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Innovative Study on Suplementary Cementetious Materials

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ABSTRACT

Now a days, the use of different types of sub-product materials has become a common practice in concrete industries. In early stages some of the countries are used limestone and Ground granular blast furnace slag (GGBS) cement as cementetinous materials for construction purpose before the invention of Portland cement. In this Thesis, the feasibility of adding some of SCM's (Supplementary Cementetious Materials) like slag cement or GGBS cement and fly ash cement are used as supplementary to the Portland cement. The Steel slag, a by-product of steel making, is produced during the separation of molten steel from impurities in steel making furnaces. This can be used as coarse aggregate in concrete. These SCM's is partially replaced with filler material like silica fume in various mix proportions of 10%, 20%, 30% in concrete of M20 mix. Considering the above parameters in view, the aim of the analysis is to study the performance of various properties like compressive and flexural strength and Wet-Dry test after 26 and 56 days of concrete.
Keywords: Concrete, Motor, fly ash, SCM's (Supplementary Cementetious Materials), GGBS, silica fume, Flexural.

1. 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 by products or waste materials from other industrial processes.

2. EXPERIMENTAL MATERIALS

A. Silica Fume

Silica fume is a by-product in the contraction of high-purity quartz with coke in electric arc incinerator in the manufacture of silicon and ferrosilicon alloys. It consists of fine grains with a surface area on the form of 215,280 ft²/lb (20,000 m²/kg) when measured by nitrogen adsorption skills, with particles approximately one hundredth the size of the average cement Because of its extreme fineness and high silica content, it is a very effective pozzolanic material particle. To improve the properties, such as compressive, bond strength and abrasion resistance to Portland cement slica fume must be added.

Physical Properties of silica fume:

Table-I

Materials	Specific gravity
Silica fume	2.27

Chemical Analysis of silica fume:

Table-II

Silica fume	ASTM-C-1240	Actual Analysis
SiO_2	85% min	86.7%
LOI	6% max	2.5%
Moisture	3%	0.7%
Pozz Activity Index	105% min	129%
Sp Surface Area	>15 m2/gm	22 m2/gm
Bulk Density	550 to 700	600

B. Steel Slag:

Steel slag is the residue of steel production process and composed of silicates and oxides of unwanted elements in steel chemical composition. Fifty million tons per year of LD slag were produced as a residue from Basic Oxygen Process (BOP) in the world. In order to use these slag in cement; its hydraulic properties should be known. Chemical composition is one of the important parameters determining the hydraulic properties of the slag. In general, it is assumed that the higher the alkalinity, the higher the hydraulic properties. If alkalinity is> 1.8, it should be considered as cementitious material. The most important criterion is volume stability, in which free CaO and MgO contents of the slag play an important role. Both oxides can go into reaction with water. Hydration causes volume expansion and affects stability of volume. This is one reason why steel slag aggregate are not convenient for use in Portland cement concrete but at the moment, most steel slag being used as unbound aggregate for asphalt concrete pavement in many countries.

Physical properties of Steel slag: The different physical properties of steel slag are given below in Table

Table-III

Material	Specific gravity	Water absorption in %
Steel slag	3.35	1.1%

C. Fly ash cement:

Fly ash, which is a combination of silicon dioxide and calcium oxide, can be used as alternate for Portland cement. The materials which make up fly ash are pozzolanic, which means to crunch the cement materials together. Pozzolanic materials, including fly ash cement, add durability and strength to concrete.

Table-IV: Initial and final setting time

Cement	Consistency, %	Specific gravity	Initial setting time	Final setting time
Fly ash cement	37.5	3	3 hour 50 min	11 hour 35 min
FC10	47			
FC20	55.5			

FC 10 **-** Slag cement with 10% silica fume Replacement.
FC20 **-** Slag cement with 20% silica fume Replacement.

Table-V: Chemical Properties of Fly ash cement

Chemical Compound	Fly Ash Cement in (%)
SiO_2	6
Cao	49
MgO	0.66
Fe_2O_3	15
Al_2O_3	16

D. Slag Cement:

Slag cement has been used in concrete projects in the United States for many year ago. Earlier usage of slag cement in Europe and away exhibits that long life concrete achievements is enhanced in many forms. Based on the earlier background, reduction of life-cycle cost, lower maintenance cost and makes concrete more sustainable with the help of improved durability characteristic and it was found by modern designers . For further result on how slag cement is manufactured and it enhances the durability and sustainability of concrete.

Table-VI: Physical Properties of Slag cement

Cement	**Consistency, %**	**Specific gravity**	**Initial setting time**	**Final setting time**
Slag cement	32	2.95	2 hour	4 hour
SC10	35			
SC20	40.5			

SC 10 - Slag cement with 10% silica fume Replacement.
SC20 - Slag cement with 20% silica fume Replacement.

Table-VI: Chemical properties of slag cement

Chemical Compound	**Slag Cement in (%)**
SiO_2	12
Cao	43
MgO	0.37
Fe_2O_3	12
Al_2O_3	26

E. 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 $SiO2$), 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

Table-VII Physical properties of sand

Fine aggregate	**Specific gravity**	**Water absorption in %**
Sand	2.65	0.6

3. RESULTS AND DICUSSION OF CONCRETE

A. 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-VIII

Type of cement	% of SF replaced	7days	28days	56 days
Fly ash cement	0	23.33	37.1	45.1
	10	21.61	27.77	30.44
	20	20.66	23.1	28
Slag cement	0	16.6	26.21	28.44
	10	18.44	25.33	25.55
	20	19.2	24.89	21.1
Slag and fly ash Cement blend (1:1)	0	27.05	27.55	33.11
	10	22	23.77	29.77
	20	20	22.88	28.88

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

Graph-I

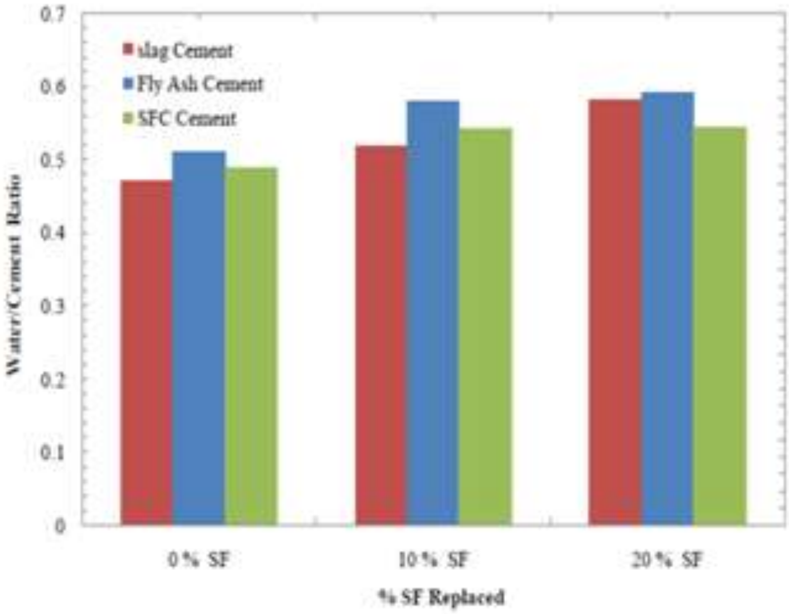

Table-IX

Type of cement	%of SF replaced	7days	28days	56 days
Fly ash cement	0	23.33	37.1	45.1
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Slag cement	0	16.6	26.21	28.44
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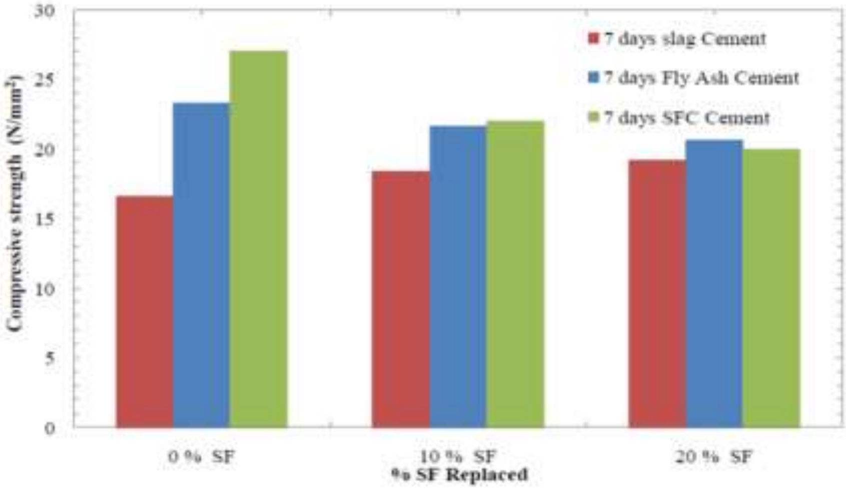
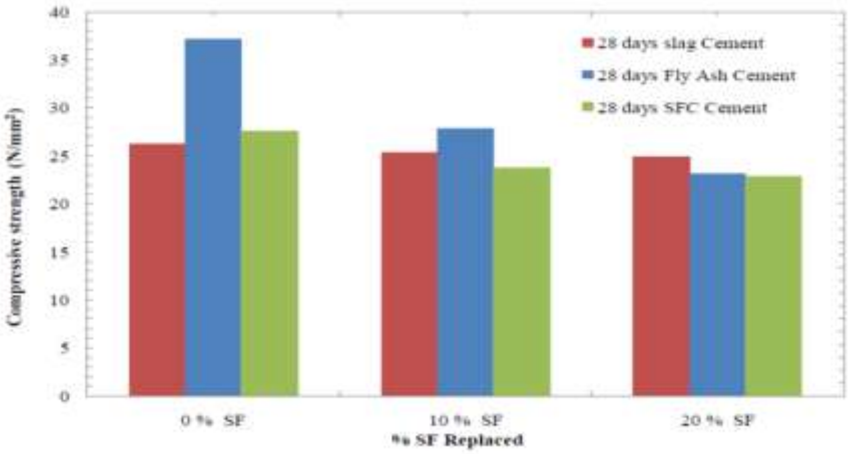
	20	19.2	24.89	21.1
Slag and fly ash Cement blend (1:1)	0	27.05	27.55	33.11
	10	22	23.77	29.77
	20	20	22.88	28.88

B. Compressive Strength Test by CTM:

Graph-II: Compressive strength for 7days



Graph-III: Compressive strength for 28days



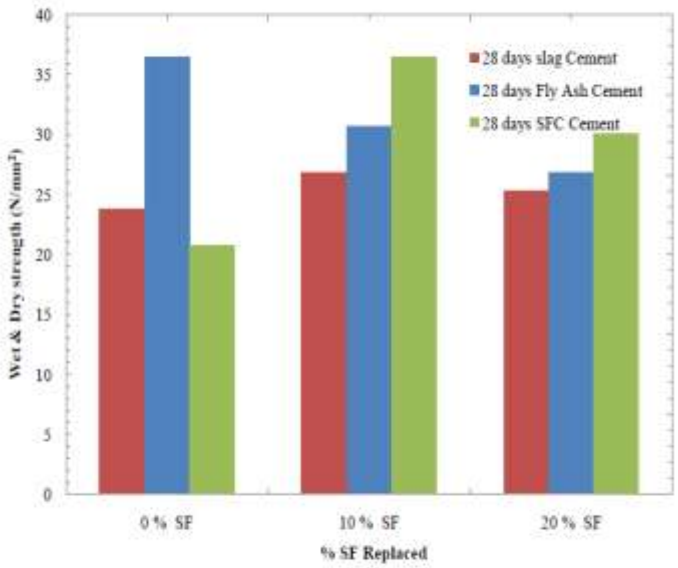
C. Wet and Dry Test:

Table shows 28 days and 56 days wet and dry test of concrete cube.

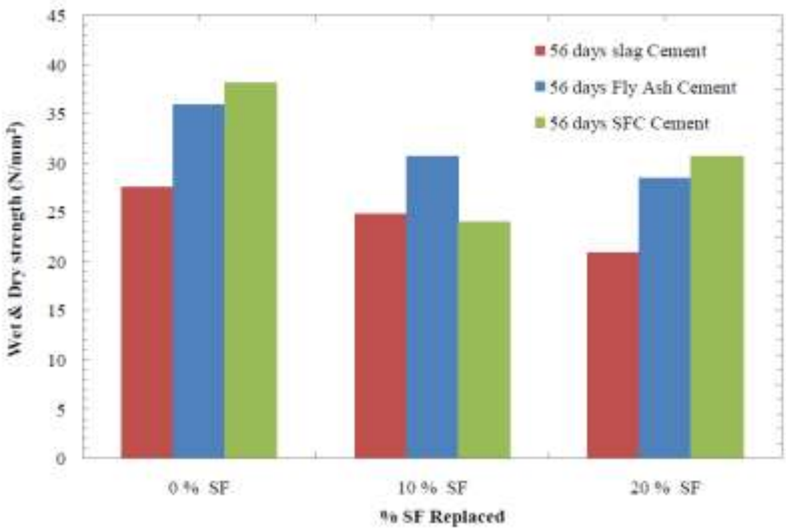
Table-X

Type of cement	% of SF replaced	28 days (N/mm^2)	56 days (N/mm^2)
Fly ash cement (FC)	0	36.5	36.0
	10	30.7	30.66
	20	26.8	28.44
Slag cement (SC)	0	23.8	27.55
	10	26.8	24.88
	20	25.3	20.88
Slag and fly ash Cement blend (1:1) (SFC)	0	20.7	38.22
	10	36.5	24
	20	30.1	30.66

Graph-IV: Graph shows 28 days wet and dry test of concrete cube.



Graph-V: Graph shows 56 days wet and dry test of concrete cube



D. Flexural Test:

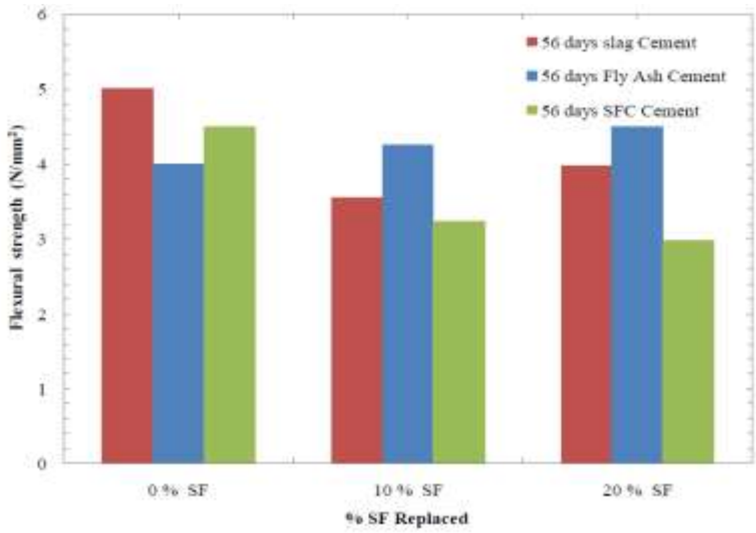
The flexural strength of steel slag concrete at 28 days and 56 days is given below

Table-XI

Type of cement	% of SF replaced	28days (N/mm^2)	56days (N/mm^2)
Fly ash cement (FC)	0	6.875	4
	10	7	4.25
	20	6.875	4.5
Slag cement (SC)	0	7	5
	10	6.5	3.55
	20	6.125	3.975
Slag and fly ash Cement blend (1:1)	0	7	4.5
	10	6.725	3.23
	20	4.75	2.975

From above table we see that flexural strength of steel slag concrete is decreased from 28 days to 56 days.

Graph-VI: Graph shows the flexural strength for 56days



4. 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 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. Combination of fly ash cement and silica fume makes the concrete more cohesive or sticky than the concrete containing slag cement and silica fume causing formation of more voids with fly ash cement. Therefore the concrete mixes containing fly ash and silica fume show higher capillary absorption and porosity than concrete mixes containing slag cement and silica fume.
5. The total replacement of natural coarse aggregate by steel slag is not recommended in concrete. A partial replacement with fly ash cement may help to produce high strength concrete with properly treated steel slag.
6. 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.
7. 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.

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