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Experimental Approach in Various Possessions of High Performance Self-Compacting Concrete Incorporating NanoSilica

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Abstract: **In this advance civilization, structural concrete research of self-compacting concrete is a revolutionary disk of social development and implemented worldwide. In the current scenario of modern construction Self-compacting concrete contributes a dynamic role to fulfil the demand of modern architectural and it's complex form work with reinforcement having intricate geometrical configuration where SCC easily flow around the impenetrable reinforcement without blocking and fill into all corners and junctions of formwork without mechanical compaction targeting avoid honeycombs/voids as well as save time, labour and energy. In this research work there are wide ranges of experimental approach in various possessions of self-compacting concrete incorporating NanoSilica 0%, 0.25%, 0.50%, 0.75%,1.0% replaced by cement which cover the assortments of experiments of Fresh Concrete Test i.e. Slump flow test, J-Ring test, V-Funnel test, L-Box test and U-Box test, with different Control Mixes i.e. CM, CM1, CM2, CM3 and CM4 of target strength of 30 Mpa grade, perform after the curing time period of 7, 28 and 56 days. NanoSilica is a revolutionary modern colloidal material which will react with C_3S and C_2S in the cement and produce CSH that will form a flexible high performance bond of gel. The extraordinary results shows the Designed Rheological workability (DRW) categorized as high performed filling ability, passing ability, segregation resistance which make the concrete high perform mechanical behaviour that is High Performance Self-Compacting Concrete (HPSCC).**

Keywords: **Self-Compacting Concrete, Slump flow test, J-Ring, V-Funnel L-Box, U-Box, Sulphate resistance, High Performance Self-Compacting Concrete (HPSCC).**

I. INTRODUCTION

In the field of advance concrete research self-compacting concrete contribute a innovatory role for the development and its usage worldwide. Self-compacting concrete (SCC) is well-defined as a high flow ability, non-segregation concrete that doesn't require mechanical vibration and ability to compact itself by its own weight. Self-compacting concrete is classified by a low yield stress, Designed Rheological workability (DRW), filling ability, passing ability, segregation resistance, High Strength Dense Micro Structure (HSDMS), High Deformability, High Durability as a High Performance Concrete (HPC).It's a kind of High Performance Self-compacting Concrete (HPSCC) with the application of nanotechnology as a NanoSilica [1].The introduction of "current" self-compacting concrete (SCC) is associated with the drive towards better quality concrete pursued in Japan around 1983, where the lack of uniform and complete compaction had been identified as the primary factor responsible for poor performance of concrete structures (Dehn et al., 2000). Due to the fact that there were no practical means by which full compaction of concrete on a site was ever to be fully guaranteed, the focus therefore turned onto the elimination of the need to compact, by vibration or any other means. This led to the development of the first practicable SCC by researchers Okamura and Ozawa, around 1986, at the University of Tokyo [2].

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The prime aim of this study is to investigate the mechanical properties (compressive strength and splitting tensile strength) and sulphate resistance of self compacting concrete. For this purpose cement is replaced by weight in five different proportions of 0%, 0.25%, 0.50%, 0.75% and 1.0% by NanoSilica. Specimens are tested for compressive strength, splitting tensile strength and sulphate resistance. Testing is done at age of 7, 28 and 56 days, as per Indian Standard Specifications (BIS: 516 – 1959) [3] and (BIS: 5816-1999) [4] respectively. Sulphate resistance test was conducted as per (ASTM C 1012) [5].

Self compacting concrete made in this work by incorporating NanoSilica passes all fresh stage tests of SCC. Furthermore hardened stage tests (compressive strength and splitting tensile strength) results were also positive. Also there was up grading in sulphate resistance test of SCC when cement is replaced by NanoSilica.

II. EXPERIMENTAL WORK METHODOLOGY

In the experimental program, the comparison of the properties of Self Compacting concrete made with different replacement level of NanoSilica i.e. (0%, 0.25%, 0.50%, 0.75% and 1.0%). The basic tests of fresh properties of concrete carried out on concrete samples, and then the various tests conducted on the specimens as compressive strength, splitting tensile strength and sulphate resistance test of SCC.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Case 1: Experimental approach on Fresh Concrete Test:

In this research work there are wide ranges of experimental approach in various possessions of self-compacting concrete incorporating NanoSilica 0%, 0.25%, 0.50%, 0.75%, 1.0% replaced by cement which cover the assortments of experiments of **Fresh Concrete Test** i.e. Slump flow test, J-Ring test, V-Funnel test, L-Box test and U-Box test, with different Control Mixes i.e. CM, CM1, CM2, CM3 and CM4 is as per EFNARC [6]

A) Slump Flow

Table 1: Slump Flow Test with different percentage replacement by NanoSilica.

Sr. No.	% Replacement by NanoSilica	Mix Designation	Slump Flow (dia-mm)
1	0 %	CM	660
2	0.25 %	CM 1	620
3	0.50 %	CM 2	605
4	0.75 %	CM 3	580
5	1.0 %	CM 4	560

B) J-Ring

Table 2: J-Ring Test with different percentage replacement by NanoSilica.

Sr. No.	% Replacement by NanoSilica	Mix Designation	J-Ring (mm flow)	J-Ring (mm height)
1	0 %	CM	620	3.5
2	0.25 %	CM 1	590	3.8
3	0.50 %	CM 2	585	4.3
4	0.75 %	CM 3	550	4.7
5	1.0 %	CM 4	515	5.4

C) V-Funnel

Table 3: V-Funnel Test with different percentage replacement by NanoSilica.

Sr. No.	% Replacement by NanoSilica	Mix Designation	V-Funnel Test (seconds)
1	0 %	CM	9
2	0.25 %	CM 1	10.2
3	0.50 %	CM 2	10.9
4	0.75 %	CM 3	11.5
5	1.0 %	CM 4	12

D) L-Box

Table no. 4: L-Box Test with different percentage replacement by NanoSilica

Sr. No.	% Replacement by NanoSilica	Mix Designation	L-Box Test (H_2/H_1mm)
1	0 %	CM	0.9
2	0.25 %	CM 1	0.85
3	0.50 %	CM 2	0.84
4	0.75 %	CM 3	0.82
5	1.0 %	CM 4	0.8

E) U-Box Test.

Table no. 5: U-Box Test with different percentage replacement by NanoSilica.

Sr. No.	% Replacement by NanoSilica	Mix Designation	U-Box Test (H_2/H_1mm)
1	0 %	CM	0
2	0.25 %	CM 1	1.0
3	0.50 %	CM 2	2.5
4	0.75 %	CM 3	5.0
5	1.0 %	CM 4	8.0

F) Combined Test Results of SCC with Different NanoSilica Percentage

Table no. 6: Combined Tabulated Results for different Percentage of NanoSilica

Test Method	CM (0%)	CM1 (0.25%)	CM2 (0.50%)	CM3 (0.75%)	CM4 (1.0%)
Slump flow	660	620	605	580	560
J-Ring	3.5	3.8	4.3	4.7	5.4
V- Funnel	9	10.2	10.9	11.5	12
L-Box	0.9	0.85	0.84	0.82	0.8
U-Box	0	1.0	2.5	5.0	8.0

CASE 2: EXPERIMENTAL APPROACH ON HARDEN CONCRETE TEST:

The mechanical strength of SCC is generally categorized in terms of compressive strength and split tensile strength

Compressive Strength Test

Table No 7: Compressive Strength for different replacement Levels of NanoSilica (N/mm^2)

Sr. No.	Mix Designation	Replacement by NanoSilica	Duration of Moist Curing (Days)		
			7(N/mm^2)	28(N/mm^2)	56(N/mm^2)
1	CM	0 %	26.32	36.64	39.37
2	CM1	0.25 %	27.16	36.91	40.11
3	CM2	0.50 %	31.19	37.48	40.24
4	CM3	0.75 %	32.38	38.1	42.87
5	CM4	1.0 %	34.59	39.22	44.46

Split Tensile Strength Test

Table No 8: Split Tensile Strength for different replacement Levels of NanoSilica (N/mm^2)

Sr. No.	Mix Designation	Replacement by NanoSilica	Duration of Moist Curing (Days)		
			7(N/mm^2)	28(N/mm^2)	56(N/mm^2)
1	CM	0 %	2.95	3.92	4.20
2	CM1	0.25 %	3.51	3.95	4.30
3	CM2	0.50 %	2.77	3.98	4.44
4	CM3	0.75 %	3.19	4.15	4.62
5	CM4	1.0 %	2.81	4.35	4.89

Resistance to sulphate attack of concrete

This test was conducted on 150 x 150 x 150mm cube specimens. The cubes were casted and cured in water for 28 days. Magnesium sulphate solution of 50g/l is used. Cubes are immersed in solution after 28 days curing, and are tested for compressive strength after a period of 56 days. The cubes are tested and any reduction or change is noted. The compressive strength test results on immersed cube specimens are given in Table 9.

Table 9: Compressive strength of concrete mixes after immersion in 50gm/litre of $MgSo_4$ solution

Mix	56 Days Compressive Strength (MPa)	
	Control (56 days)	Immersed
CM	39.37	36.66
CM1	40.11	38.43
CM2	40.24	38.79
CM3	42.87	41.46
CM4	44.46	42.59

IV. CONCLUSIONS

From this study, the following conclusions can be drawn:

1) It has been verified, by using the Slump flow, J- Ring, V-Funnel, L-Box and U-tube tests, that self-compacting concrete achieved consistency and self-compact ability under its own weight, without any external vibration or compaction.

2) Self-compacting concrete can be obtained in such a way, by adding chemical and mineral admixtures, so that its compressive strength and splitting tensile strengths are higher than those of normal concrete.

3) Also, due to the addition of NanoSilica and superplasticizer admixtures, self-compacting concrete has shown smaller interface micro cracks than normal concrete, fact which led to enhance bond between aggregate and cement paste and to an increase in compressive strength and splitting tensile strengths.

4) From the test results of hardened concrete, it is been found that the all the mixes achieved the target strength of 30 Mpa grade.

5) Use of fly ash improves the setting characteristics of the SCC mix.

6) The compressive strength was conducted for all the different ratio of mixes i.e. (CM, CM1, CM2, CM3 and CM4), it was found from the results that mix CM4 (1.0% of NanoSilica added) gives better strength.

7) The compressive strength of all specimens when immersed in 50g/l $MgSo_4$ solution for 56 days, The strength of the mix tends to decrease when compared with the compressive strength of specimen cured in water at same ages.

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