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Physical and Mechanical Properties of Self-curing and Self-compacting Concrete using Nano-silica as Mineral Admixture

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ABSTRACT: The aim of this research is to investigate the effect of different proportions of nano silica and polyethylene glycol 400 (PEG 400) on self-compacting high strength concrete. Finding out optimum content of nano silica, concrete mixes of proportions 0%, 1%, 2%, 3% of cement content (NSSCC). By substituting the optimum nano silica dosage in self-curing concrete mixes which contains PEG 400 in 0%, 0.5%,1%, 2%, 3% proportions of cement (SCSCC). The physical properties are measured in time and diameter for slump flow, V- funnel tests. Mechanical properties are performed in terms of compressive strength, split tensile strength and flexural strength. The experimental results are almost satisfied the EFNARC guidelines. Fresh properties of concrete has decreased as increasing nano silica proportions. Mechanical properties of SCSCC are less compared to NSSCC.

Keywords*: *Nano silica, Polyethylene glycol, Fresh properties, Hardened properties.

I. INTRODUCTION

Concrete curing is one of the crucial challenge in construction sector, especially in water scarcity areas. Productive curing improves the strength and durability of concrete. Standard curing methods are usually the best methods for curing and gives maximum strength and durability. Sometimes the adequate curing conditions cannot be provided so, self-curing concrete is recommended in such cases. The sustainable amount of strength achieved by conventional water curing method can be achieved by adding chemical curing agents to concrete. Self-curing concrete is a type of concrete which maintain its own moisture due to the addition of chemical curing agent, So regular curing method is not required. The main concept of self-curing concrete is to reduce the evaporation of water from concrete and therefore increases water retention capacity compared to normal concrete. One of the major problem after placing concrete is compaction, especially in confined zones due to shortage of skilled labor. Durability of concrete depends upon compaction. Self-compacting concrete is one of the most significant developments of construction sector,

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It was firstly initiated in japan in 1986 by Okamura. SCC is a type of concrete mix which possess high deformability, resistance to segregation, less yield stress. SCC can flow by its weight and fills heavy reinforcement formworks. SCC is distinguished by its passing ability, filling ability and resistance to segregation, this can be achieved by using super plasticizers or water reducing admixtures. Such features of SCC which can come up with more architectural possibilities in narrow sections and better surface quality. Generally concrete is a porous material, this makes it as an easy target for entrance of water and other liquids which can decrease the durability. Concrete structures that are designed with less concern about durability issues will suffer from structural degradation. Concrete is made up of amorphous phase, nano meter to micro meter size crystals and bound water. The modification in such a scale that can influence the mechanical and durability properties. The calcium silicate hydrate (C-S-H) the main component of concrete is in few nano meter size. So, the addition of nano particles can overcome the finer filling size. By adding nano silica, due to its large surface area and high reactivity it can accelerates cement hydration and formation of C-S-H by producing nucleation sites due to its higher surface energy. Nano silica fills very fine pores and `reacts with $Ca(OH)_2$ to create more gels which causes denser microstructure and
powerful interfacial transition zone.

II. REVIEW CRITERIA

The main aim of this experiment is to find out the optimum usage of nano silica in concrete mix to obtain greater strengths, and by using the optimum proportion of nano silica in self-curing self-compacting concrete to achieve great strengths with out curing. Physical and mechanical properties are observed for Mix proportions of nano silica are considered as 1%, 2% and 3%, Self-curing agent Polyethylene glycol 400 are considered as 0.5%, 1%, 2% and 3%. The results should guide to explain the effect of nano silica and self-curing agent compared to control mix.

III. MATERIALS

The materials used in this experiment are Cement, Fly ash, Nano silica, coarse aggregate, fine aggregate, master glenium sky 8233 and polyethylene glycol 400. The cement used is Penna Ordinary Portland cement with 28 days strength of 53 Mpa (IS: 269-2015) with specific gravity of 3.02. Fly ash of class F is used and acquired from RCC plants near college.

Specific gravity of fly ash is 2.02. Nano silica is collected from a commercial nano silica supplier with specific gravity of 1.03. Fine aggregate used is obtained from the local supplier which passing from 2.36mm sieve of Zone-2 (IS 383-1970) with specific gravity of 2.63 and fineness modulus as 2.59, Similarly coarse aggregate which passing from 12.5mm sieve having specific gravity of 2.36. Master glenium Sky 8233 is the super plasticizer used in this experiment which is obtained from the commercial supplier. Polyethylene glycol 400 is self curing agent used in this experiment.

Table-I: Chemical properties of cement and nano silica

Chemical Analysis	Cement in %	Nano silica in%
SiO_2	22.74	99.80
Al_2O_3	3.22	0.056
Fe_2O_3	3.72	0.016
CaO	63.1	-
MgO	1.56	-
K_2O	0.62	0.007
Na_2O	0.39	0.005
SO_3	0.37	-

IV. MIX DESIGN

In this study, total 9 concrete mixes were casted . In every mix cement content is taken as 500 kg/m3,fly ash is 100 kg/m3, water binder ratio is taken as 0.28. 0.65% to the cement content of superplasticizer is taken. The dosage of nano silica and PEG 400 are shown in table.

Table-II: Dosge of Nano silica and PEG 400

MIX DESIGNANTION	NANO SILICA (kg/m3)	PEG 400 (kg/m3)
NSSCC 1	0	0
NSSCC 2	5	0
NSSCC 3	10	0
NSSCC 4	15	0
SCSCC 1	10	0
SCSCC 2	10	2.5
SCSCC 3	10	5
SCSCC 4	10	10
SCSCC 5	10	15

V. EXPERIMENTAL PROCEDURE

Blending of concrete components was accomplished by utilizing pan mixer in concrete lab in college. The dry constituents of concrete were placed in the mixer and mixed for 2 mins to make sure that uniformity is achieved. From total water content 1litere of water was added for every 100ml of superplasticizer. Firstly, the normal water was added gradually during mixing and then the remaining water with superplasticizer was added. For self curing concrete mixes the self curing agent was added to normal water content which is separated for superplasticizer. The mix proportions were shown in the table. . After completion of mixing process tests were performed on fresh concrete to determine the workability of SCC. Fresh properties of SCC mixtures were examined through the slump flow test and V-funnel test. Specimens of size 100mm X 100mm X 100mm cubes were casted for compressive strength , 200mm X 100mm diameter of cylinders were casted for split tensile strength and 100mm X 100mm X 500mm prisms were casted for Flexural strength.

VI. RESULT AND DISCUSSION

A. Fresh properties:

Fig. 1 & 2 represents the influence on Nano silica and polyethylene glycol on fresh properties of concrete. The addition of Nano silica reduced the workability in terms of slump flow and V-funnel. Addition of polyethylene glycol increased the workability as increasing the dosage shown in graph.

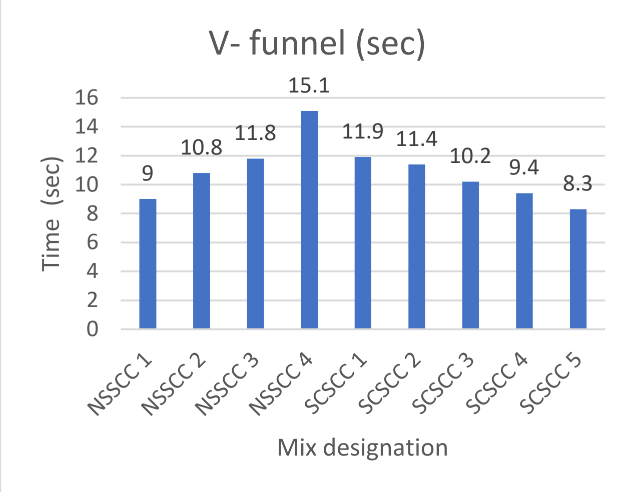

Fig. 1. V-funnel test values.

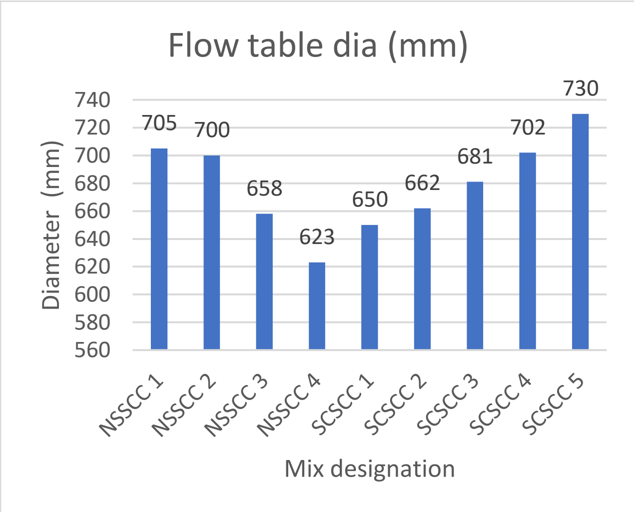

Fig. 2. Flow table diameter

B. Compressive strength:

Fig. 3 & 4 represents compressive strength values at 28 days. Addition of Nano silica can improve the compressive strength up to 2% dosage.

Which can result compressive strength of 82.3Mpa, compared to control mix it is 20.9% more. By adding 2% Nano silica to the self-curing mixes the compressive strengths are increased up to 3% of PEG 400. At 3% PEG 400 strength achieved was 80.03Mpa compared to control mix it is 18.7% more and compared to mix which contains 2% of Nano silica without self-curing agent it is about 29.2% more.

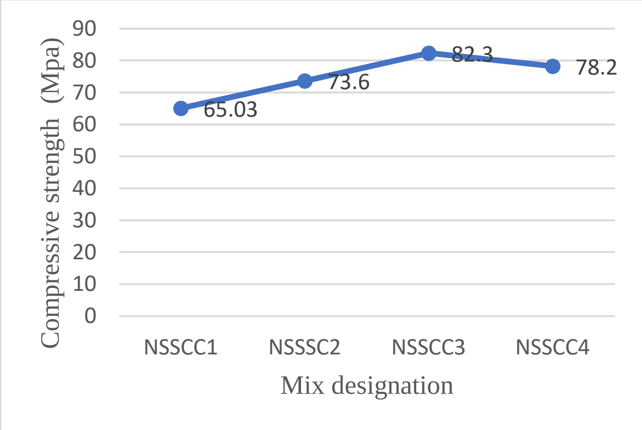

Fig. 3. Compressive strength @28 days

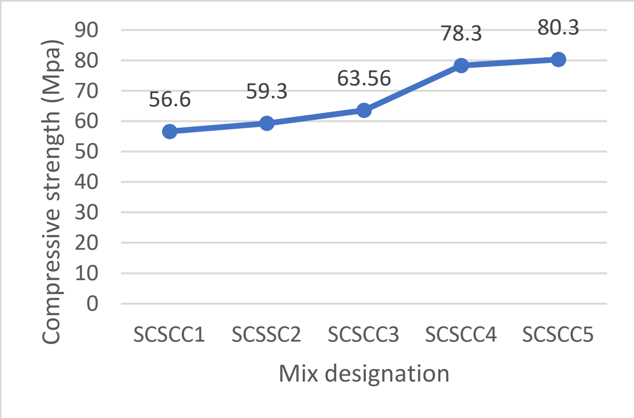

Fig. 4. Compressive strength @28 days

C. Split tensile strength:

Fig. 5 & 6 represents split tensile strength values at 28 days. Same as compressive strength the peak strength in split tensile strength also achieved at 2% dosage of Nano silica with 6.3Mpa, compared to control mix it is about 42.2% more. For self curing mixes maximum strength achieved at 2% dosage of Nano silica and 3% PEG 400 dosage with 6.08Mpa, When compared to control mix it is 40.1% more and mix with without curing agent it is about 22.3% more.

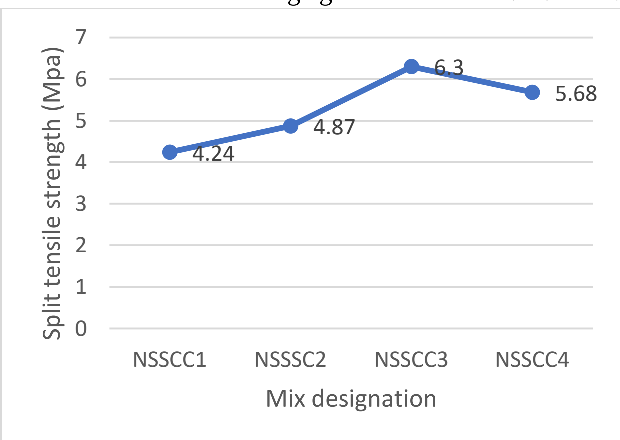

Fig. 5. Split tensile strength @28 days

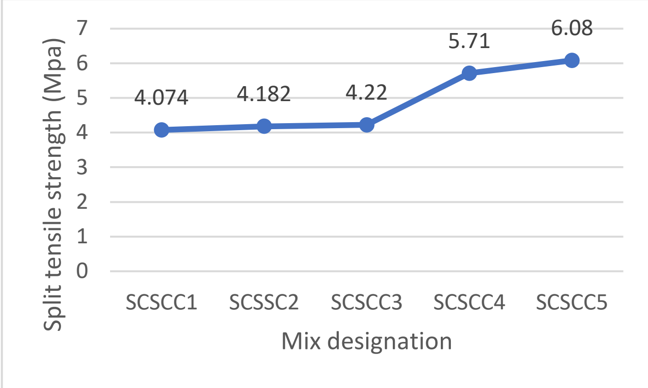

Fig. 6. Split tensile strength @28 days

D. Flexural strength:

Fig. 7 & 8 represents flexural strength values at 28 days. At 2% dosage of nano silica the flexural strength is maximum and it is 9.4Mpa, compared to control mix it is about 24.8% more. For self curing mixes maximum strength was achieved at 3% dosage of PEG 400 and it is 7.2Mpa, compared to control mix it is 5.5% more and compare to 0% PEG 400 mix it is about 13.8% more.

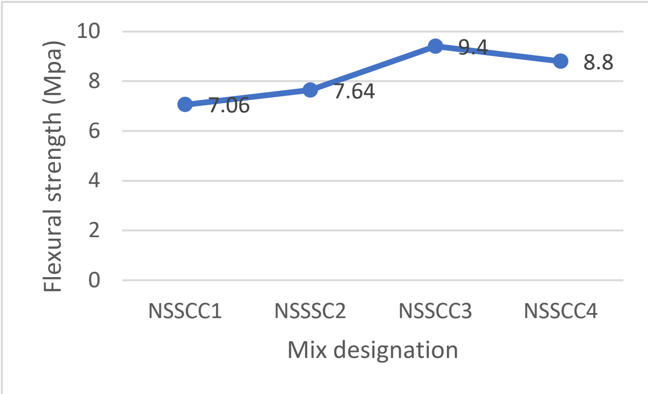

Fig. 7. Flexural strength @28 days

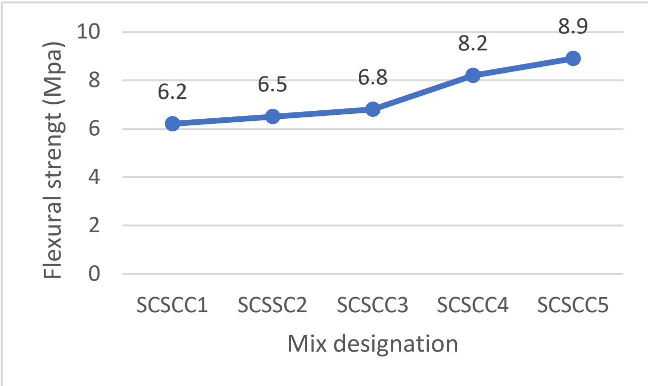

Fig. 8. Flexural strength @28 days

VII. CONCLUSION

- Addition nano silica increases the density of concrete up to 2% dosage. At 3% dosage of nano silica still increases the density but in smaller extant compared to 2% addition.

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The irregular dispersion of nano particles causes porous clusters which could cause decay in strength of cement matrix and increases porosity.

- Workability properties are decreased by increasing in nano silica dosage and increases when increasing PEG 400 dosage.
- All hardened properties like compressive strength, split tensile strength and flexural strengths are maximum at 2% dosage of nano silica and 3% dosage of PEG 400.

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