Characteristics of Fresh & Hardened Concrete with Incorporation of Nano Silica & Artificial Sand

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Abstract— Concrete is the largest consuming construction material along the Globe. Technological developments in this field introducing new technologies and materials to save natural resources, environment and to enhance the properties of concrete. Cementitious materials play a vital role in the construction industry. In concrete, cement is the basic binding material and its production emits huge quantities of CO2 and leads to pollution of air such as greenhouse effect. In this research work nano silica of 1 to 100 nm size is used as partial replacement of cement and Natural river sand is completely replaced with artificial sand produced form crushing of rocks. The workability of concrete is tested by slump test and for hardened concrete, compressive strength, split tensile strength and flexural strengths were tested with suitable specimens. The workability reduction of fresh concrete by use of artificial sand in place of river sand is maintained by adding suitable super plasticizer upto 1.1% it is found that at 8% replacement of cement with nano silica gives maximum strengths and optimum workability.

Key words: Nano Silica, Artificial Sand, Concrete, Workability, Compressive Strength, Split Tensile Strength & Flexural Strength

I. INTRODUCTION

Nano technology is one of the emerging technologies and it is introduced in different fields to enhance the properties of materials and structures to suit the needs in different situations. Introduction of nano sized particles shows improvement in the performance and properties of materials with normal grain size and same chemical composition. Nano silica is one of such material introduced in concrete to enhance properties to suit the requirements in different environments. The addition of ultra-fine particles in concrete results in concrete with different characteristics from conventional concrete. From the past research works it is proved that addition of nano silica decrease the setting time and reduce the bleeding of water and segregation of aggregates. Due to its ultra-fineness its surface area increased tremendously and it improves pozzolanic reaction as it is proportional to the surface area available. It is observed that the strength properties of hardened concrete improved when the cement is partially replaced with nano silica upto 8% and then it starts to decrease. The space between the C-S-H gels formed during the hydration process is filled with ultra-fine particles of nano silica and results in highly demystified concrete with extensive modification in fresh and hardened concrete properties. The properties mainly enhanced with addition of nano particles are strength, durability and shrinkage. It is observed that nano sized particles not only fill the pores as filler material but, also it helps to stimulate pozzolanic reactions. The purity of nano silica used here is very high say 99.99% and Blaine's fineness value is $60m^2/g$. Recently there is very acute shortage of natural river sand which is used as fine aggregate and hence an effort is made to use an alternative material for River sand and for that the artificial sand which is obtained from crushing of rocks, screened and washed with effective gradation of particles with zone II obtained from local quarry is used instead of river sand.

The aim of this experimental work is to find out the effects on workability of fresh concrete and strength properties of hardened concrete due to addition of nano silica as partial replacement of cement with 4%, 6%, 8% and 10% in concrete with fine aggregate as artificial sand manufactured from crushing of rocks obtained from local quarry.

II. MATERIALS & METHODS

Commercially available ordinary Portland cent of 53 grade confirming to IS12269 – 2013as a binding material, Nano silica with particle size 1 to100 nm is additional cementations material, hard broken granite stone aggregates of gradation 10 to 20mm is used as coarse aggregate and artificial sand manufactured from local quarry confirming to IS383 – 2009 Zone II is used as fine aggregate and for water, potable water of PH 6.8 is used. The physical properties of materials are tabulated below.

S. No	Property	value
1	Grade	53Mpa
2	Specific gravity	3.15
3	Initial setting time	35 minutes
4	Final setting time	9 Hrs

Table 1: Physical Properties of Ordinary Portland cement

S. No	property	value
1	Specific gravity	1.20
2	Blaine's fineness value	$60m^2/g$
3	Size	1 to 100 nm
4	purity	99.90% SiO2

Table 2: Physical Properties of Nano Silica

S. No	Properties	Value
1	Specific gravity	2.67
2	Size	10to 20mm gradation
3	Water absorption	0.30%

Table 3: Physical Properties of Coarse Aggregate

S. No	Property	Value
1	Specific gravity	2.70
3	Gradation	Zone II
4	Fineness modulus	4.75

Table 4: Physical Properties of Fine Aggregate

III. MIX DESIGN

M_{20} grade of concrete is the minimum grade of concrete recommended by IS 456 – 2000 and hence the mix design is done for this grade by using the guidelines given in IS 10262 – 2009 and IS 456 -2000. The mix design is done for a target mean strength of 26.67 N/mm^2 at 28 days of water curing. The mix ratio obtained as 1: 1.6: 3.2 and water cement ratio as 0.485. The various mix ratio with partial replacement of cement with nano silica as 4%, 6%, 8% and 10% is given in the table below.

Mix designation	Nano silica	cement
P0	0%	100%
P1	4%	96%
P2	6%	94%
P3	8%	92%
P4	10%	90%

Table 5: Different Mix Ratios of Concrete Cast for Experimental Investigation

IV. OBJECTIVES OF THE TEST

1) To investigate the influence of nano silica in concrete for different parameters in fresh and hardened condition.
2) To find out the suitability of artificial sand as an alternative river sand.

V. SCOPE OF THE TEST

The nano silica is first thoroughly mixed with cement in a dry pan and properly mingled. The other ingredients are separately added and mixed in dry condition in another pan. Then the whole mixture put in a pan mixer and thoroughly mixed by adding suitable quantity of water and high range water reducer. The fresh concrete is tested for its workability by slump cone test then, for strength tests the cubical specimens of 150mm cube, cylindrical specimens of 150mm dia and 300mm height and prisms of 100mm x 100mm x 500mm were cast for testing compressive strength, split tensile strength and flexural strength test respectively in required numbers as 3 specimen for each test.

VI. FRESH CONCRETE FOR WORKABILITY - SLUMP TEST RESULTS

S. No	Mix designation	Slump value
1	PO	92.00 mm
2	P1	88.00mm
3	P2	86.50mm
4	P3	84.20mm
5	P4	81.60mm

Table 6: Slump Values

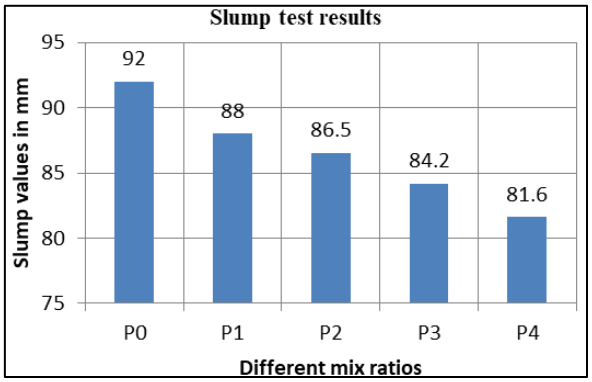

Chart 1: Slump Test Values

VII. HARDENED CONCRETE STRENGTH TEST RESULTS

Mix designation	Compressive strength in N/mm^2	
	7 Days	28 Days
P0	15.40	28.50
P1	17.83	30.21
P2	19.15	32.83
P3	20.10	33.48
P4	18.89	30.38

Table 7: Compressive Strength Test Results

Mix designation	Split tensile strength in N/mm^2	
	7 Days	28 Days
P0	2.28	3.81
P1	2.59	4.11
P2	3.12	4.83
P3	3.73	5.28
P4	2.98	4.01

Table 8: Split Tensile Strength Test Results

Mix designation	Flexural strength in N/mm^2	
	7 Days	28 Days
P0	1.15	1.52
P1	1.04	1.41
P2	0.98	1.35
P3	0.82	1.23
P4	0.65	1.13

Table 9: Flexural Strength Test Results

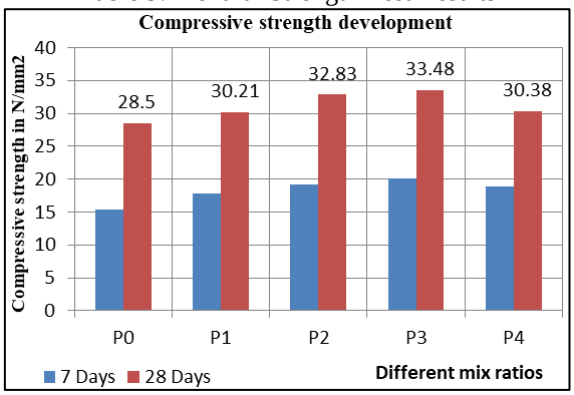

Chart 2: Compressive Strength Development

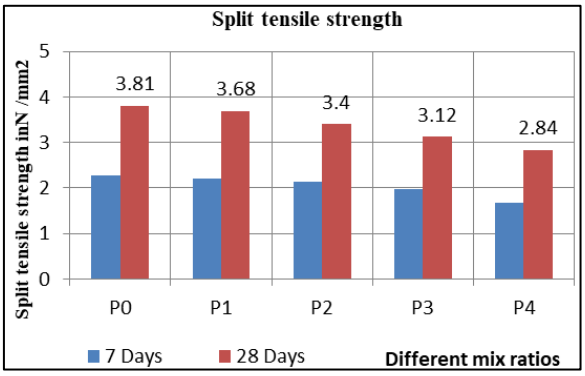

Chart 3: Split Tensile Strength Development

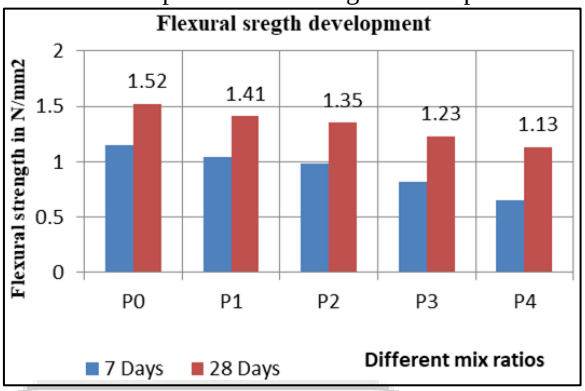

Chart 4: Flexural Strength Development

VIII. Experimental Results Analysis

A. *Slump Values*

It is observed that the results of slump value indicate there is decrease in workability when the river sand is replaced by artificial sand also addition of nano silica affects workability. The workability is improved and maintained within the limit of requirement by addition of super plasticizer upto 1.2%.

B. *Compressive Strength Results*

It is noted that the replacement of natural river sand by artificial sand does not affecting its compressive strength. Cement is replaced by nano silica for 4%, 6%, 8% and 10%. It is observed that compressive strength is improved upto 8% replacement then starts to decrease. This is due to the fact that increase in pozzolanic reactions leads to strength development and when nano silica addition is increased beyond 8% the strength is reduced due to agglomeration effect of nano silica mixture with cement. It is noted that highest compressive strength at the age of 28 days is corresponding to P4 at 8% replacement with strength improvement of 17.47% in compare with control mix.

C. *Split Tensile Strength Results*

It is noted that the replacement of Cement by nano silica for 4%, 6%, 8% and 10%. The split tensile strength decreases slightly with the addition of nano silica. The reduction in tensile strength may be due to improper dispersion of nano particles in concrete and it needs further investigation. When compressive strength improved 17.47% at 8% replacement the tensile strength reduced to 18%.

D. *Flexural Strength Test Results*

The flexural strength decreases slightly with the addition of nano silica. Both The reduction in tensile strength and flexural strength may be due to improper dispersion of nano particles in concrete and it needs further investigation. When compressive strength improved 17.47% at 8% replacement the flexural strength reduced to 19%.

IX. Conclusions

1) It is observed that replacement of cement with nano silica improves compressive strength upto 17.47%.
2) The split tensile strength is reduced with addition of nano silica and there is a reduction of 18% strength at 8% replacement when compressive strength increased to 17.47%. This results should be investigated further.
3) The flexural strength is reduced with addition of nano silica and there is a reduction of 19% strength at 8% replacement when compressive strength increased to 17.47%. This results should be investigated further.
4) The complete replacement of river sand by artificial sand does not have much effect on strengths of concrete.

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