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Effect of Silica Fume on Metakaolin-Ggbs Based Geopolymer Concrete

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Abstract: Geopolymer concrete is a versatile product gains importance due to its reduced greenhouse effect thereby global warming, it is devoid of cement. Geopolymer concrete (GPC) is prepared by geopolymerization of alkaline solution with binder materials. In the present study METAKAOLIN and GGBS are the binder materials. This paper deal with the effect of silica fume on the mechanical properties of METAKAOLIN-GGBS based Geopolymer concrete. Sodium silicate (Na2Sio3) and sodium hydroxide (NaOH) are used as alkaline activators. The molarity of NaOH is 12M. The ratio of Na2Sio3 and NaOH is 2.5. The samples prepared were cured at ambient temperature. Further study is done in the above GPC mix by replacement of METAKAOLIN with silica fume at different percentages i.e., 10%, 20%, 30%, 40%. Mechanical properties of geopolymer concrete with silica fume were studied and compared with conventional GPC. It was found that the optimum replacement of silica fume for METAKAOLIN was 20% corresponding to maximum strength properties.

***Keywords* -Geopolymer concrete, METAKAOLIN, GGBS, Silica Fume, Alkaline activators, Mechanical properties.**

I. INTRODUCTION

Geopolymer is defined as ―a mineral aluminosilicate polymer synthesized from alkaline activation of various aluminosilicate materials of the ecological source or by-product materials like metakaolin, fly ash and ground granulated blast furnace slag‖ . Geopolymers are used as an alternate for cement which is rich in aluminates and silicates. Based on the obtainability, metakaolin is considered one of the significant sources of geopolymer. Geopolymers are usually understood as alkali-activated aluminosilicates. They may be considered as an inorganic two- component system that consists of a reactive solid source of Sio2 and Al2O3, and an alkaline activator solution. The combination of sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) as alkaline activator liquid greatly affects the mechanical properties of geopolymer concrete.

Silica Fume has a chemical composition alike geopolymer. Silica Fume is a crystalline aluminosilicate structure with tetrahedral unit of SiO4 and AlO4. Silica Fume reacts with alkali solution and forms polymerization of inorganic constituents. Aluminosilicates acts as an important compound in improving the strength of geopolymer concrete. Because of this, Silica Fume can be used as a replacement for a binder content in the preparation of geopolymer concrete. For geopolymer concrete production, alumino-silicates is the main material. Silica Fume reaction with calcareous materials can form calcium aluminate silicates hydrates (C-A- S-H) which contributes strength to the concrete.

Silica fume, a by-product of the ferrosilicon industry, is a highly pozzolanic material that is used to enhance mechanical and durability properties of concrete. It may be added directly to concrete as an individual ingredient or in a blend of Portland cement and Silica Fume.

In this paper, the study of mechanical properties of METAKAOLIN-GGBS based geopolymer concrete is carried out by replacing METAKAOLIN with Silica Fume. The maximum percentages of Silica Fume replacement is determined for the yielding of better strength in the concrete.

II. EXPERIMENTAL STUDY

2.1 Materials

Metakaolin, GGBS, and Silica Fume with a specific gravity of 2.6, 2.9 and 2.64 respectively are used as binders. Sodium silicate and sodium hydroxide are used as alkaline activator solutions. The specific gravity of river sand and coarse aggregates are 2.6 and 2.77 respectively. The chemical composition of materials is shown in Table 1.

Chemical analysis %	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	K2O	Na2O
MK	56.10	40.23	0.85	0.55	0.19	0.16	0.51	0.24
GGBS	40.55	12.83	1.10	0.75	35.28	5.87	0.68	0.79
SF	91.57	0.38	0.15	-	0.32	4.05	2.58	0.55

2.2 Preparation of Geopolymer Concrete

METAKAOLIN-GGBS based geopolymer concrete with 70:30 ratio is prepared and cured at ambient temperature with 12M molarity , Na2SiO3/NaOH ratio=2.5, AAS/Binder ratio=0.375 and 60:40 ratio of coarse and fine aggregates in the total mass of aggregates. Further mixes are prepared by replacing metakaolin with silica fume by different percentages i.e., 10,20,30,and 40%. These specimens were cured for 28 days at ambient temperature.

III. RESULTS AND DISCUSSION

3.1 Compressive Strength

Mechanical properties of METAKAOLIN-GGBS based geopolymer concrete using different percentages of silica fume are shown in table 2. Cubes of 100mm x 100mm x 100mm are cast for all mixes to find the compressive strengths. Fig.1 shows the 28 days compressive strengths of GPC mixes with and without silica fume. The maximum strength obtained is at 20% replacement of silica fume and is 15.36% higher compared to that of the control mix.

Table 4. 1. Mechanical properties of Metakaolin -GGBS based GPC mixes for 28 days

Mixes	Compressive strength (MPa)	Split tensile strength (MPa)	Flexural strength (MPa)
SF00	41	3.50	4
SF10	43.6	3.81	4.8
SF20	47.3	4.45	5.6
SF30	40.6	2.86	5.4
SF40	36.6	2.22	5

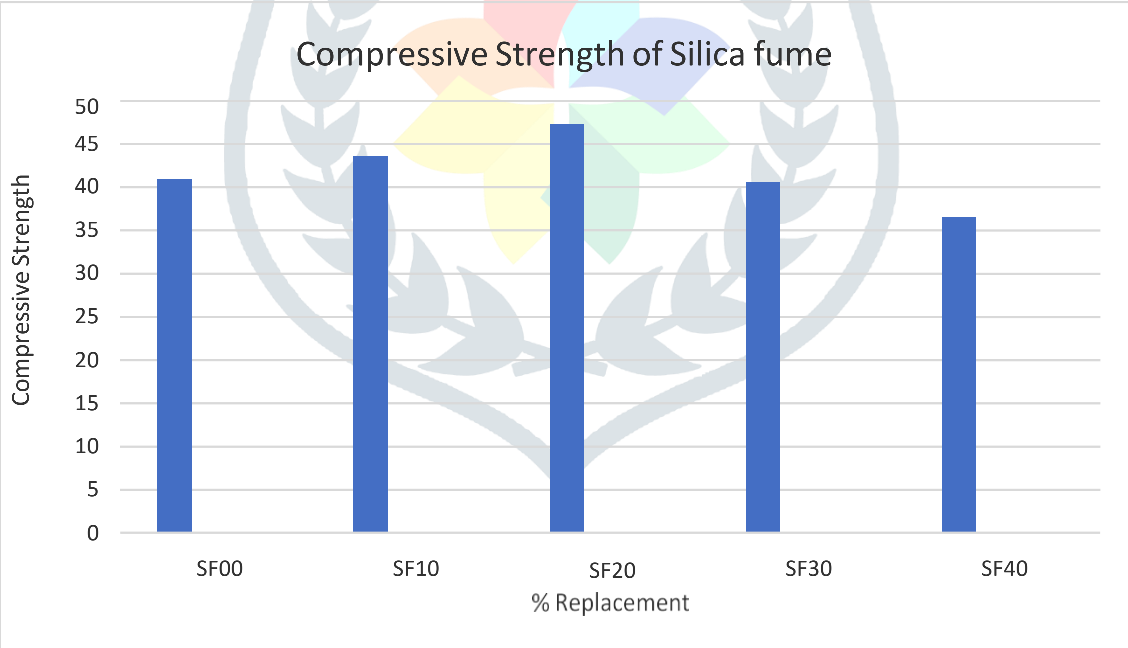

Fig 1. 28 days compressive strengths of GPC mixes

3.2 Split Tensile Strength

Cylinders having a diameter of 100mm and a height of 200mm are used to find the split tensile strength of GPC in this study. Fig 2 represents the 28 days split tensile strengths of GPC mixes with and without silica fume. The maximum strength obtained is at 20% replacement of silica fume and is 27.14% higher compared to that of the control mix.

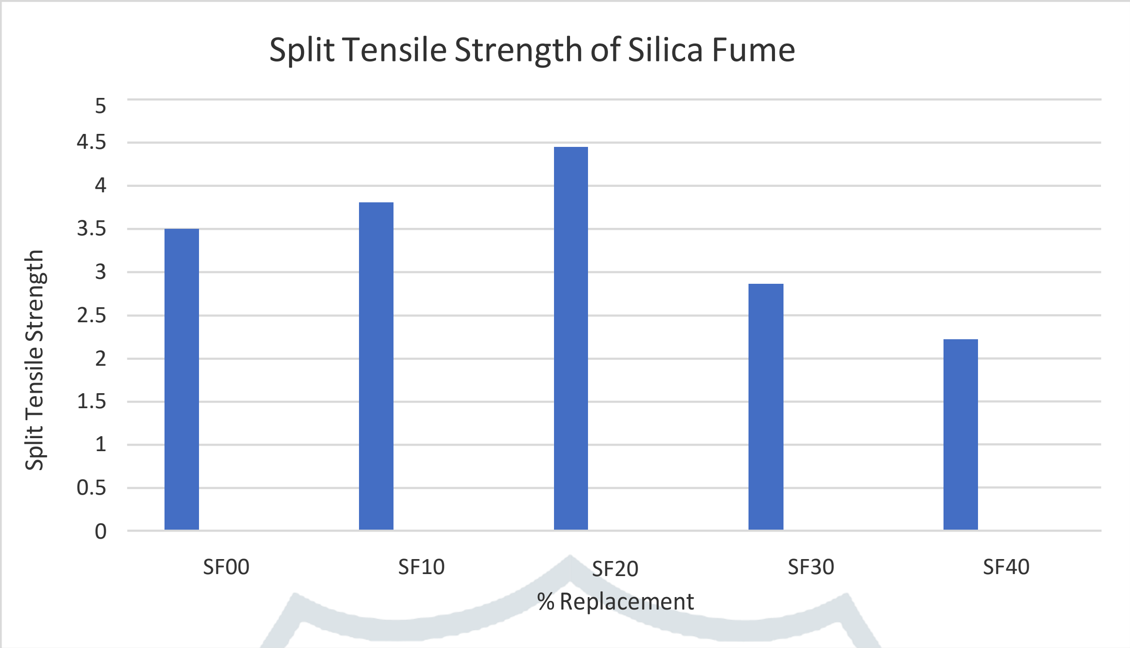

Fig 2. 28 days split tensile strengths of GPC mixes

3.3 Flexural Strength

Beams of 100mm x 100mm x 500mm are cast for all mixes to find the flexural strengths. Fig 3 explains the 28 days strengths of GPC mixes with and without silica fume. The maximum strength obtained is at 20% replacement of silica fume and is 4.67% higher than to that of the control mix.

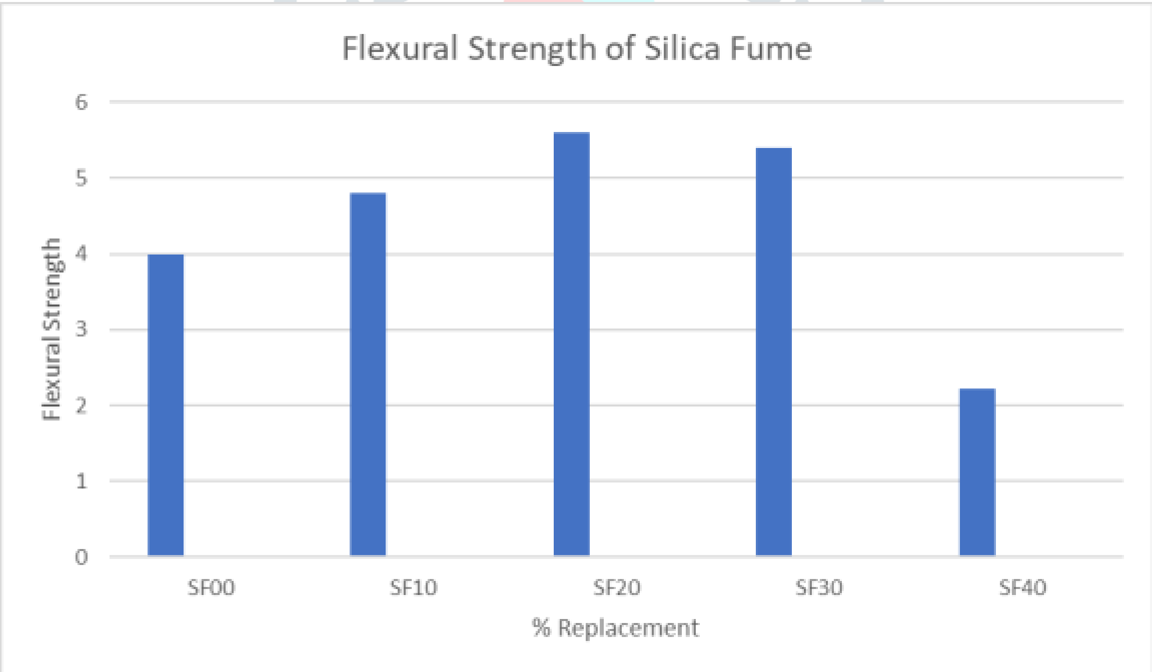

Fig 3. 28 days flexural strengths of GPC mixes

IV. ACKNOWLEDGMENT

From the present study of Metakaolin-GGBS based geopolymer concrete, the following conclusions were made:

- The mechanical properties of GPC were found to be improved up to 20% of silica fume replacement and decreases thereafter.

Maximum compressive, split tensile and flexural strengths at ambient temperature were Sobtained at 20% of silica fume replacement and found to be 15.36%, 27.14% and 40% which are higher than that of the control mix.

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