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Experimental Analysis of Steel Slag Concrete under the Influence of Micro Silica and Determination of Strength Characteristics

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Abstract:

Concrete is the most widely utilizing construction material because it can be designed to withstand the variant environmental conditions while taking on the most inspirational forms. Engineers are continually insisting the limits to improve its performance with the help of adhesive chemical admixtures and supplementary cementitious materials. Nowadays, most concrete mixture contains supplementary agents which forms mix. These materials are commonly byproducts from other processes. The main benefits of these elements are their ability to replace certain amount of cement and still able to display cementitious property, thus reducing the cost of using Portland cement. The fast growth in urbanization outraged in tons and tons of byproduct or waste materials, which can be used as binding agents 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 binding agents used in concrete.

Introduction:

Concrete is a mixture of cement, sand, coarse aggregate and water. Its success lies in its versatility as can be designed to withstand harshest environments while taking on the most inspirational forms. Engineers and scientists are further trying to increase its limits with the help of innovative chemical admixtures and various supplementary cementitious materials SCMs.

Early SCMs consisted of natural, readily available materials like volcanic ash or diatomaceous earth. The engineering marvels like Roman aqueducts, the Coliseum are examples of this technique used by Greeks and Romans. Nowadays, most concrete mixture contains SCMs which are mainly byproducts or waste materials from other industrial processes.

Literature Survey:

Many works have been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. M.D.A. Thomas, M.H.Shehata[1] et al. have studied the ternary cementitious blends of Portland cement, silica fume, and fly ash offer significant advantages over binary blends and even greater enhancements over plain Portland cement. Sandor Popovics[2] have studied the Portland cement-fly ash – silica fume systems in concrete and concluded several beneficial effects of addition of silica fume to the fly ash cement mortar in terms of strength, workability and ultra sonic velocity test results. Jan Bijen[3] have studied the benefits of slag and fly ash added to concrete made with OPC in terms of alkali-silica reaction, sulphate attack. L. Lam, Y.L. Wong, and C.S. Poon[4] in their studied entitled Effect of fly ash and silica fume on compressive and fracture behaviors of concrete had concluded enhancement in strength properties of concrete by adding different percentage of fly ash and silica fume. Tahir Gonen and Salih

Yazicioglu[5] studied the influence of binary and ternary blend of mineral admixtures on the short and long term performances of concrete and concluded many improved concrete properties in fresh and hardened states. Mateusz Radlinski, Jan Olek and Tommy Nantung[6] in their experimental work entitled Effect of mixture composition and Initial curing conditions on the scaling resistance of ternary concrete have find out effect of different proportions of ingredients of ternary blend of binder mix on scaling resistance of concrete in low temperatures. S.A. Barbhuiya, J.K. Gbagbo, M.I. Russeli, P.A.M. Basheer[7] studied the properties of fly ash concrete modified with hydrated lime and silica fume concluded that addition of lime and silica fume improve the early days compressive strength and long term strength development and durability of concrete. Susan Bernal, Ruby De Gutierrez, Silvio Delvasto[8], Erich Rodriguez carried out Research work in Performance of an alkali-activated slag concrete reinforced with steel fibers. Their conclusion is that The developed AASC present higher compressive strengths than the OPC reference concretes. Splitting tensile strengths increase in both OPCC and the AASC concretes with the incorporation of fibers at 28 curing days. Hisham Qasrawi , Faisal Shalabi, Ibrahim Asi [9] carried out Research work in Use of low CaO unprocessed steel slag in concrete as fine aggregate.Their conclusion is That Regarding the compressive and tensile strengths of concrete steel slag is more advantageous for concretes of lower strengths. O. Boukendakdji, S. Kenai, E.H. Kadri, F. Rouis [10] carried out Research work in Effect of slag on
the rheology of fresh self- compacted concrete. Their conclusion is that slag can produce good self-compacting concrete. Shaopeng Wu, Yongjie Xue, Qunshan Ye, Yongchun Chen[11] carried out Research work in Utilization of steel slag as aggregates for stone mastic asphalt (SMA) mixtures. Their conclusion is that The test roads shows excellent performances after 2-years service, with abrasion and friction coefficient of 55BPN and surface texture depth of 0.8 mm.

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 ft^2/lb (20,000 m^2/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, bond strength, and abrasion resistance. These improvements stems 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. Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion, especially in chloride-rich environments such as coastal regions .When silica fume is incorporated, the rate of cement hydration increases at the early hours due to the release of OH ÿ ions and alkalis into the pore fluid. The increased rate of hydration may be attributable to the ability of silica fume to provide nucleating sites to precipitating hydration products like lime, C±S±H, and ettringite. It has been reported that the pozzolanic reaction of silica fume is very significant and the non-evaporable water content decreases between 90 and 550 days at low water /binder ratios with the addition of silica fume.

Table No. 3. 1

Materials	Specific gravity
Silica fume	2.95

RESULTS AND DISCUSSIONS

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):

1) 300 gm of sample coarser than 150 micron sieve is taken.
2) Approximate percentage of water was added to the sample and was mixed thoroughly for 2-3 minutes.
3) Paste was placed in the vicat"s mould and was kept under the needle of vicat"s apparatus.
4) Needle was released quickly after making it touch the surface of the sample.
5) Check was made whether the reading was coming in between 5-7 mm or not and same process was repeated if not
6) The percentage of water with which the above condition is satisfied is called normal consistency.

Normal consistency of different binder mixes were tabulated below in Table

Mix	Description	Cement (grams)	Silica fume (grams)	Consistency (%)
SC0	SC	300	00	31.5
SC15	SC with 15% SF	270	30	37
SC25	SC with 25% SF	240	60	42
FC0	FC	300	00	37.5
FC15	FC with 15% SF	270	30	48
FC25	FC with 25% SF	240	60	57
SFC0	SC:FC (1:1)	150 each	00	36.5
SFC15	SC:FC (1:1) with 15% SF	135 each	30	43.5
SFC25	SC:FC (1:1) with 25% SF	120 each	60	48.5

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From the above table we can conclude that water requirement increases with increase in percentage of replacement by silica fume and fly ash cement consumes more water due to its fineness. Water requirement or normal consistency of a binder mix increases with increment in percentage of silica fume replacement.Water requirement in case of fly ash cement binder mix is more because it is finer when compared to slag cement.

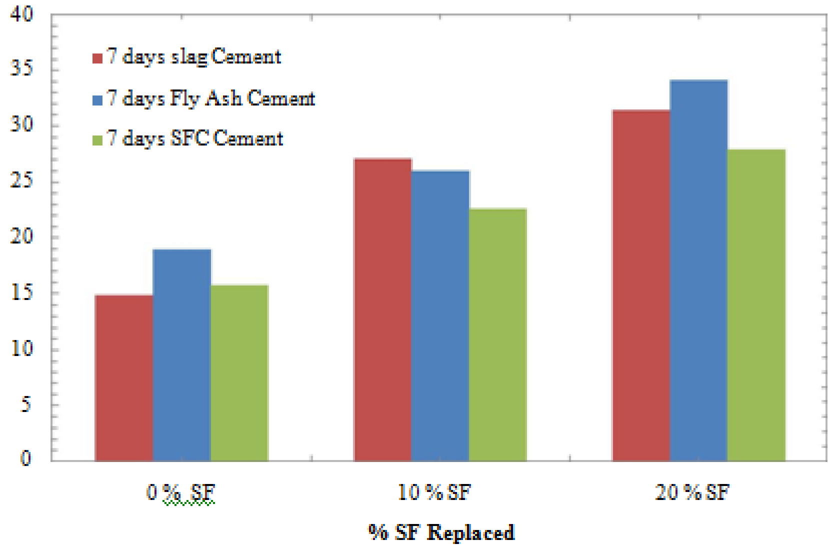


Figure.4.2 Compressive strength for mortar for 7 days

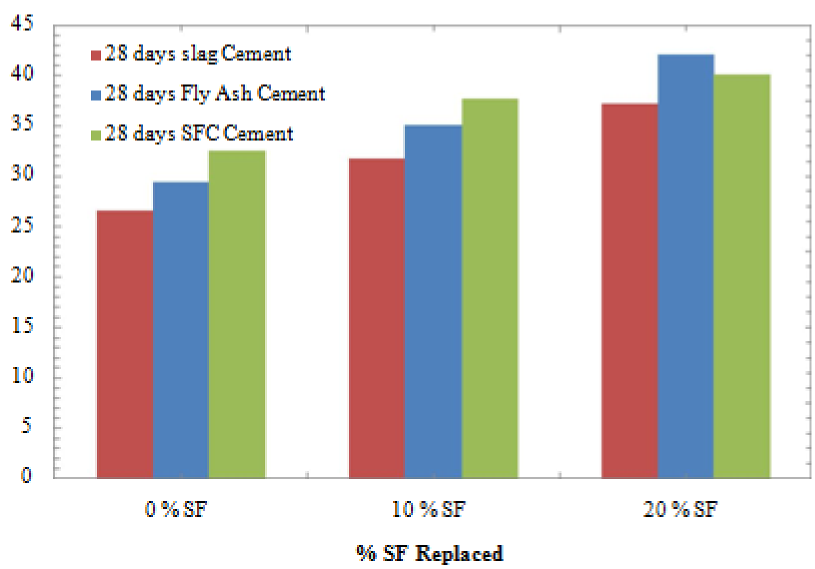


Figure.4.3 compressive strength for mortar for 28 day

4.2 EXPERIMENTAL STUDY ON CONCRETE CUBE.

Here we prepared concrete with ratio 1:1.5:3 from different types of cement + silica fume replacement as binder mix, sand as fine aggregate and steel slag as coarse aggregate. Then its physical properties like capillary absorption, water/cement ratio, compressive strength, porosity, flexural strength, and wet-dry test was predicted. These test results both in tabular form and graphical presentation are given below.

4.2.1 Water /Cement Ratio and Slump.

The water cement ratio and slump of steel slag concrete with different binder mix with silica fume replacement is given below.

Table No. 4.6

Type of cement	% of SF replaced	W/C Ratio	Slump in (mm)
Fly ash cement	0	0.51	52
	15	0.640	56
	25	0.630	61
Slag cement	0	0.47	63
	15	0.575	54
	25	0.605	59
Slag and fly ash cement blend (1:1)	0	0.489	60
	15	0.585	56
	25	0.598	53

From the above table we concluded that W/C ratio increases with increase in silica fume replacement. Because silica fume consumes more water.

Compressive Strength by Rebound Hammer Method.

Type of cement	% of SF replaced	7 days	28 days	56 days
Fly ash cement	0	24.54	29.55	36.4
	15	24	26.1	26.4
	25	25.6	23.6	29.8
Slag cement	0	18.2	22.3	26.35
	15	19.1	22.9	27.9
	25	19.5	22.0	28.1
Slag and fly ash cement blend (1:1)	0	20.9	25.4	31.45
	15	22.9	23.8	29.9
	25	23.4	21.5	28.8

Compressive Strength by Compression Testing Machine.

Type of cement	% of SF replaced	7days	28days	56 days
Fly ash cement	0	23.33	37.1	45.1
	15	22.10	27.95	31.00
	25	21.66	23.1	28.90
Slag cement	0	16.6	26.21	28.44
	15	19.44	25.80	26.10
	25	19.8	25.2	21.9
Slag and fly ash cement blend (1:1)	0	27.05	27.55	33.11
	15	22.8	24.2	30.50
	25	20.7	22.9	29.40

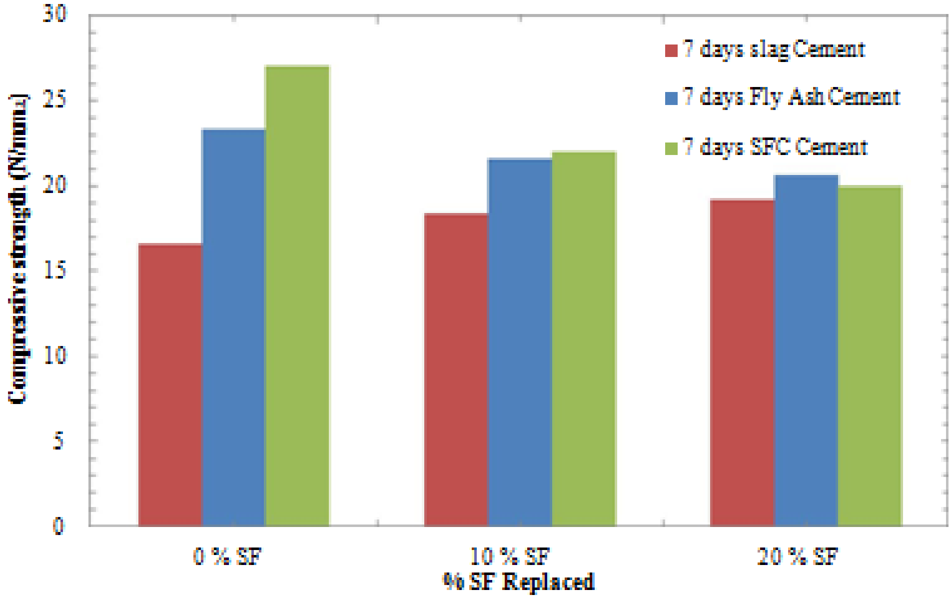


Figure.4.9 Compressive strength of concrete for 7 days

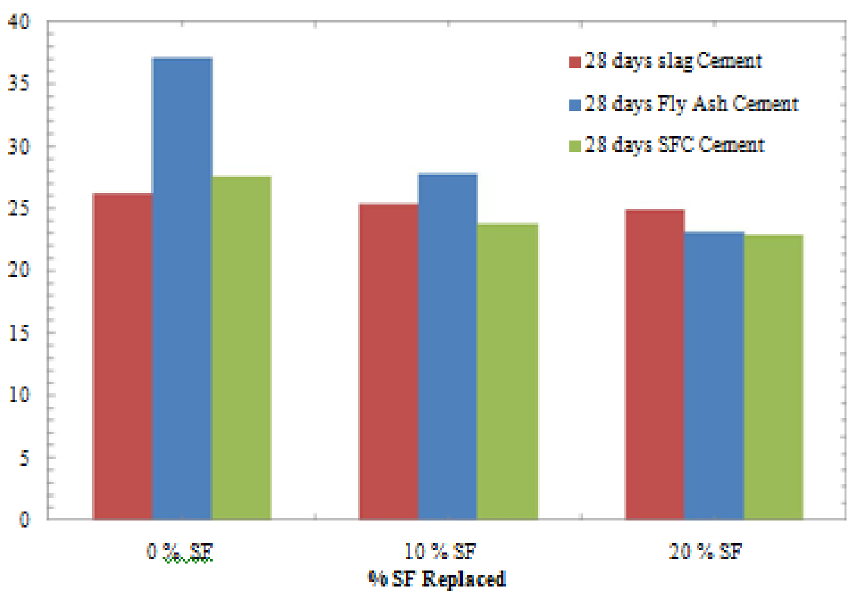


Figure.4.10 Compressive strength of concrete for 28 days

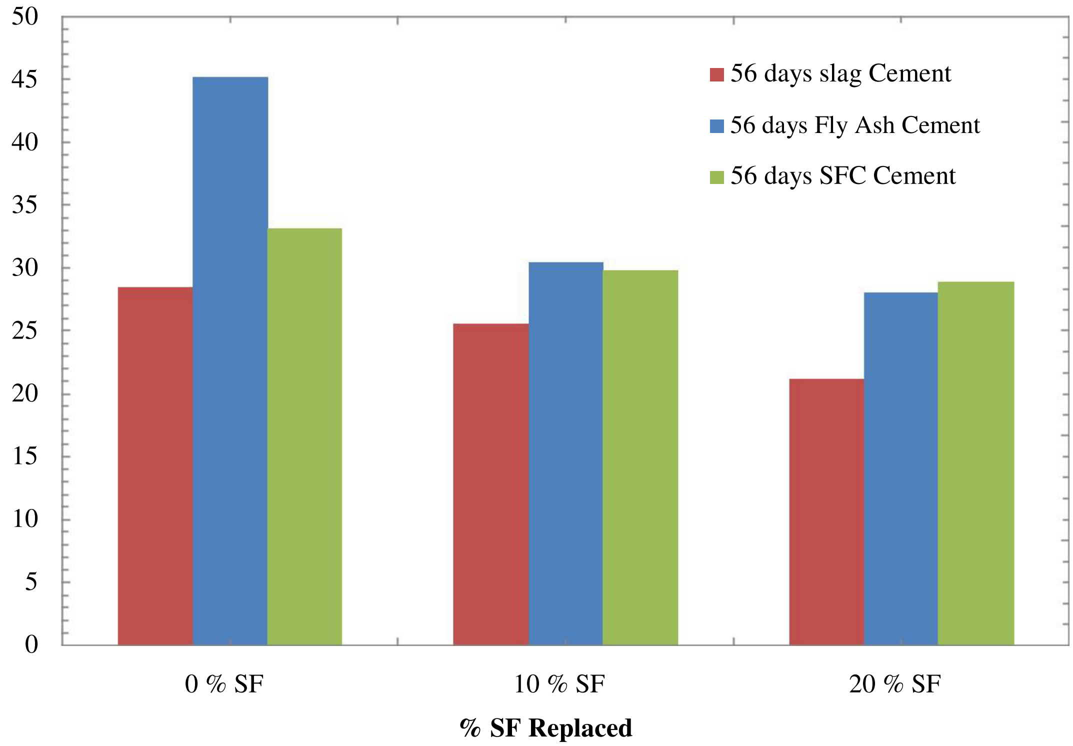
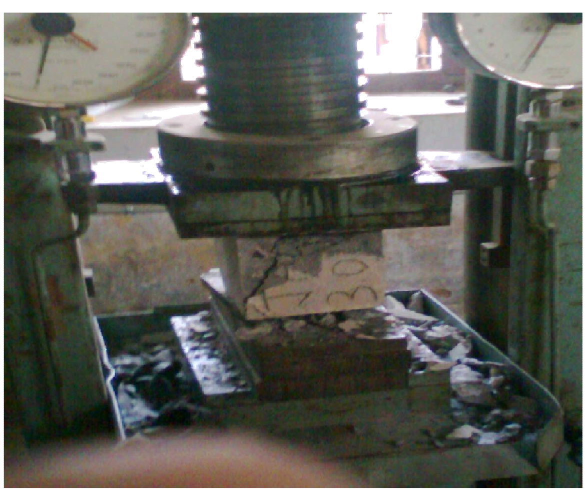


Figure.4.11 Compressive strength of concrete for 56 days

From the above graph, we can conclude that early or 7 days strength, 28 days and 56 days strength decreases with increase in percentage of replacement by silica fume. This is due to the weak bond formation between cement paste and steel slag. There are lots of voids present in concrete, which is shown by SEM (Scanning Electron Microscope) Analysis, which are given below



CONCLUSION:

From the present study the following conclusions are drawn:

1. Inclusion of silica fume improves the strength of different types of binder mix by making them more denser.
2. Addition of silica fume improves the early strength gain of fly ash cement whereas it increases the later age strength of slag cement.
3. The equal blend of slag and fly ash cements improves overall strength development at any stage.
4. Addition of silica fume to any binder mix reduces capillary absorption and porosity because fine particles of silica fume reacts with lime present in cement and form hydrates dancer and crystalline in composition.
5. The capillary absorption and porosity decreases with increase dose up to 20% replacement of silica fume for mortar.
6. Addition of silica fume to the concrete containing steel slag as coarse aggregate reduces the strength of concrete at any age.
7. the free CaO & MgO to hydrate and thereby to reduce the expansion in later age.
8. A thorough chemical analysis of the steel slag is recommended to find out the presence of alkalis which may adversely affect to the bond between binder matrix and the aggregate.

REFERENCES:-

1. Thanongsak, N., Watcharapong, W., and Chaipanich. A., (2009)**, “**Utilization of fly ash with silica fume and properties of Portland cement–fly ash–silica fume concrete”. *Fuel*, *Volume 89, Issue 3*, *March 2010*, *Pages 768-774.*
2. Patel, A, Singh, S.P, Murmoo, M. (2009), “Evaluation of strength characteristics of steel slag hydrated matrix” Proceedings of Civil Engineering Conference-Innovation without limits (CEC-09), 1[8th] - 1[9th] September‟ 2009.
3. Li Yun-feng, Yao Yan, Wang Ling, “Recycling of industrial waste and performance of steel slag green concrete”, J. Cent. South Univ. Technol.(2009) 16: 8–0773.
4. Velosa, A.L, and Cachim, P.B.,” Hydraulic lime based concrete: Strength development using a pozzolanic addition and different curing conditions” ,Construction and Building Materials ,Vol.23,Issue5,May2009,pp.2107-2111.
5. Barbhuiya S.A., Gbagbo, J.K., Russeli, M.I., Basheer, P.A.M. “Properties of fly ash concrete modified with hydrated lime and silica fume”, [a]Centre for Built Environment Research, School of Planning, Architecture and Civil Engineering, Queen‟s University Belfast, Northern Ireland BT7 1NN, United Kingdom Received 28 January 2009; revised 1 June 2009; accepted 3 June 2009. Available online 15 July 2009.
6. Gonen,T. and Yazicioglu,S. “ The influence of mineral admixtures on the short and long term performances of concrete” department of construction education, Firat University, Elazig 23119, Turkey.2009.
7. Mateusz R.J. O. and Tommy N. “ Effect of composition and Initial Curing Conditions of Scaling Resistance of Ternary(OPC/FA/SF) concrete”, Journal of Materials in Civil Engineering © ASCE/October 2008, PP 668-677.