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"STUDY ON THE EFFECT OF SILICA FUME IN STEEL SLAG CONCRETE"

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ABSTRACT - *Concrete is the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. To improve its performance with the help of different admixtures and supplementary cementitious materials. then, most concrete mixture contains supplementary cementitious material. These materials are majority byproducts from other processes These materials are larger part side-effects from different cycles in which can be used as SCMs such as fly ash, silica fume, ground granulated blast furnace slag, steel slag etc. The use of these byproducts not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hydrated states. Slag cement and fly ash are the two most common SCMs used in concrete. Slag cement and fly ash are the two most common SCM's used in concrete, their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures. Fly ash cement and their blend (in 1:1 proportion). These binder mixes are modified by 10% and 20% of silica fume in replacement. The fine aggregate used is natural sand comply to zone II as per IS 383-1982.The coarse aggregate used is steel making slag of 20 mm down size. To mixed in 1: 1.5: 3 proportions. The porosity and capillary test conducted on mortar mixes show decrease in capillary absorption and porosity with increase in silica fume percentage with both type of cements. The properties studied in 7days, 28days and 56 days compressive strengths the slump is kept between 50-70 mm, The mortar strength increases with the increasing percentage of silica fume. Comparatively higher early strength gain (7-days) is obtained with fly ash cement strength (28 days) gain is obtained with slag cement. However, concrete exhibits the opposite trend, with studies indicating a reduction in the compressive strength of concrete after 7 days, 28 days, and 56 days as a result of the addition of silica fume to the matrix.*

Keyword Steel slag, Silica fume, Fly ash, Compressive Strength, Concrete

INTRODUCTION

Cement, sand, coarse aggregate, and water are the main ingredients of concrete. Its popularity is due to its adaptability because it can be made to survive the roughest conditions while also taking on the most inspiring forms. Innovative chemical admixtures and different supplemental cementitious materials (SCMs) are created by engineers and scientists. Romans and natural, easily accessible materials like volcano ash or diatomaceous earth made up the earliest SCMsMost concrete mixtures today contain SCMs, which are primarily waste products or leftovers from other industrial operations.

SUPPLEMENTARY CEMENTITIOUS MATERIAL:

More recently, strict environmental – pollution controls and regulations have produced an increase in the industrial wastes and sub graded byproducts which can be used as SCMs such as fly ash. Ground granulated blast furnace Slag It is hydraulic type of SCM. Ground granulated blast furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag, granular product that is then dried and ground into a fine powder. Ground granulated blast furnace slag (GGBFS) has been utilized for many years as an additional cementitious material in Portland cement concretes, either as a mineral admixture or as a component of blended cement. Granulated blast furnace slag typically replaces 35–65% Portland cement in concrete.

LITERATURE REVIEW

Xiaoboi et al; (2019): Investigated the effect of silica fume(SF) on mechanical properties of concrete incorporating steel slag powder (SSP). The compressive strength and splitting strength tests of concrete with different content of SF (0%, 4%, 8% and 12%) and of SSP (0%, 10%, 20%, 30% and 40%) were carried out, and the test results were analyzed and fitted. Obtained results showed that the brittleness, compressive strength and compressive strength discreteness of concrete increased due to the incorporation of SF. SSP weakened the compressive strength of concrete, which reduced within 10% when the content of SSP was less than 20%. SF and SSP showed synergistic hydration effect when they were mixed, and the optimal group was SF8SSP30, whose compressive strength was close to that of plain concrete, and whose brittleness as well as discreteness of compressive strength were lower relatively. With the content of SSF and of SSP as variables, the tension-compression ratio and compressive strength of concrete can be well estimated by surface fitting.

B. Himanshi et al; (2018): studies the most versatile construction material because it can be designed to withstand the harshest environments while taking on the most inspirational forms. Reason their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures. Perhaps the most successful SCM is silica fume because it improves both strength and durability of concrete to such extent that modern design rules call for the addition of silica fume for design of high strength concrete. The main conclusions drawn are inclusion of silica fume increases the water requirement of binder mixes to make paste of normal consistency. Water requirement increase with increasing dose of silica fume.

Haider Feroze Rangrez et al; (2020): studied how to improve concrete structures with a new blending framework. Cement, sand and aggregate were mixed in a certain ratio. The proportion began to maximize the strength of the concrete mixture. In real time, the mixture could be easily nourished on construction projects, so it took a certain amount of time to achieve sustainable benefits. It is usually 28 days to get a full booster for the production of the mixture. Aggregates and silica fume were mixed at specific levels of 0%, 5%, 10%, 15% and 20%. This inclusion was tested and produced the strongest distribution at any given time. Analyzes of compressive strength, insulation tension, flexural strength, and shear strength tests were performed on concrete mixtures from M-0 to M-20. This paper examines the aforementioned tests on various compositions of the material.

CHEMICAL ANALYSIS OF SILICA FUME

TABLE NO. 1

Silica fume	ASTM-C-1240	Actual Analysis
Sio_2	87% min	86.7%
Loi	4%max	3.6%
Moisture	3% max	0.9%
Pozz Acuivity index	105% min	129%
Sp Surface Area	>15m2/gm	22 m2/gm
Bulk Density	550 to 700	600
+45	10% max	0.7%

SIEVE ANALYSIS OF STEEL SLAG

TABLE NO. 2

Sieve size	Wt Retain	Cum Wt Ret^n	% Cu wt Ret^n	% Passing
21 mm	274 gm	0.280 kg	5.6	95.5
12.5 mm	352 gm	4.652 kg	74.84	22.16
10 mm	790 gm	4.562 kg	92.63	8.46
4.75 mm	334 gm	4.916 kg	97.62	1.67
Total	1750 gm			

PHYSICAL PROPERTIES OF STEEL SLAG

Table No.3

Material	Specific gravity	Water absorption in %
Steel slag	3.34	1.2%

MATERIALS

Silica fume Silica fume is a byproduct in the reduction of high-purity quartz with coke in electric arc furnaces in the production of silicon and ferrosilicon alloys. Silica fume consists of fine particles with a surface area on the order of 215,280 ft²/lb (20,000 m²/kg) when measured by nitrogen adsorption techniques, with particles approximately one hundredth the size of the average cement Because of its extreme fineness and high silica content, silica fume is a very effective pozzolanic material particle. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength silica fume is a very effective pozzolanic material particle. Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvements stem from both the mechanical improvements resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.

Steel Slag: The Steel slag, a byproduct of steel making, is produced during the separation of molten steel from impurities in steel making furnaces. This can be used as aggregate in concrete. Steel slag aggregate generally exhibit a propensity to expand because of the presence of free lime and magnesium oxides that have not reacted with the silicate structure and that can hydrate and expand in humid environments. Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Incorporation of silica fume is one of the methods of enhancing the strength of concrete. The production of HSC may be hampered if the aggregates are weak. Weak and marginal aggregates are wide spread in many parts of the world and there is a concern as to the production of HSC in those regions. Incorporation of silica fume is one of the methods of enhancing the strength of concrete, particularly when the aggregates are of low quality.

Fly ash cement: Fly ash, which is largely made up of silicon dioxide and calcium oxide, can be used as a substitute for Portland cement, or as a supplement to it. The materials which make up fly ash are pozzolanic, meaning that they can be used to bind cement materials together. Pozzolanic materials, including fly ash cement, add durability and strength to concrete. Fly ash cement is also known as green concrete. It binds the toxic chemicals that are present in the fly ash in a way that should prevent them from contaminating natural resources. Using fly ash cement in place of or in addition to Portland cement uses less energy, requires less invasive mining, and reduces both resource consumption and CO2 emissions.

Slag cement: Slag cement has been used in concrete projects in the United States for over a century. Earlier usage of slag cement in Europe and elsewhere demonstrates that long-term concrete performance is enhanced in many ways. Based on these early experiences, modern designers have found that these improved durability characteristics help further reduce life-cycle costs, lower maintenance costs and makes concrete more sustainable.

Sand: Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO_2), usually in the form of quartz which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering. It is used as fine aggregate in concrete.

LABORATORY TEST CONDUCTED

Compressive Strength Test: For each set six standard cubes were cast to determine 7-days,28 day and 56 days compressive strength after curing. Also, nine no. of cube was casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086 – 1982.

Capillary absorption Test: Two cube specimens were cast for both (Mortar and concrete cube) to determine capillary absorption coefficients after 7days, 28 days and 56 days curing. This test is conducted to check the capillary absorption of different binder mix mortar matrices which indirectly measure the durability of the different mortar matrices . Procedure

1) The specimen was dried in oven at about 105^0C until constant mass was obtained.
2) Specimen was cool down to room temperature for 6hr.
3) The sides of the specimen were coated with paraffin to achieve unidirectional flow.
4) The specimen was exposed to water on one face by placing it on slightly raised seat (about 5 mm) on a pan filled with water.
5) The water on the pan was maintained about 5mm above the base of the specimen during the experiment as shown in the figure below.
6) The weight of the specimen was measured at 15 min and 30 min. intervals.
7) The capillary absorption coefficient (k) was calculated by using formula:

$$k=Q/A* \text{sqrt}(t)$$

where Q is amount of water absorbed

A is cross sectional area in contact with water is time

RESULTS AND DISCUSSIONS

Experimental study on mortar: Here we prepared mortar with ratio 1:3 from different types of cement + silica fume replacement as binder mix and sand as fine aggregate. Then its physical properties like capillary absorption consistency, compressive strength and porosity was predicted. These test results both in tabular form and graphical presentation are given below.

Normal Consistency for Mortar: Normal consistency of different binder mixes was determined using the following procedure referring to IS 4031: part 4 (1988):

CONCLUSION

From the present study the following conclusions are drawn:

1. SC At 20% Replacement By SF The Maximum Value At 7 Days Was Found To Be 35.12 For The Minimum Value Of SC Is Found 19.95 By 0% Replacement Of SF In SC. Also In 28 Days.

2 The Maximum Value Of SC Was 42.15 By 20% Replacement SF In SC ..

3. The Maximum & Minimum Value Was Found By 20% Replacement Was 42.15 & 35.12 Respectively .

4. For FC The Maximum Value Was 36.44 By 20% Replacement Of SF In FC In 7days Similarly In 28 Days For Maximum And Minimum Value Was 26.57 And Maximum Was 37.23

5. So, Finally From The About Conclusion We Find That As We Increase The % Of SF In SC.

6. FC And FSC Then Resultant Represent Is As The % Of SF Increased By 0% Of 20% In SC,FC And FSC The Strength Of Concrete To Some Extent Get Increased After 20% Replaced Of SF In FC And FSC The Result In Showing The Value Is Low Than As Compared To Nominals Concrete Was Less.

7. So, The % Of SF Fit For The Partial Replacement In FSC Is To 20% Only,

8. The steel slag should be properly treated by stock piling it in open for at least one year to allow the free CaO & MgO to hydrate and thereby to reduce the expansion in later age.

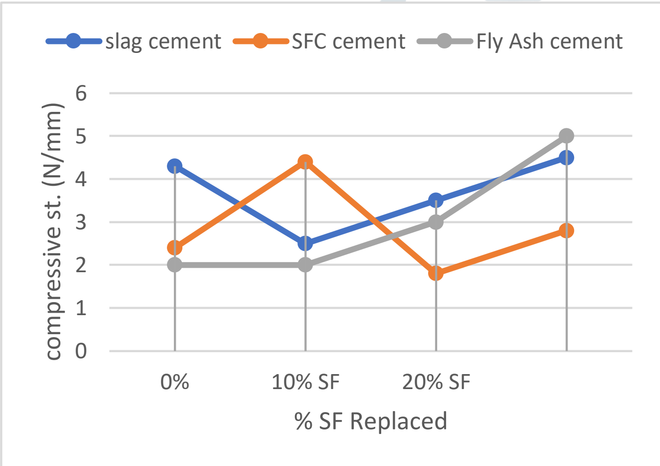
9. This is due to the formation of voids during mixing and compacting the concrete mix in vibration table because silica fume make the mixture sticky or more cohesive which do not allow the entrapped air to escape.

EXPERIMENTAL STUDY ON MORTAR.

Table No.4

	Description	Cement (grams)	Silica fume	Consistency (%)
SC0	SC	350	00	32.6
SC10	SC with 10% SF	260	30	36
SC20	SC with 20% SF	235	60	41.5
FC0	FC	300	00	37.5
FC10	FC with 10% SF	275	35	48
FC20	FC with 20% SF	242	65	56.5
SFC0	SC:FC (1:1)	155 each	00	36.5
SFC10	SC:FC (1:1) with 10%SF	138 each	30	42.5
SFC20	SC:FC (1:1) with 20%SF	125 each	60	48.6

Where, SC = slag cement
FC = fly ash cement
SF = silica fume
SFC = slag and fly ash cement
SC0 = Slag cement with 0% silica fume replacement.
SC10 = Slag cement with 10% silica fume replacement.



COMPRESSIVE STRENGTH OF MORTAR

Table No.5

	% of SF replaced	7 days	28 days
Slag cement (SC)	0	19.95	29.43
	10	24.96	35.09
	20	35.12	42.15
Fly ash cement (FC)	0	15.84	26.57
	10	28.07	31.74
	20	36.44	37.23
Slag and fly ash cement blend (1:1) (SFC)	0	16.74	32.57
	10	24.55	38.69
	20	28.89	41.14

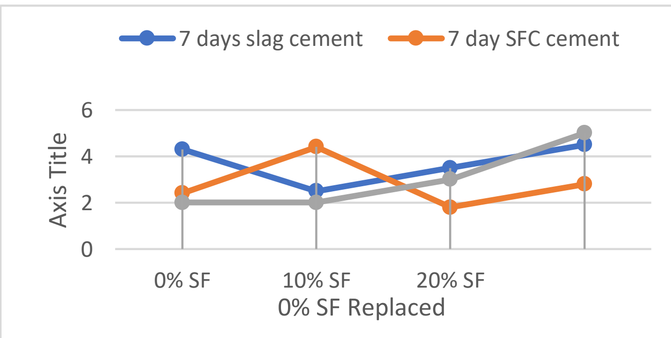


Fig No.5 Compressive strength for mortar for 7 days

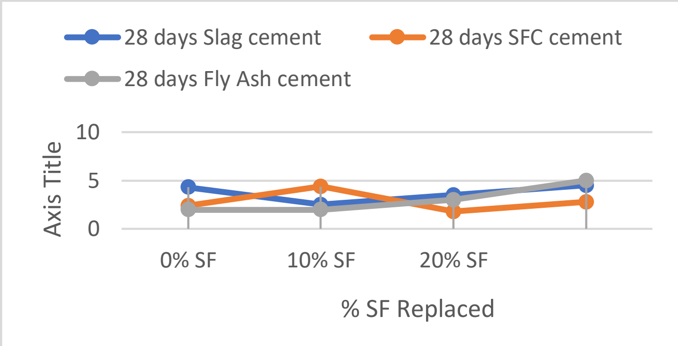


Fig.2 No.5 compressive strength for mortar for 28 day

CAPILLARY ABSORPTIO

Table No- 6

	% silica fume Replace	28 days($k*10^{-3}$ cm/s)	56 days($k*10^{-3}$ cm/s)
Slag cement	0	1.240	1.097
	10	0.815	0.785
	20	0.630	0.519
Fly ash cement	0	0.890	0.797
	10	0.640	0.594
	20	0.542	0.486
Slag and fly ash cement blend (1:1)	0	0.976	0.875
	10	0.846	0.631
	20	0.590	0.546

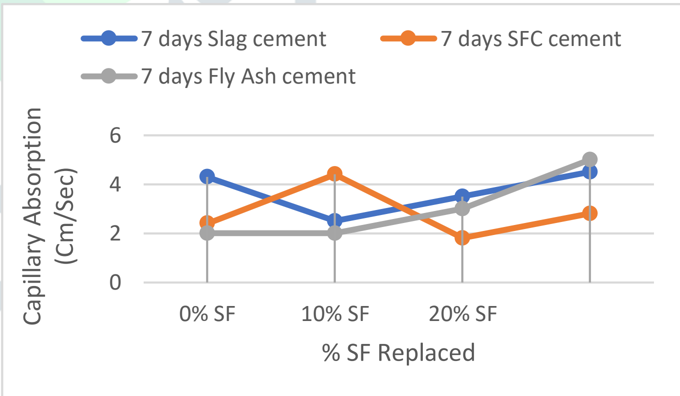


Fig- 6 Capillary Absorption for mortar for 7 days

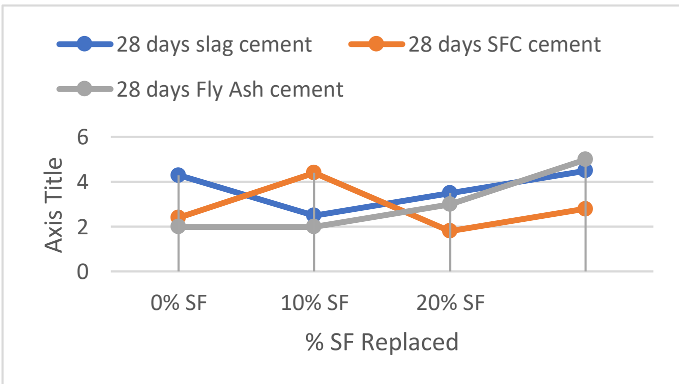


Fig- 6 Capillary Absorption for mortar for 28 days

POROSITY TEST OF MORTAR

Table-7

	% of SF replaced	7 days (%)	28 days (%)
Slag cement	0	8.98	8.77
	10	7.48	6.13
	20	5.86	7.35
Fly ash cement	0	7.35	6.28
	10	6.17	5.48
	20	4.56	3.53
Slag and fly ash cement blend (1:1)	0	9.78	8.52
	10	7.54	7.32
	20	6.82	5.71

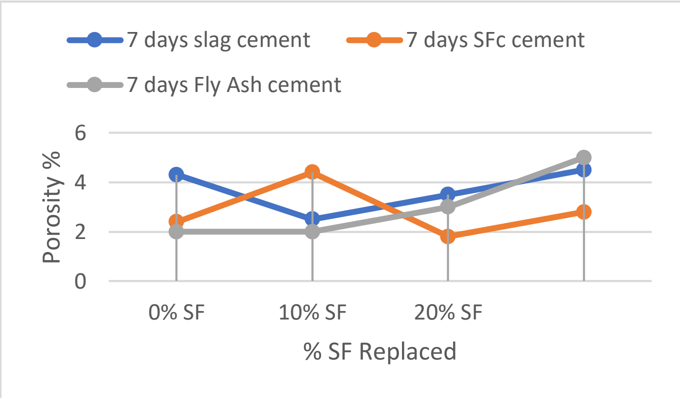


Fig.7 Porosity of mortar for 7 days

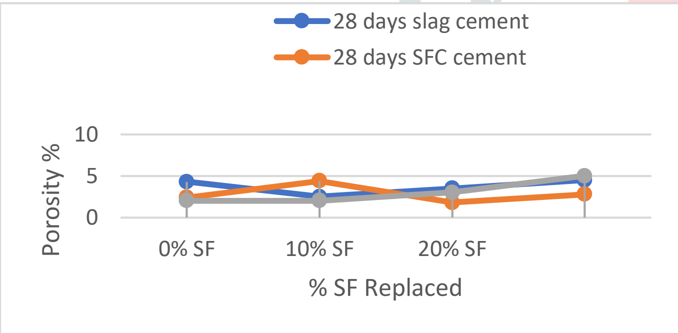


Fig. 7 Porosity of mortar for 28 days

WATER /CEMENT RATIO AND SLUMP

Table-8

	% of SF Replaced	W/C Ratio	Slump in (mm)
Fly ash cement	0	0.52	53
	10	0.60	53
	20	0.570	57
Slag cement	0	0.47	63
	10	0.520	51
	20	0.575	56
Slag and fly ash cement blend (1:1)	0	0.475	62
	10	0.548	54
	20	0.550	53

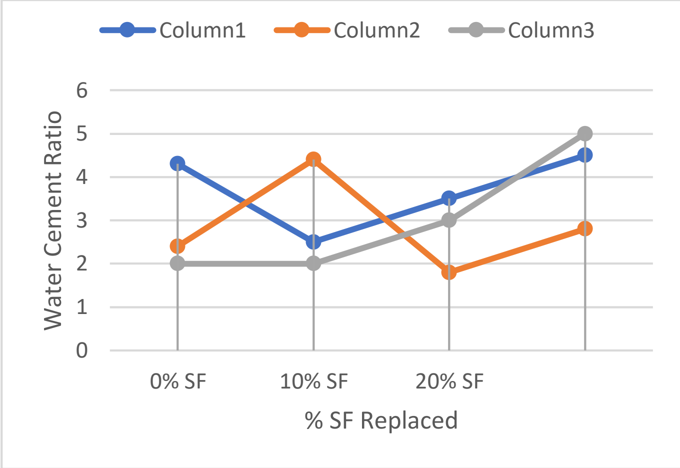


Fig. 8 Water Cement Ratio for steel slag concrete

WATER CEMENT RATIO FOR STEEL SLAG CONCRETE

	% of SF replaced	7days	28days	56 days
Fly ash cement	0	24.35	38.17	44.17
	10	22.62	28.78	31.46
	20	21.66	24.16	29.15
Slag cement	0	17.63	27.22	27.95
	10	18.70	24.36	26.56
	20	21.24	23.95	22.12
Slag and fly ash cement blend (1:1)	0	26.05	28.53	34.12
	10	23.24	24.75	30.15
	20	20	23.85	29.90

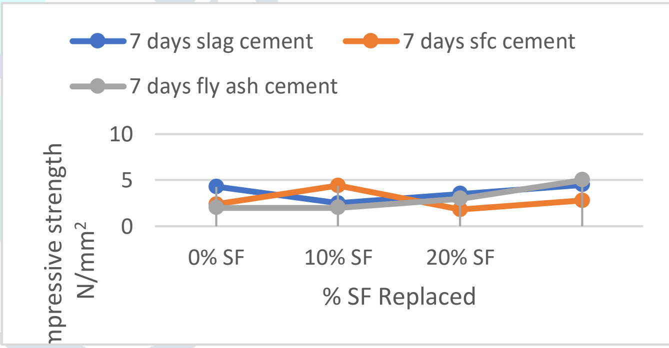


Fig. 9 Compressive strength of concrete for 7 days

Fig.-9 Compressive strength of concrete for 28 days

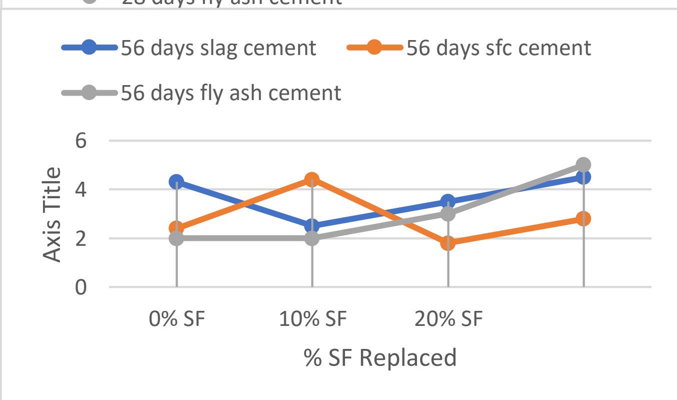


Fig-9 Compressive strength of concrete for 56 days

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