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RESEARCH ARTICLE

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NANO SILICA AND SILICA FUME ADDED CONCRETE

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ABSTRACT

The use of silica fume has been considered as a pozzolanic material for several years. Besides, doing research about nano materials and its application in concrete is increasing. The present study investigates the simultaneous use of nano silica and silica fume in concrete. In order to such a purpose, silica fume in measures of 5, 10 and 15 percent and nano silica in measures of 0.5, 1 and 1.5 percent were replaced with cement and totally ten mixture plans for doing the compressive strength and flexural strength experiments. Finally, the results showed that using such materials improves the qualities of concrete. Using both 10% silica fume and 1% nano silica, as a cement replacement, resulted in 52.5% increase in compressive strength and 69.8% increase in flexural strength in comparison to control sample. Furthermore, it was understood that the simultaneous use of these materials is more influential than their single use.

Key Words: Nano silica, Silica fume, Compressive strength, Flexural strength.

1. INTRODUCTION

Concrete, as a constructive material, has been used in construction industry for about two centuries. Approximately, the whole bulk of the concrete is used in one year is more than one ton apiece. Therefore, doing research about using modern technologies in production concrete is of great importance. Reducing the necessary amount of Portland cement without reducing the performance of concrete is significant for big projects that require a large amount of cement. Furthermore, Portland cement clinker production consumes large amounts of energy and has a notable environmental impact. For instance, 1.7 tones raw materials are needed to produce 1 ton clinker which leads to emission of greenhouse and other gases into the atmosphere. Approximately 850 kg of CO_2 is emitted per ton of clinker produced. Hence, pozzolan and cementitious materials play an important role in concrete production.

Previous studies show that silica fume, as an active pozzolan, cuts down cement consumption and increase the strength of concrete. Besides, various combinations of a pozzolan and silica fume were used to produce high strength concrete. On the other hand, the usage of nano silica in concrete has been increasing in recent years. Moreover, the mechanical properties of concrete were significantly improved with the use of nano silica and pozzolan together [6].

1.2 Silica fume

Silica is the common name for materials composed of silicon dioxide (SiO_2) and occurs in crystalline and amorphous forms. Silica fume or micro-silica (SF) is a byproduct of the smelting process in the silicon and ferro silicon industry. The American concrete institute defines silica fume as

'Very fine non-crystalline silica produced in electric arc furnaces as a by-product of production of elemental silicon or alloys containing silicon'. It is a grey colored powder, similar to Portland cement or fly ashes. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle size (diameter) of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

1.3 Nano silica

Nano silica is typically a highly effective pozzolanic material. It normally consists of very fine vitreous particles approximately 1000 times smaller than the average cement particles. It has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability. NS reduces the setting time and increases the strength (compressive, tensile) of resulting cement in relation with other silica components that were tested. Nano-silica is obtained by direct synthesis of silica sol or by crystallization of nano-sized crystals of quartz.

2. EXPERIMENTAL INVESTIGATION

2.1 Constituent Materials Used

2.1.1Cement

The Ordinary Portland Cement (OPC) of 53 grade with brand name "Dalmia" was used.

2.1.2 Fine Aggregate

The fine aggregate used for the study was manufactured sand and confirms the requirements as per IS: 383-1970.

2.1.3 Coarse Aggregate

Crushed granite metal of 20mm nominal size was used. The fine and coarse aggregates were tested as per the standard specifications.

2.1.4 Water

Portable water in the campus confirming to IS: 456-2000 was used for the project.

2.1.5 Super Plasticizer

In this study Master Rebuild was used as super plasticizer. This was obtained from BASF Construction Chemicals (India) Pvt. Ltd.

2.1.6 Silica Fume

The silica fume was in powder form with an average of 93% silicon dioxide. Grey in colour. Specific gravity of silica fume is 2.2gr/cm^3.

2.1.7 Nano Silica

A cement paste is compound of small grains of hydrated calcium silicate gels, nano-sized particular pores, capillary pores, and large crystals of hydrated products. Thus, there should be room for nano-phase materials to fill the pores of the cement paste. Amorphous nano-scale silica, which is the main component of a pozzolan, reacts with calcium hydroxides formed by the hydration of calcium silicates.

2.2 Mix Proportion

The mix proportions are given in table 1.

Table-1: Mix Proportion

Material	Quantity (kg/m3)
Cement	351.78
Fine aggregate	847.97
Coarse aggregate	1091.496
Water	147.75
Admixture	1.75

Table-2: Percentage Replacement of Cement by Silica Fume and Nano Silica

Mix No.	Silica Fume Percentage	Nano Silica Percentage
1	0	0
2	5	0
3	10	0
4	15	0
5	0	0.5
6	0	1
7	0	1.5
8	5	0.5
9	5	1
10	10	0.5
11	10	1

2.3 Testing Procedure

The specimens of size 150x150x150mm cube were used for compression testing and the flexural strength was conducted on beam of size 100x100x500mm. The specimens were tested at 28 day to obtain the compressive strength and flexural strength of concrete.

3 EXPERIMENTAL RESULTS

3.1 Compressive Strength Test Results

Results obtained from the compressive strength testing are tabulated in table3

Table-3: Compressive Strength of Cube

CUBE DESIGNATION	COMPRESSIVE STRENGTH(N/mm2)
	28Day
CONTROL MIX	33.5
SF 5	33.95
SF 10	35
SF 15	34.33
NS 0.5	36.33
NS 1	40
NS 1.5	39.11
SF 5 NS 0.5	45.77
SF 5 NS 1	47.11
SF 10 NS 0.5	48
SF 10 NS 1	51.11

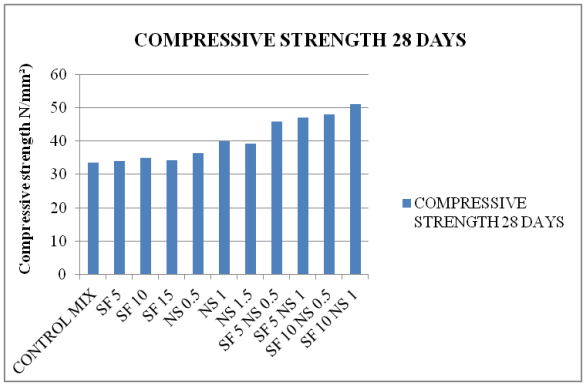

Chart 1-: Variation of Compressive Strength at 28th Day

From the results, it is clear that the use of silica fume and nano silica increase the compressive strength of concrete. The 28 days compressive strength of concrete has been increased for 10% replacement of cement by silica fume and 1% replacement of cement by nano silica. Beyond that the strength is slightly decreased. It has been observed that the compressive strength of concrete at 28 day is maximum with 10% SF and 1% NS combination. With the partial replacement of cement by 10 % SF and 1% NS, the compressive strength at 28 days is increased by 52.5%.

3.2 Flexural Strength Test Results

Results obtained from the flexural strength testing are tabulated in table 4

Table-4 Flexural Strength of Beam

BEAM DESIGNATION	FLEXURAL STRENGTH(N/mm2)
	28Day
CONTROL MIX	4.65
SF 5	5.75
SF 10	6.4
SF 15	6.25
NS 0.5	6.75
NS 1	6.9
NS 1.5	6.5
SF 5 NS 0.5	7.25
SF 5 NS 1	7.5
SF 10 NS 0.5	7.65
SF 10 NS 1	7.9

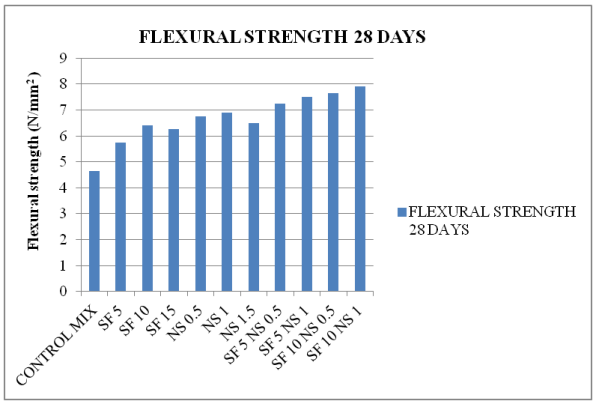

Chart 2-: Variation of Flexural Strength at 28th Day

The result shows the flexural strength study of concrete. The optimum replacement level for flexural strength is 10% SF by weight of cement and 1% NS by weight of cement. The flexural strength of concrete at 28 day is maximum with 10% SF and 1% NS combination. With the partial replacement of cement by 10% SF and 15 NS the flexural strength at 28 days, is increased by 69.8%.

4. CONCLUSION

The combination of silica fume with nano silica as a replacement for cement is investigated in this study.

- The silica fume was used in quantities of 5, 10 and 15 percent and nano-SiO2 was 0.5, 1 and 1.5 percent of the cement.
- The optimum replacement of silica fume and nano silica is 10% and 1% respectively.
- The simultaneous use of silica fume and nano-SiO2 increase noticeably the strength of concrete compared with their single use, besides, in view of the two materials, influence process in the case of their simultaneous use in concrete, all defects of concrete in all ages will be covered and caused them to strengthen each other.

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