EFFECT OF NANO SILICA ON THE COMPRESSIVE STRENGTH OF CONCRETE

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ABSTRACT- *Due to rapid industrialization and urbanization in the country lot of infrastructure developments are taking place. This process as in turn lead questions to mankind to solve the problems generated by this growth. The problems defined are acute shortage of construction materials, increase the productivity of waste and other products usually M30 concrete is used for most of the constructional works. Hence in this project M30 concrete is taken and waste plastics and waste rubber is used. The present investigation deals with Partial replacement of Waste Plastics and waste rubber as partial replacements in concrete at an increment of 5% each time. i.e; 0%, 5%, 10%, 15%, 20%... with equal replacements in fine and coarse aggregates.*

Cubes and Cylinders were cast and tested at 7 and 28 days of age. The results were compared with the results of concrete specimens cast with 0% of Waste Plastics and Waste Rubber. The concrete with waste plastic and waste rubber can be used for construction of rigid pavements, sewers, tennis courts and walker areas which leads to decrease in the overall thickness of the pavement.

Keywords—Waste plastics, rubber, Compressive Strength, tennis courts.

1. INTRODUCTION

Concrete is the material of present as well as future. The wide use of it in structures, from buildings to factories, from bridges to airports, makes it one of the most investigated material of the 21st century. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve the strength and durability of concrete. Out of the various materials used in the production of concrete, cement plays a major role due its size and adhesive property. So, to produce concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to concrete improve its properties. Some of these are fly ash, blast furnace slag, rice husk, silica fumes and even bacteria. Of the various technologies in use, nano-technology looks to be a promising approach in improving the properties of concrete.

Nanomaterials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area (Alireza Naji Givi, 2010). Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved . Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure.

The use of nanosilica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. It sets early and hence generally requires admixtures during mix design. Nano-silica mixed cement can generate nano-crystals of C-S-H gel after hydration. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving the permeability and strength of concrete.

II. LITERATURE REVIEW

H. Li et. al. (2004) experimentally investigated the mechanical properties of nano-$Fe_2O_3$and nano-SiO_2 cement mortars and found that the 7 and 28 day strength was much higher than for plain concrete. The microstructure analysis shows that the nanoparticles filled up the pores and the reduced amount of $Ca(OH)_2$ due to the pozzolanic reaction.

Tao Ji (2005) experimentally studied the effect of Nano SiO_2on the water permeability andmicrostructure of concrete. The findings show that incorporation of Nano SiO_2 can improve the resistance to water of concrete and the microstructure becomes more uniform and compact compared to normal concrete.

H. Li et.al. (2006) studied the abrasion resistance of concrete blended with nano particles of $TiO_2$and SiO_2 nano particles along with polypropylene (PP) fibers. It was observed that abrasion resistance can be improved considerably by addition of nano particles and PP fibers. Also the combined effect of PP fiber + Nano particles shows much higher abrasion resistance than with nano particles only. It was found that abrasion resistance of nano TiO_2 particles is better than nano SiO_2 particles. Also relationship between abrasion resistance and compressive strength is found to be linear.

B.-W Jo et. al. (2007) studied the characteristics of cement mortar with Nano SiO_2particlesexperimentally and observed higher strength of these blended mortars for 7 and 28 days. The microstructure analysis showed that SiO_2 not only behaves as a filler to improve microstructure, but also as an activator to the pozzolanic reaction.

M.Nill et.al. (2009) studied the combined effect of micro silica and colloidal nano silica onproperties of concrete and found that concrete will attain maximum compressive strength when it contains 6% micro silica and 1.5% nano silica. The highest electrical resistivity of concrete was observed at 7.5% micro and nano silica. The capillary absorption rate is lowest for the combination of 3% micro silica and 1.5% nano silica.

III. SCOPE AND OBJECTIVE

The main objectives of the present study are as mentioned below:

To study the effect of nano-silica on the compressive strength of concrete.

To study the microstructure of the hardened cement concrete.

To explain the change in properties of concrete, if any, by explaining the microstructure.

IV. EXPERIMENTAL INVESTIGATION

Materials Used:

The materials used in this investigation are…

- 43 Grade Ordinary Portland cement
- Nano silica
- Fine Aggregate
- Coarse Aggregate
- Water

Cement:

Cement used in the investigation was 43 Grade Ordinary Portland cement confirming to IS12269. The cement was obtained from a single consignment and of the same grade and same source. Latter procuring the cement was stored properly.

Properties of cement:

Specific gravity = 3.03

Consistency = 31%

Initial setting time = 51 min

Final setting time =315 min

Properties of fine aggregate:

Bulk Density=1.49 g/cc

% of voids ratio=34.23%

Voids Ratio=0.58

Specific Gravity=2.28

Fineness modulus= 2.9

Properties of Coarse Aggregates:

20mm Aggregate

Bulk Density=1.44 g/cc

% of voids ratio=50.22%

Voids Ratio=1.0085

Specific Gravity=2.89

Nano silica properties

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA (m^2/g)	200 + 20	202
PH VALUE	3.7 – 4.5	4.12
LOSS ON DRYING @ 105 DEG.C (5)	≤ 1.5	0.47
LOSS ON IGNITION @ 1000 DEG.C (%)	≤ 2.0	0.66
SIEVE RESIDUE (5)	≤ 0.04	0.02
TAMPED DENSITY (g/L)	40 – 60	44
SiO2 CONTENT (%)	≥ 99.8	99.88
CARBON CONTENT (%)	≤ 0.15	0.06
CHLORIDE CONTENT (%)	≤ 0.0202	0.009
Al_2O_3	≤ 0.03	0.005
TiO_2	≤ 0.02	0.004
Fe_2O_3	≤ 0.003	0.001

V. RESULTS AND DISCUSSIONS

- ***COMPRESSIVE STRENGTH***

7-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (µs)
1	8.18	4491	33.4
2	8.22	4491	33.4
3	8.24	4386	34.2

Table 4.3: UPV Test for specimen with nano-silica 0.6% b.w.c for 7 day

7-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (µs)
1	8.26	4630	32.4
2	8.08	4630	32.4
3	7.98	4702	31.9

Table 4.4: UPV Test for specimen with nano-silica 1% b.w.c for 7 day

7-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (µs)
1	8.24	4491	33.4
2	8.14	4360	34.4
3	8.30	4559	32.9

28-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (μs)
1	8.42	4808	31.2
2	8.36	4854	30.9
3	8.14	4777	31.4

Table4.6: UPV Test for specimen with nano-silica 0.3% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (μs)
1	8.06	4673	32.1
2	8.32	4732	31.7
3	8.22	4854	30.9

Table4.7: UPV Test for specimen with nano-silica 0.6% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	Weight (kg)	Velocity (m/s)	Time (μs)
1	8.18	4702	31.9
2	8.24	4777	31.4
3	8.22	4777	31.4

Table4.15: Comparison of compressive strength for 28 day

28-DAY RESULTS	STRENGTH (MPa)	INCREASE IN STRENGTH (%)
CONTROL	35.31	-
NS 0.3% b.w.c	35.17	-0.39
NS 0.6% b.w.c	36.48	3.31
NS 1% b.w.c	39.82	12.77

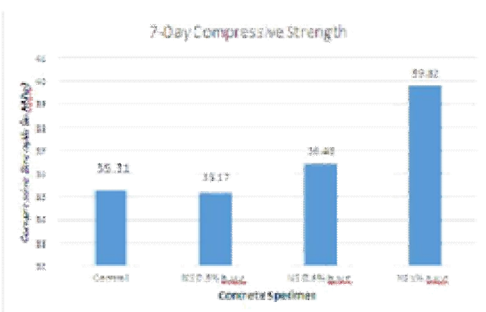

Fig. 4.1: 7-day compressive strength of four specimen

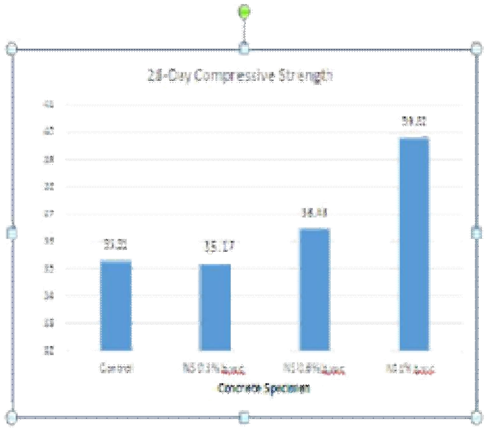

Fig 4.2 28-day compressive strength of four specimen

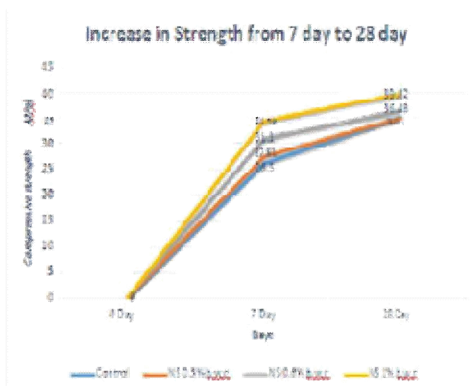

Fig 4.3: Change in compressive strength of four specimen from 7 day to 28 day

VI. CONCLUSIONS

From the test results, the SEM micrographs and the relative chemical composition of the specimen a number of conclusions can be drawn. These conclusions are justified in the next section. The conclusions drawn are:

i. From the compressive strength results, it can be observed that increase in compressive strength of concrete is observed on addition of a certain minimum quantity of Nano SiO_2. The increase in strength is maximum for NS 1% b.w.c and least for NS 0.3% b.w.c.

ii. On addition of Nano SiO2 there is a substantial increase in the early-age strength of concrete compared to the 28 day increase in strength.

iii. The UPV test results show that the quality of concrete gets slightly affected on addition of Nano SiO2 but the overall quality of concrete is preserved.

iv. The Nano SiO2 added to the mix filled up the pores in between the C-S-H gel, hence, making the microstructure more compact and uniform

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