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EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLCAMENT CEMENT WITH SILICA FUME

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Abstract— nowadays, high-quality, high-performance concrete is widely used in construction. Supplementary material is used to reduce the amount of cement in concrete. Silica fume is substituted for 0 percent, 10%, 20%, and 30% of the total weight of cement, respectively. For concrete grade M-30, the water cement ratio is 0.45. The effect of the same proportion at the varied levels 0%, 10%, 20% for the time period of 7, 14, and 28 days of curing as a replacement cement by silica fume (SF) on slump test, split tensile strength, compression test, and flexural strength was conducted and analysed.

Keywords— ***slum test, compressive strength, split tensile strength, flexural strength.***

I. INTRODUCTION

Ordinary Portland Cement (OPC) is the most widely used construction material on the world. Around 2.0 billion of tons were produced every year, with 3.5 billion expected in 2015. In Nigeria, 8.21 millions of tons are required per year, with 4.6 million tones manufactured locally. The remainder is imported Portland cement. The demand for cement will be lowered if alternative cement is produced locally. The search for suitable materials for the production of pozzolanic cement commenced. An increase in demand for the use of extra cement materials was addressed. As a substitute to cement, waste materials such as ash and silica fume are used.

Micro silica is a very fine substance with atoms ranging in size from 1 µm in diameter. Silica fume is a pozzolanic substance with a high silica content that is also environmentally friendly. Silica fume is added to concrete to improve properties such as compressive strength, bonding strength, and abrasion resistance. When silica fume is present in concrete, the permeability of the concrete is reduced, and the reinforced concrete structure is better protected from corrosion. Nanotechnology is now widely used in a wide range of fields. Micro silica increases the bulk characteristics of concrete and cuts the time it takes to place it in comparison to traditional concrete. The pozzolanic nature of nano silica is greater.

Nano silica is a much finer particle than silica fume, and it reduces the pores in the concrete as well as the permeability of the concrete. After that, Nano silica is added to the concrete to protect the reinforcing metal from corrosion. Corrosion in steel is caused by the presence of w/c ratio, concrete permeability, chloride ions, Ph value, and carbonation. Corrosion also causes pits in the reinforcing steel, reduces the weight of the steel, and reduces the strength of the reinforcing steel. The addition of micro silica as an alternative to cement had been tested experimentally.

ADVANTAGES OF SLICA FUME:

- Silica fume improve the properties of fresh and hardened concrete.
- Fresh concrete made with silica fume is more cohesive.
- Silica fume reduce the segregation and bleeding.
- Silica fume improve the durability of concrete.

II. LITERATURE REVIEW

VinayDhakad and Ajay Bidare (2017) To reduce the amount of cement in concrete supplementary material are used. Silica fume is most popular material used in the concrete to improve its flexural, split tensile strength. For this purpose silica fume is replaced by 0%, 5%, 7.5%, 12.5%, 15%, 20% & 25% by the weight of cement. Water binder ratio is taken 0.42 for M-25 grade of concrete. Workability of concrete decreases as proportion of silica fumes increasesMaximum split tensile strength was observed when silica fume replacement is about 20%. 4. Maximum flexural strength was observed when silica fume replacement is about 15%.

Alvin Harison and Vikas Srivastava (2017) The addition of silica fume reduces workability. 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. The tensile and flexural strength of silica fume concrete is almost similar to the referral concrete. The addition of silica fume improves the bond strength of concrete. The modulus of elasticity of silica fume concrete is almost similar to the referral concrete.

Amar kendre et.al.,(2019) The use of silica fume as a mineral admixture to produce high strength high performance concretes is gaining importance in recent years The work was focused on concrete mixes having a fixed water cement ratio of 0.35 with the addition of super plasticizer at a constant total binder cement content of 412 kg/m3 . The percentage of silica fume replaced with cement in this research was: 5%, 10%, 15% and 20%. At 10% replacement of cement with silica fume, it gave the highest compressive strength. But higher replacement of cement by silica fume gave lower strength. The compressive strength increased of specimen with silica fume increased as compared to the specimen without silica fume. It was observed that with the addition of silica fume, the compressive strength of concrete was increased greatly at early ages after which not much increase was observed. Compressive, split tensile and flexural strength of the standard concrete specimen was increased significantly for specimen containing silica fume.

Shivam malviya et.al.,(2020) The use of silica fume had a major impact on industries, the ability to routinely & commercially produce silica fume modified concrete of flowable in nature but yet remain cohesive, which in turn produces high early and later age strength including resistant to aggregate environments. In this project, an experimental study has been conducted on concrete by varying the percentage of silica fume as 0%, 5%,10% and 15% respectively to study the increase in the compressive strength of concrete. Based on the experimental investigation, the compressive strength was found to increase at 10% addition of silica fume in the concrete.

K.Ramadevi and Ruthresh Rajendran (2021) To reduce the quantity of cement in concrete, supplementary material is utilized. Silica fume is substituted by 0%,5%,10%,15%,20%&25% by the

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overall weight of cement. W/c ratio is taken 0.45 for M-30 grade of concrete. different tests were conducted and analysis the effect of the same percentage at the various of 0%,5%,10%,15%,20%&25% for the time period of 7 and 28 days of curing as a replacing cement by silica fume (SF) on Split tensile strength, compression test, flexural strength. At 20% substitution of cement with silica fume (SF), the compressive was found to be 49.70 N/mm2.It can be seen that the compressive strength strengthens by 26.4% than the control mix.At 20% substitution of cement with silica fume, the split tensile strength was found to be 5.13 N/mm2.

III. MATERIALS USED:

a. *Cement:*

In this project OPC 53 grade Dalmia cement confirming to BIS: 12269-1989 is used. The physical properties and chemical properties of cement were given in Table 3.1 and 3.2. These tests are conducted as per IS 4031-3 (1999) and IS 4031-6 (1999).

Table 3.1 Physical properties of cement

S. No	Properties	Values obtained	Permissible limits As per IS 12269
1	Consistency	28 %	2.5-2.8
2	Specific gravity	3.15	-
3	Initial setting time	34	>30 min
4	Final setting time	253	<600 min
5	Fineness	7	<10 %

Table 3.2 Chemical properties of cement

Chemical compositions	Results (%)	Permissible limits as per IS : 12269
SiO_2	21.54	-
Fe_2O_3	3.63	-
Al_2O_3	5.32	-
MgO	1.08	Maximum 6
SO_3	2.18	-
CaO	63.3	-
LOI	1.1	-

b. *Fine aggregate:*

In this study M-sand passing through 4.75mm IS sieve is used which belongs to zone II (as per IS 383). Various tests were carried out as per IS: 2386-1968 part III.

Table 3.3: Physical Properties of Fine aggregate

S. No	Properties	Values obtained	Permissible limits as per IS 383:1970
1	Zone	II	I to IV
2	Specific gravity	2.8	-
3	Dry rodded density	1802 Kg/m^3	-
4	Slit Content	0.3%	Max 3% by weight
5	Water absorption	1 %	-

c. *Coarse aggregate:*

In this study, locally available aggregates passing through IS 20mm sieve and retained on IS 4.75mm sieve in saturated surface dry condition are used as coarse aggregates. The aggregates are angular type crushed granite aggregates. The coarse aggregates was tested as per IS 2386:1968 part III and its properties are tabulated in table 3.4.

Table 3.4 Physical Properties of coarse aggregate

S. No	Properties	Values obtained	Permissible limits as per IS 12269
1	Specific gravity	2.82	2.5 – 2.8
2	Dry rodded density	1637 Kg/m^3	-
3	Water absorption	0.52%	2%

d. *Silica fume*

Silica fume is a very thin powder that is largely made up of shapeless silicon dioxide. Also used are the words 'condensed silica fume' and' micro silica.' In any scenario, these terms may be used to any powder produced by the refining industry, therefore adhering to the established 'Silica Fume' requirements is critical for a product with the qualities and quality necessary for use in concrete. The substance comes from the silicon and ferrosilicon purification industries. Silica fume is a grey powder in its most basic form (although shades of nearly white to nearly black, due to variable carbon content, may be seen from different furnace operations). The qualities of a silica fume for usage in concrete are as follows:

Table 3.5 Physical Properties of Silica Fume

Sl.No	Properties	Result
1.	colour	Grey
2.	Specific gravity	2.30
3.	Fineness modulus	20000m2/kg
4.	Bulk modulus	247kg/m3

Table 3.6: Chemical Properties of Silica Fume

Sl.No	Properties	Result
1.	Sio2	95.00%
2.	Al2o3	2.52%
3.	Fe2o3	0.5
4.	Mg0	0.9
5.	Cao	0.1
6.	Na2o	0.4
7.	K2o	0.05
8.	C	0.5
9.	S	0.2
10.	Loss of ignition (c + s)	1.92%

IV MIX PROPORTION

Table 4 Concrete mix proportion

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Mix	% OF S F	CEMENT (KG)	F A (KG)	C A (KG)	W/C	S F (KG)
CC	0	440	753	1139	0.45	0
M10	10	396	753	1139	0.45	44
M20	20	352	753	1139	0.45	88
M30	30	308	753	1139	0.45	132

V TEST RESULTS AND DISCUSSION:

The test is carried out on one concrete cube, cylinder and beam which are casted by the above mentioned raw materials and they are tested on 3rd, 7th and 28th days.

i) Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. The apparatus for conducting the Slump test essentially consists of a metallic mould in the form of a frustum of a cone having bottom diameter as 20cm, top diameter as 10cm and height as 30cm. For tamping the concrete, a steel tamping rod of 16mm diameter, 600mm long with a bullet end is used. Fig.6.1 shows the apparatus for slump test. The test is carried out as per IS: 1199-1959

Fig 1 Slump test

Table 5.1 Slump test

S. No	Mix Designation	Slump value (mm)
1	CC	115
2	M10	100
3	M20	92
4	M30	90

ii) Compresssive Strength

For compressive strength test the cubes are casted with dimension of 150mm X 150mm X 150mm. They are carried out according to IS 516-1959. After 24 hour the specimens were stored in a curing tank for 28 days. The cubes were tested in compression testing machine up to sustain without fracture and the load was noted.

Fig 2 Compressive strength test

Table 5.2 Compressive strength of concrete

Mix	% of silica fume	Compressive strength (N/mm^2)		
		7 days	14 days	28 days
CC	0	25.21	34.26	39.03
M10	10	28.12	38.12	41.23
M20	20	30.31	43.26	48.70
M30	30	26.78	36.17	39.20

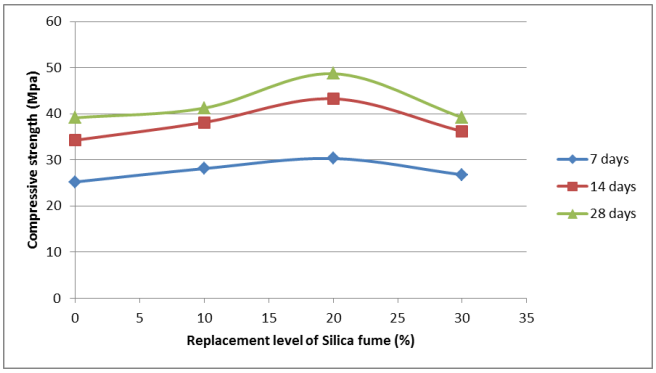

Fig 3 Compressive strength

iii) *Split Tensile Strength*:

The split tensile test is an indirect method for determining the tensile strength of concrete. This tests are carried out IS 516 & IS 5816-1999. The testing cylinders are of 150mm diameter and 300mm height which is tested in compression testing machine, the specimens are placed in horizontally between the loading surface and the load applied until failure the cylinder, along the vertical diameter. For the split tensile test, the cylindrical mould is casted and stored in a curing tank for 28 days. The cylinders were tested in compression testing machine as shown in fig7.2, until failure and the load was noted.

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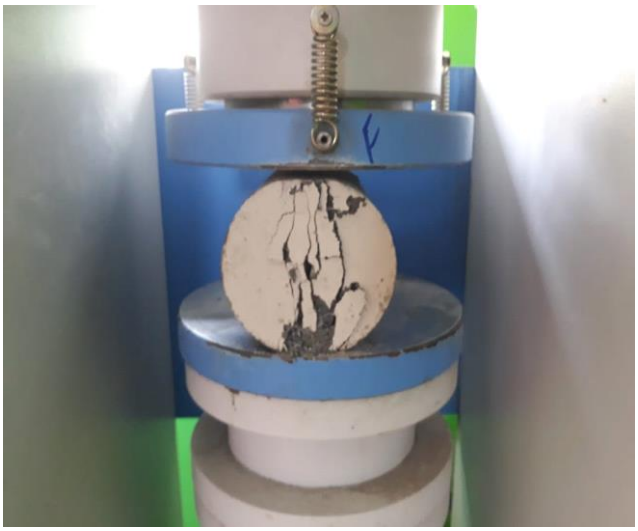

Fig 4 Split tensile strength test

TABLE 5.3 Split tensile strength of concrete

Mix	% of silica fume	Split tensile strength strength (N/mm^2)		
		7 days	14 days	28 days
CC	0	2.5	3.43	3.96
M10	10	2.75	3.6	4.36
M20	20	2.96	3.87	4.91
M30	30	2.64	3.02	4.10

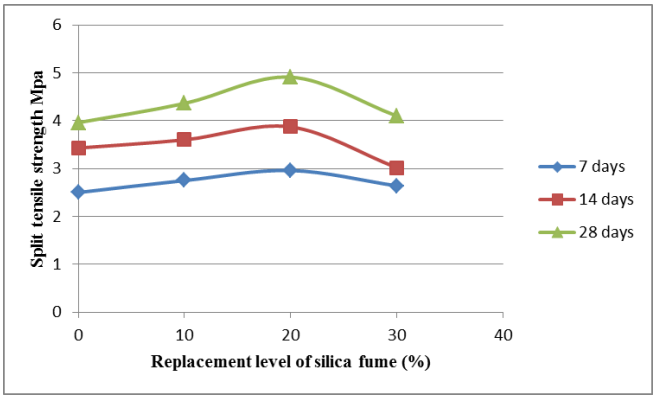

Fig 5 Split tensile strength

iv) Flexural Strength:

Flexural strength of concrete beam specimens was tested in accordance with IS 516:1959 in this study. The beam specimen of size 100mm x 100mm x 500mm was casted for testing the flexural strength. The beam specimens immediately after curing should be tested for their flexural strength.

The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device.

After curing of Beam specimens they are placed in testing machine having a maximum capacity of 40 tonne. The load is applied on the beam specimens. The specimen is failed at ultimate load which is noted from dial gauge reading. From the result flexural strength is increased with respect to the grade of concrete when adding 30 % of MK and 30% of GGBS when compared to the conventional concrete.

Fig 6 Flexural strength test

TABLE 5.24 Flexural strength of concrete

Mix	% of silica fume	Flexural strength at 28 days (N/mm^2)
CC	0	4.32
M10	10	4.49
M20	20	4.77
M30	30	4.42

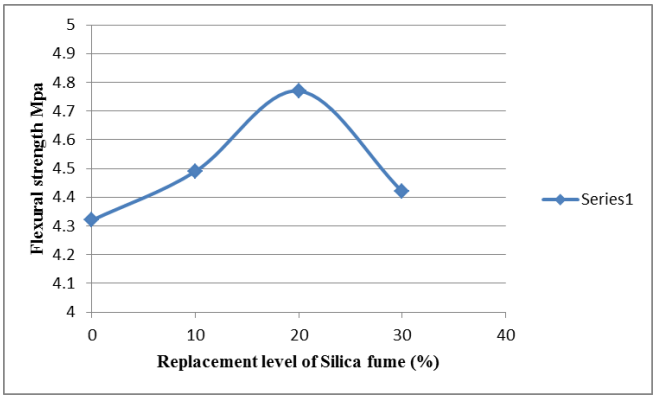

Fig7 Flexural strength

VI CONCLUSIONS:

- Workability of concrete decreased on the replacement of silica fume as partial replacement of cement.
- Slump values decrease almost linearly with increase in Silica fume content
- The increase in replacement level of cement with silica fume there is an increase in compressive strength up to 20% (48.70 N/mm^2) when compared with Conventional concrete (CC).

- When compared with CC. If replacement level increased to 30 %, compressive strength is reduced. But the strength is comparatively more when compared to CC.
- Similar results are found for the split tensile strength. The 20% replacement shows more strength (4.91 N/mm^2).
- Inclusion of cement with SF there is an enhanced the flexural strength up to 20% (4.77 N/mm^2) when compared with CC
- Partial Replacement of cement by silica fume shows more compressive strength, split tensile strength and Flexural strength when compared with Conventional Concrete.

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