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A STUDY ON STRENGTH OF CONCRETE USING MICROSILICA AND NANOSILICA AS A PARTIAL REPLACEMENT OF CEMENT

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Abstract

Amorphous silica particles come in two different sizes, microsilica and nanosilica, each of which has distinct characteristics and finds use in a wide range of industries. Microsilica, also referred to as silica fume, is a byproduct of the manufacturing of ferrosilicon alloys and silicon metal. It is made up of extremely reactive, small particles that range in size from 0.1 to 0.3 micrometres on average. On the other hand, nanosilica refers to silica particles that are frequently produced utilising cutting-edge nanotechnology processes and have diameters that are typically less than 100 nanometers. Both microsilica and nanosilica have remarkable surface area-to-volume ratios, which improve mechanical characteristics and increase reactivity when added to various materials. These silica particles can operate as fillers, reinforcements, and modifiers, giving composites, coatings, adhesives, and cementitious materials desirable properties. Microsilica and nanosilica are significant additions for enhancing the strength, durability, and performance of construction materials due to their special characteristics, including their high surface area, low thermal conductivity, and strong pozzolanic reactivity. Additionally, due to the capacity to build thick and compact microstructures with small particle sizes, permeability is decreased and chemical resistance is increased. In this study, we examine the strengths of microsilica without nanosilica at 10% cement replacement and microsilica at 10% cement replacement with 1% nanosilica and compare with M40 conventional concrete.

***Keywords**: Microsilica, Nanosilica, Pozzolanic reactivity, Low thermal conductivity, Strength, Durability*

I. INTRODUCTION

For the building industry to advance, concrete's performance as a construction material must be improved. Several improvements to the inert qualities of traditional concrete have been made during the past few decades. Nanoindentation results of cement paste samples with similar percentages of silica fume and nanosilica were compared. Samples with nanosilica had almost twice the amount of high-stiffness C-S-H as the samples with silica fumes [1]. The use of silica fume leads to reduction in cement quantity for construction purpose ad its uses should be promoted for better performance as well as for environmental sustainability [2]. The use of silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect [3]. The excess addition of silica fume and nanosilica reduces workabililty. However, in some cases it improves the workability. Silica fume inclusion increases the compressive strength
of concrete significantly (6-57%). The increase depends upon the replacement level [4].

II. MATERIAL PROPERTIES

Cement

The Portland Pozzolana Cement of the Ultratech brand that complied with IS 1489 - 2015 (Part 1) was used. It contains 4% gypsum, 15–35% pozzolanic material, and the remaining clinker. According to the BIS code, PPC is comparable to grade 33. The PPC increases the concrete's density and impermeability by reacting with the calcium hydroxide that is released when Portland cement hydrates. However, these cements' actual strength at the production is substantially higher than the BIS specification. The primary ingredients used to make cement are lime, silica, alumina, silica and iron oxide. The various properties of Cement are shown in table below.

Table 1: Properties of Cement

Parameters	Values
Specific Gravity	2.88
Standard consistency	32%
Initial Setting time	45 min
Final setting time	240 min

Fine Aggregate:

Fine aggregates are defined as those that pass through an IS sieve with a mesh size of 4.75mm. Under grading zone II, M-Sand is utilized as a fine aggregate in accordance with IS 383 - 2016. The table below displays the test results for the fine aggregate qualities.

Table 2: Properties of Fine Aggregate (M – Sand)

Parameters	Values
Specific Gravity	2.605
Sieve analysis	Zone II
Fineness modulus	2.937

Water absorption	1%

Coarse Aggregate:

The majority of the aggregate that passes through a 4.75mm IS sieve is referred to be coarse aggregate. The strength of concrete is determined by the characteristics of coarse particles. Therefore, the aggregate should be devoid of contaminants such as minerals and chemicals. Crushed angular metal from a local source was used as coarse aggregate.The choice of coarse aggregate must take into account a number of factors. The characteristics are described below.

Table 3: Properties of Coarse Aggregate

Parameters	Values
Specific Gravity	2.74
Size of aggregate	20mm & 10mm
Water absorption	0.45%

Microsilica

Micro silica, commonly referred to as silica fume, is an amorphous polymorph of the mineral silica. It is made up of 150 nm-diameters, spherical particles on average.

The silica fume is "very fine non-crystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon," according to the American Concrete Institute. Typically, the powder is grey in colour and somewhat resembles fly ashes or Portland cement.

Table 4: Properties of micro silica

Property	Percentage (%)
Particle size	Less than 1µm
Specific surface area	15000 - 30000 m^2/kg
Bulk density	130-430 kg/m^3
Specific gravity	2.2
Color	Grey
Shape	Spherical
SiO_2	85 – 98%

Nanosilica

Like Silica Fume, nano silica is a substance that is distinguished by having a high SiO2 percentage of above 99%. It is also known as quartz dust or silica dust. By including Nano silica, the aggregate mix's grading curve is completed in the zone of smallest sizes, reducing the amount of cement required.

Table 5: Properties of Nano silica

Property	**Percentage (%)**
Colour	White
Form	Amorphous
Apparent density	0.3696 g/cm^3
Particle size	10 – 20 nm
Silica content (Dry basis)	99.8%
Dispersity (ccl4)	98.6%
Free water content	≤3%
Specific surface area	100 m^2/g

Superplasticizer

As a water-reducing agent, the Superplasticizer is utilised. Conplast SP430 is a superplasticizing admixture free of chloride that is based on certain sulphonated napthalene polymers. It is provided as a dark solution that dissolves quickly in water. Conplast sp430 complies with ASTM C 494 as Type A and Type F and BS 5075 part 3 as well. Research makes uses of type F. Below are listed the super plasticizer's qualities.

Table 6: Properties of Super plasticizer

Appearance	Brown liquid
Specific gravity	Typically 1.20 at 20°C
Chloride content	Nil to BS 5075
Air entrainment	less than 2% additional air is entrained at normal dosages
Alkali content	less than 72 g

III. Mix Design

Table 7: Mix proportions of Conventional concrete

Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	W/C Ratio (Lit)	Superplasticizer (Conplast sp430) (ml)
440	623	1216	154	4400
1	1.42	2.76	0.35	10

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Table 8: Mix proportions of 10% Microsilica in concrete

Cement (Kg)	Micro silica (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	W/C Ratio (Lit)	Superplasticizer (Conplast sp430) (ml)
396	44	623	1216	154	4400
0.9	0.1	1.42	2.76	0.35	10

Table 9: Mix proportions of 10% Microsilica with 1% Nanosilica in concrete

Cement	Micro silica	Nano Silica	F.A	C.A	W/C Ratio	Superplasticizer (Conplast sp430) (ml)
391.6	44	4.4	623	1216	154	4400
0.89	0.1	0.01	1.42	2.76	0.35	10

IV. TESTS AND RESULTS

In this testing investigation, specimens are cast and tested to measure the compressive strength, split tensile strength, and flexural strength of conventional concrete, 10% Microsilica replacement in cement, and 10% Microsilica replacement in cement with 1% Nanosilica. For compressive strength, split tensile strength, and flexural strength, the specimen sizes are 150 mm x 150 mm x 150 mm, 150 mm x 300 mm, and 100 mm x 100 mm, 500 mm, respectively.

Table 10: Mix proportions

Mix	Binder			Fine Aggregate (%)	Coarse Aggregate (%)
	Cement (%)	Microsilca (%)	Nanosilica (%)		
M1	100	0	0	100	100
M2	90	10	0	100	100
M3	89	10	1	100	100

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Table 11: Test Results

Mix	Compressive Strength (N/mm^2)		Split tensile strength (N/mm^2)		Flexural strength (N/mm^2)
	7 days	28 days	7 days	28 days	28 days
M1	25.64	41.93	2.03	3.19	3.29
M1	27.63	43.42	2.1	3.26	2.8
M1	26.49	42.24	2.15	2.98	2.95
Average	**26.59**	**42.53**	**2.09**	**3.14**	**3.01**
M2	35.42	44.38	2.65	3.83	6.8
M2	36.09	46.48	2.8	4.15	5.2
M2	33.22	44.12	2.22	3.9	5.6
Average	**34.91**	**44.99**	**2.56**	**3.96**	**5.87**
M3	23.42	34.33	1.56	2.49	3.5
M3	22.21	30.71	1.95	2.83	3.1
M3	25.24	38	1.70	3.18	2.22
Average	**23.62**	**34.35**	**1.74**	**2.83**	**2.94**

M1 – Conventional concrete

M2 – 10% Microsilica replacement in cement

M3 – 10% Microsilica replacement in cement with 1% nanosilica

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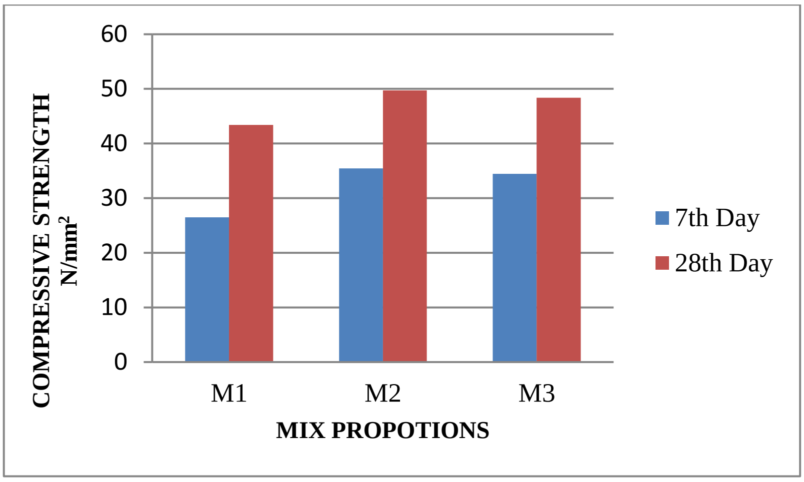

FIG 1: COMPRESSIVE STRENGTH RESULT

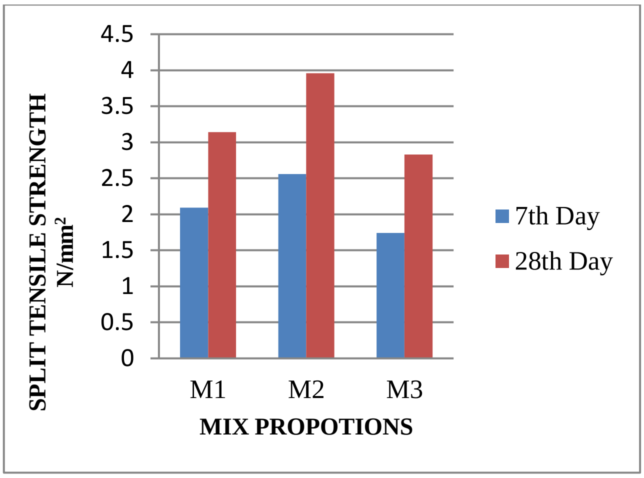

FIG 2: SPLIT TENSILE STRENGTH RESULT

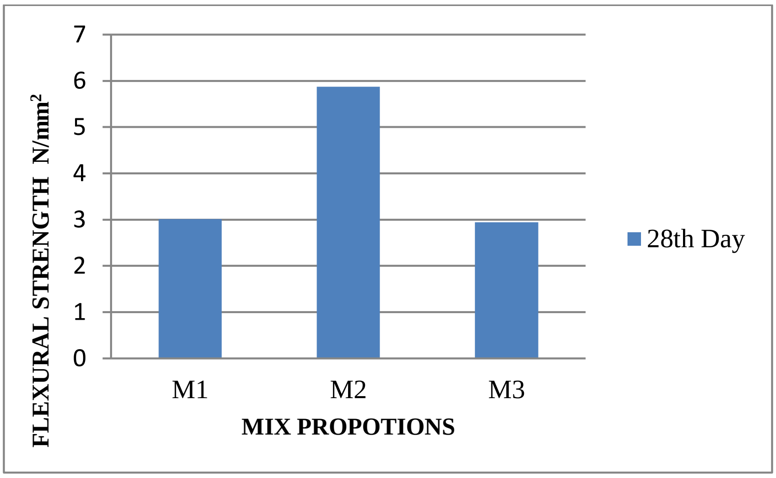

FIG 3: FLEXURAL STRENGTH RESULT

V. CONCLUSIONS

In this testing investigation, compare the strength of compressive strength, split tensile strength, flexural strength to 10% replacement of microsilica in cement, and 10% replacement of microsilica in cement with 1% nanosilica, with conventional concrete. According to the test results, 10% microsilica substitution in cement produces superior results than two.

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