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Comparative Study of Silica Powder based Concrete with Normal

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Abstract - *The silica powder based concrete (SPC) is one innovation which provides strength, durability and other properties to concrete. In this work we tested M50 grade concrete cubes of size 150x150x150 with Nano silica powder and Class C fly-ash and tested their properties for 7, 14 & 28 days respectively. Cement was replaced with varying percentages of Nano silica and the results were tabulated. The results showed that 10% replacement of cement with silica powder gave the maximum strength to the concrete, increased its initial strength and also durability.*

***Key Words*: SPC, Nano-silica, Fly-ash, High strength, Durability.**

1. INTRODUCTION

"Nano" in Greek means "dwarf", the ISO defines Nano technology as usage of Nano materials in order to bring changes in the Nano level of a product. The size of Nano particle is 10-9m which is less than one billionth of a meter. Nanoparticles have a high surface-area-to volume ratio. In this, nanoparticles with less than 100 nm diameter have been used, as 50% of its atoms are at the surface and are thus very reactive. The concept of SPC overcomes many limitations and weakness of normal concrete. The development of the SPC is mainly due to its dense, compact and homogeneous internal structure which also makes it resistant to chemical or weather actions. Nano Silica is a mineral which when added to concrete increases properties such as thermal resistance, reduced alkali reactions along with an increase in strength and durability. Flyash is an amorphous material, which is considered pozzolanic because of its high silica content when in size less than 100 µm, which, when partially replaced with cement influences its physical, mineralogical and chemical properties.

2. MATERIALS SPECIFICATIONS

2.1 Cement

Ordinary Portland cement grade 53 confirming IS 8112-198 was used. The material properties of cement were determined by examining the cement as per IS 12269:1987 (reaffirmed 2004) using pycnometer and Vicat's apparatus.

Table -1: Test results of OPC 53 cement

Sl. No	Test particulars	Results Obtained
1.	Specific Gravity	3.15
2.	Standard consistency	29%
3.	Setting time	
	(i) Initial setting time	175 minutes
	(ii) Final setting time	275 minutes

2.2 Water

Water is a critical and decisive component of concrete. It actively takes part in the chemical reaction with the cement in concrete and results in hardening of concrete. The water used was confirmed to the requirements of IS 456-2000.

2.3 Fine Aggregates

Locally available sand belonging to zone II conforming IS 383:1970 was used for the present work.

Table -2: Test results of local sand

SI.No	Test particulars	Results Obtained
1.	Specific gravity	2.605
2.	Water absorption	2.45%
3.	Type of sand	Medium sand (zone II)

2.4 Coarse Aggregates

Crushed blast stones of size 12.5 mm and 20 mm conforming IS 383:1970 were used for the present study.

Table -3: Test results of coarse aggregates

SI.No	Test particulars	Results Obtained
1	Specific gravity	2.78
2	Water absorption	1.4%

2.5 Nano silica powder

Nano silica in slurry form was used as a partial replacement of cement to impart high strength and durability. Supplied

by M/s BEE CHEMS, Kanpur, India containing nano silica granules of size less than 40 microns was used for partial replacement of cement.

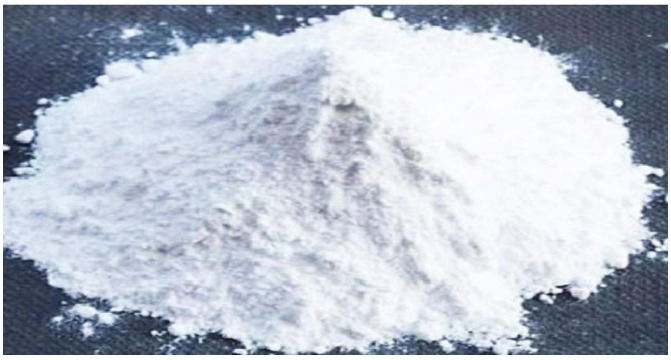

Fig -1: Nano silica powder

2.6 Super plasticizer

During this investigation, Sika Plastocrete super (specific gravity 1.04) was used, based on Sulphonated naphthalene polymers, with pH > 6, complies with IS 9103-1999.

2.7 Fly-ash

Locally available class C fly-ash (< 100 micrometre) of sp. Gravity 2.21 was used for partial replacement of cement.

Fig -2: Fly-ash

3. Mix proportions

Concrete Mix design of normal concrete (Control sample) was designed using to IS 10263-2009 for M50 with the addition of super plasticizer 1.2% by weight of cement.

Table -4: Mix proportional of normal concrete

Cement	Fine aggregate	Coarse aggregate	W/c ratio	Super plasticizer
1	1.72	2.42	0.35	0.012

4. Literature review

To enhance the concepts and knowledge areas regarding the grey area of nanomaterials the following literature and their results were taken into account before the feasibility study for usage of nano silica was carried out.

Kushal Ghosh et al. in the study revealed that the apparent porosity and sorptivity and microstructure depended basically on alkali and silica content. However, generally there is a decrease in water sorptivity and water absorption with an increase in compressive strength and bulk density.

Marcelo Gonzalez et al. in the incorporation of nanosilica in the concrete mix was able to generate a denser concrete and less permeable concrete, which reduced the freeze/thaw actions. The addition of nanosilica was not able to generate any significant modification in terms of internal damage (measured by the Durability Factor).

Khaleel H. Younis et al. in the addition of nanoparticles of silica at contents of 0.4%, 0.8%, and 1.2% results in an increase in the compressive strength of 10%, 18%, and 22% for mixes containing 50% RA and of 6%, 13%, and 16% for mixes made with a 100 % RA, respectively.

Yuvraj, S. described, the addition of nS increases the compressive strength of concrete along with its pozzolanic properties. Thus, elaborating how measuring permeability helps detect durability problems and allows timely and cost-effective protection of the concrete structure.

Rupasinghe et al. from the results, it are often concluded that nano-silica reacts with the CH from the hydration of the cement paste and forms stronger bonds. Thus, a rise in pozzolanic reaction leads to a rise of compressive strength.

Abyaneh, M.R.J. et al. they studied the effect of nS and micro silica on compressive strength, electrical resistivity and water absorption of OPC, PPC, PSC concrete at 7, 14, 28 days.

Vijaya Sekhar Reddy et al. it had been observed from the results that the utmost percentage loss in weight and percentage reduction in compressive strength thanks to acids for M40 grade concrete are 1.25%,16% with the replacement of 10% Metakaolin and therefore the minimum percentage loss in weight and strength are 1.18%, 14.9% with replacement of 20% Flyash. There's considerable variation in loss of weight and strength only with Silica Fume replacement.

Rajmane, N.P. et al. the study presented shows that ash can partially replace sand in cement concrete. Which successively results in lower density, manufacturing cost, a reduced coarse aggregate content, a lower degree of permeability and increases durability than those of normal cement concrete.

Arun Nishchal Guleria et al. examined the effect of Micro Silica and Nano Silica within the concrete properties with their different percentages within the different sorts of concrete.

Mainak Ghosal et al. the results showed that the optimizations for nanomaterials in OPC mortar are nS=0.75%, CNT=0.02% and TiO2=1.0% for cement mortar up to twenty-eight days as per within the long-term strength, some contradictions were noticed where more addition of nanomaterials yielded good results.

Belkowitz, S.J & Armentrout.D, here, the crystallographic structures of micro silica were examined and it had been found that because the silica particles decrease in size and incorporate a wider gradation of sizes, the calcium silicate hydrates became more rigid; which reportedly increased the compressive strength.

5. Tests and observations

5.1 Compression test

The compression test for normal and silica powder cube was carried out on 7th, 14th and 28th day and was measured in terms of MegaPascal.

Fig -3: Cube before test

Fig -4: Cube after test

Table -5: Compressive strength of concrete cubes using Nano silica

Specimen	%Replacement SP/F	7th day	14th day	28th day	%Increase in strength
Control Sample	0	22.3	30.6	53.8	-
SP10	10 (SP)	27	34.6	62.2	15.6
SP15	15 (SP)	32.4	41.4	73.1	35.9
SP20	20 (SP)	29	37.1	67	24.5
SP25	25 (SP)	27.8	35.6	64.2	19.3
SP30	30 (SP)	26.4	37.7	60.1	11.7
SPF	10 (SP) +15 (F)	26.2	35	63.5	18
SPF1	15 (SP) +15 (F)	28.4	38.7	68.1	26.6

*Cube size=150*150*150mm

SP=SILICA POWDER, F=FLY-ASH

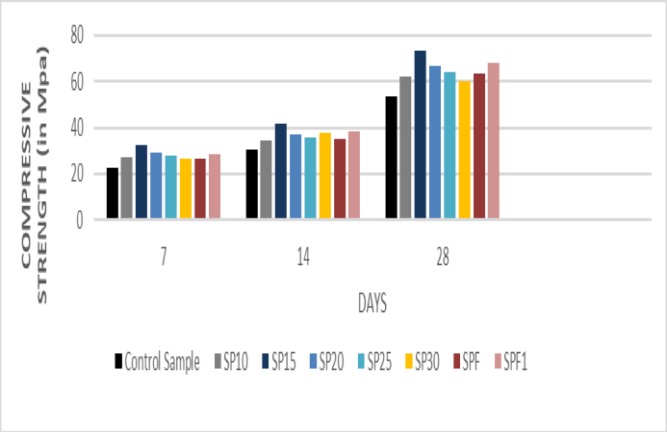

Chart -1: Compressive strength of different nano concrete

5.2 Water absorption test

The cubes after 28 days curing were placed in the oven at 1500C.After 24 hours they were removed from the oven and kept for cooling.

Table -5: Water absorption test results for M50 concrete

Designation of concrete mixes.	Oven-dried weight (kg)	Saturated weight (kg)	Water absorption Value (%)	Decrease from normal concrete (%)
Control Sample	8.27	8.45	2.17	-
SP10	8.24	8.40	1.98	8.75
SP15	8.22	8.31	1.96	9.67
SP20	8.17	8.26	1.80	17.05

SP25	8.13	8.33	1.67	23.04
SP30	8.11	8.24	1.63	24.88
SPF	8.20	8.39	2.33	+7.37
SPF1	8.18	8.37	2.31	+6.45

('+' indicates increase in percentage compared to normal concrete)

6. Results & Discussion

Through this study, we found that concrete cubes made with replacement of Silica fume gives a reliable result.

1. By replacing 10%, 15%, 20%, 25% & 30% of OPC cement with silica in powder form, we found optimum compressive strength on the 28th day observed at 15% replacement (73.10MPa) which increased by 35.90% as compared to normal concrete and it was also observed that it gives high initial strength in 7th (32.40MPa) and 14th (41.40MPa) day, increased by 45.29% and 35.29% in comparison to normal concrete.

2. The combination replacement of fly-ash and silica powder with cement on the 28th day yielded SPF (63.50MPa) and SPF1 (68.10MPa) which increased by 18% and 26.60% in compressive strength as compared to normal concrete.

3. The results of the water absorption test indicate that there is a significant reduction in water absorption in SP15 (9.67%), SP20 (17.05), SP25 (23.04%), SP30(24.88%) although SPF (+7.37%) and SPF1 (+6.45%) showed relatively high water consumption as compared to normal concrete.

7. CONCLUSIONS

The above study shows the partial replacement of nanomaterials like silica powder along with usage of other pozzolanic materials such as fly-ash improves the strength of concrete.

For rapid construction of projects in and to gain high initial strength, 15% replacement of nanosilica powder is recommended.

Taking high strength & water absorption into consideration, replacement of the silica powder by 15% yields the best result, with a 35.90 % increase in strength and 10% reduction in water.

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