INVESTIGATION ON GEOPOLYMER CONCRETE USING GRANITE SLURRY POWDER AS PARTIAL REPLACMENT OF FINE AGGREGATE

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Abstract - *The objective of this project is to study the strength properties of class F fly ash (FA) based geo polymer concrete (GPC) using granite slurry powder (GS) as sand replacement at different levels (0%, 20% and 40%). Sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) solution has been used as alkaline activator. In the present investigation it is proposed to study the engineering properties of GPC (FA50-GGBS50) viz. compressive strength, split tensile strength after 7, 28 and 90 days of ambient room temperature curing. From the results, it is concluded that the increased replacement level of granite slurry powder (GS) increased the compressive strength, splitting tensile strength values of GPC mixes. Results recommended using GS as sand replacement in fly ash and GGBS blended GPC mixes.*

***Key Words*: Geo polymer concrete, Fly ash, Ground Granulated Blast Furnace Slag, Granite Slurry, Compressive Strength, Split Tensile Strength**

1.INTRODUCTION

It is widely known that the production of Portland cement consumes considerable energy and at the same time contributes a large volume of CO_2 to the atmosphere. The climate change due to global warming has become a major concern. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO_2), to the atmosphere by human activities. The cement industry is held responsible for some of the CO_2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere. However, Portland cement is still the main binder in concrete construction prompting a search for more environmentally friendly materials. Several efforts are in progress to supplement the use of Portland cement in concrete in order to address the global warming issues. These include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and the development of alternative binders to Portland cement. One possible alternative is the use of alkali-activated binder using industrial by-products containing silicate materials. In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash, GGBS and rice husk ash. He termed these binders as geopolymers [1]. The most common industrial by-products used as binder materials are fly ash (FA) and ground granulated blast furnace slag (GGBS). In 2001, when this research began, several publications were available describing geopolymer pastes and geopolymer coating materials. However, very little was available in the published literature regarding the use of geopolymer technology to make low-calcium (ASTM Class F) fly ash and GGBS based geopolymer concrete. The research reported in this thesis was dedicated to investigate the process of making fly ash and GGBS based geopolymer concrete and the short-term engineering properties of the hardened concrete [2-6].

2. EXPERIMENTAL STUDY

The objective of this project is to study the mechanical properties of fly ash and GGBS blended GPC mixes using Granite Slurry powder as replacement of fine aggregate for 0%, 20%, 40%. Compressive strength test was conducted on the cubical specimens for all the mixes after 7, 28, and 90 days of curing as per IS 516 [7]. Three cubical specimens of size 150 mm x 150 mm x 150 mm were cast and tested for each age and each mix. Splitting tensile strength (STS) test was conducted on the specimens for all the mixes after 28 and 90 days of curing as per IS 5816 [8]. Three cylindrical specimens of size 150 mm x 300 mm were cast and tested for each age and each mix.

3. MIX DESIGN

Assume that normal-density aggregates in SSD condition are to be used and the unit-weight of concrete is 2400 kg/m^3. Take the mass of combined aggregates as 77% of the mass of concrete, i.e. 0.77x2400=1848 kg/m^3. The combined aggregates may be selected to match the standard grading curves used in the design of Portland cement concrete mixtures. For instance, the coarse aggregates (70%) may comprise 776 kg/m³ (60%) of 20 mm aggregates, 517 kg/m³ (40%) of 10 mm aggregates, and 554 kg/m³ (30%) of fine aggregate to meet the requirements of standard grading curves.

The mass of geo polymer binders (fly ash and GGBS) and the alkaline liquid = 2400 – 1848 = 552 kg/m³. Take the alkaline liquid-to-fly ash+GGBS ratio by mass as 0.35; the mass of fly ash+GGBS = 552/ (1+0.35) = 409 kg/m³ and the mass of alkaline liquid = 552 – 409 = 143 kg/m³. Take the ratio of sodium silicate solution-to-sodium hydroxide solution by mass as 2.5; the mass of sodium hydroxide solution = 144/ (1+2.5) = 41 kg/m³; the mass of sodium silicate solution = 143 – 41 =102 kg/m³. The sodium hydroxide solids (NaOH) is mixed with water to make a solution with a concentration of 10 Molar. This solution comprises 40% of NaOH solids and 60% water, by mass.

For the trial mixture, water-to-geopolymer solids ratio by mass is calculated as follows: In sodium silicate solution, water = 0.559x102 = 57 kg, and solids = 102 – 57 = 45 kg. In sodium hydroxide solution, solids = 0.40x41 = 16 kg, and water = 41 – 16 = 25 kg. Therefore, total mass of water = 57+25 = 82 kg, and the mass of geopolymer solids = 409 (i.e. mass of fly ash and GGBS) + 45 + 16 = 470 kg. Hence, the water-to-geopolymer solids ratio by mass = 82/470 = 0.17. Extra water of 90 litres is calculated on trial basis to get adequate workability. Superplasticizer was added to maintain adequate workability.

Table 1: GPC mix proportions

Materials		Mass (kg/m³) FA50-GGBS50-GS0	FA50-GGBS50-GS20	FA50-GGBS50-GS40
Coarse aggregate	20 mm	776	776	776
	10 mm	517	517	517
Fine aggregate	Sand	554	443.2	332.4
	GS	0	110.8	221.6
Fly ash (Class F)		204.5	204.5	204.5
GGBS		204.5	204.5	204.5
Sodium silicate solution		102	102	102
Sodium hydroxide solution		41 (10M)	41 (10M)	41 (10M)
Extra water		90	90	90
Superplasticizer		2.86	2.86	2.86
Alkaline solution/ (FA+GGBS) (by weight)		0.35	0.35	0.35

4. MECHANICAL PROPERITIES OF GPC

Table 2 shows the compressive strength and splitting tensile strength of GPC mixes (FA50-GGBS50-GS0, FA50-GGBS50-GS20 and FA50-GGBS50-GS40) at different curing periods.

Table 2: Compressive strength and Split Tensile Strength of GPC

Mechanical property	Age (days)	FA50-GGBS50-GS0	FA50-GGBS50-GS20	FA50-GGBS50-GS40
Compressive strength, f'_c (MPa)	7	38.12	40.28	42.14
	28	52.5	54.09	56.32
	90	63.88	66.02	68.36
Splitting tensile strength, f_{ct} (MPa)	7	2.05	2.24	2.75
	28	3.12	3.48	3.61
	90	3.56	4.02	4.6

From the results it is concluded that GS acts as filling material which fills the voids of the concrete and hence makes the concrete dense. Hence from the Figure 1 and Figure 2, it is concluded that the increased replacement level of GS increased the mechanical properties of FA and GGBS blended GPC mixes at ambient room temperature curing. Keeping in view of sustainability, GS can be used as partial replacement of sand in FA and GGBS blended GPC mixes [9-11].

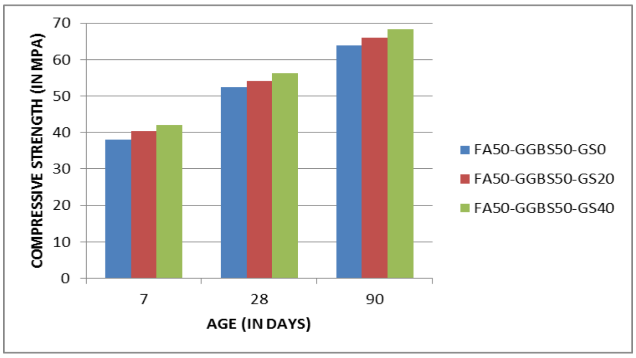

Figure 1. Compressive strength versus age

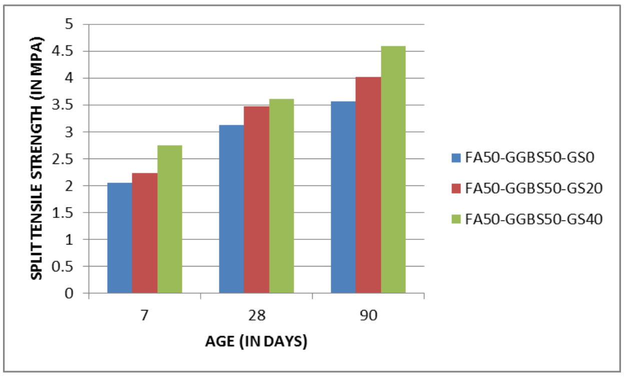

Figure 2. Split Tensile Strength versus age

5. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

1. The increased level of GS replacement increased the compressive strength, splitting tensile strength values of GPC at all curing periods.
2. From the results it is concluded that GS acts as filling material which fills the voids of the concrete and hence makes the concrete dense.
3. Granite slurry powder can be used as partial replacement of sand in FA and GGBS blended GPC mixes.
4. Keeping in view of savings in natural resources, sustainability, environment, production cost, maintenance cost and all other GPC properties, it can be recommended as an innovative construction material for the use of constructions.

REFERENCES

[1] Davidovits J. Geopolymers: Man-Made Geosynthesis and the Resulting Development of Very Early High Strength Cement, Journal of Materials Education, 16 (1994) 91-139.

[2] Palomo SA, Grutzeck MW, Blanco MT. Alkali-activated fly ashes – A cement for the future, Cement and Concrete Research, 29 (1999) 1323-1329.

[3] Palomo SA, Femandez-Jimenez A. Alkaline activation of fly ashes: NMR study of the reaction products, *Journal of the American Ceramic Society*, 87 (2004) 1141–1145.

[4] Gourley JT. Geopolymers, opportunities for environmentally friendly construction materials, conference, adaptive materials for a modern society, Sydney, Institute of materials engineering Australia, Nos. (15-26), 49(2003) 1455-61.

[5] Bhikshma V, Koti reddy M, Srinivas Rao T. An Experimental Investigation on Properties of Geopolymer Concrete (No Cement Concrete), Asian Journal of Civil Engineering, 13 (2012) 841-853.

[6] Sujatha T, Kannapiran K, Nagan S. Strength assessment of heat cured geopolymer concrete slender column, Asian Journal of Civil Engineering, 13 (2012) 635-646.

[7] IS 516 (1991). Methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi, India.

[8] IS 5816 (1999). Splitting tensile strength of concrete method of test, Bureau of Indian Standards, New Delhi, India.

[9] Guru Jawahar J., Mounika G. Strength properties of fly ash and GGBS based geopolymer concrete. Asian Journal of Civil Engineering, 2016, 17(1), pp 127-135.ISSN 1563-0854

[10] Sreenivasulu C., Guru Jawahar J., Vijaya Sekhar Reddy M., Pavan Kumar D. Effect of Fine Aggregate Blending on Short-Term Mechanical Properties of Geopolymer Concrete. Asian Journal of Civil Engineering, 2016, 17(5), pp 537-550.

[11] C. Sreenivasulu., Ramakrishnaiah A., Guru Jawahar J. Mechanical properties of geopolymer concrete using granite slurry as sand replacement. International Journal of Advances in Engineering and Technology, 2015, 8(2), pp 83-91.

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