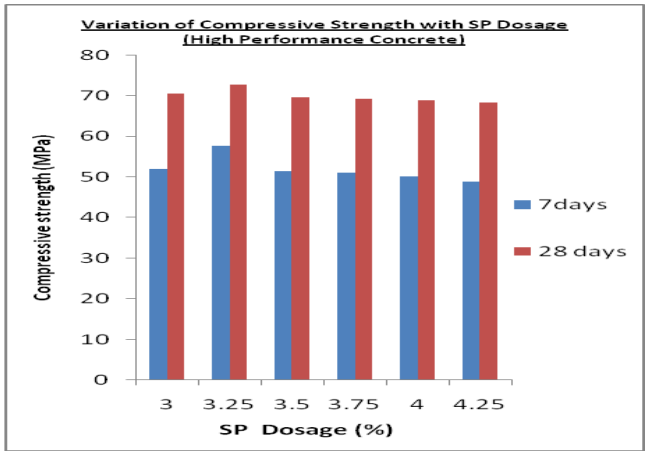

Fig. 2(a)

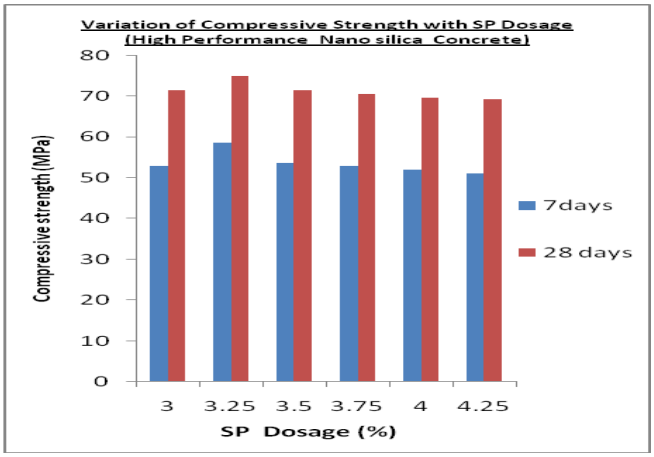

Fig. 2(b)

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