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DURABILITY STUDY ON CEMENTLESS CONCRETE UNDER AMBIENT TEMPERATURE

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Abstract: Cement and Concrete are the major material for the construction sector. Cement is a vital ingredient in manufacturing concrete. The challenges in using cement is, as it produces more amount of carbon di-oxide, in turn pollutes the environment. In this scenario, a novel material should be replaced to concrete, is Alumina Silicate Concrete. This research investigation brings the outline of a research on mechanical and durability characteristics of alumina - silica based concrete produced with Fly ash of Class-F (FAF), GS (Granulated Slag) manufactured using alkaline based activators in normal temperature. GS was partially substituted to FAF from 0 to 50%, at a constant NaOH of 10M and the samples are subjected to normal temperature. Main parameters of this research are Mechanical properties and also durability properties. The durable parameters such as resistance against chloride, Absorption of water and sorptivity also conducted.

IndexTerms - Fly Ash, GGBS, Geopolymer concrete, Strength parameters.

I. Introduction

Geopolymer concrete or geopolymers has been trending as a new product in replacing cement in the building sector. [1-3]. Geopolymers production reduces carbon di-oxide emission and also creates the sustainable environment [4-5]. It has been manufactured by blending alkalies and silica materials. The process can be done in temperature or normal curing. The constituents for the production of geopolymers are Clay / metakaolin. Recent technology is under progress by utilizing waste products to make use in developing the product [5, 6-13]. Ramamohana B et.al [14,15] found out that polymerization of GGBS and Fly ash in geopolymer had high impact on mechanical characteristics of alumina silicate concrete and also 14 M gave best properties for GC when compared with different concentrations of NaOH solution. This research investigation studies the results of a research work in mechanical characteristics and various durable parameters of alumina silicate concrete produced with the blending FAF & GS.

II. Experimental Work

Materials

FAF (Classified by ASTM C618-99, procured in Chennai and GS procured from the industry are utilized in this research. The properties of GS and FAF were studied by XRF method and the findings are indicated in Table 1. Aggregates lesser than 20mm (Coarse) SG 2.74 and dried sand in confirmation to (IS 383 – Zone II) SG 2.62 is utilized for the experimental study. Aggregate of size lesser than twenty mm with a specific gravity of 2.74 and sand confirmation to IS 383 – Section II is taken for the research work.

Test parameters

The parameters which were taken for the production of GC samples, consists of a standard 10M. Concentration.GS is partially substituted to FAF by 0 to 50% and other ingredients for the mix are kept constant. A detail of mix designation is given in Table 2. Na_2SO_4 solution with sodium hydroxide ratio by weight should be around two. For this research, an overall of seven different proportions have been analyzed and reported.

Table 1. Chemical Characteristics of Ingredients

Materials	Chemical Characteristics in %								
	Silicon di-oxide	Aluminum oxide	Calcium oxide	Iron oxide	Magnesium oxide	Sulphate	Sodium oxide	Potassium oxide	Loss of ignition
GS	31.70	17.50	34.80	1.10	9.10	1.70	1.25	0.83	1.39
Fly ash	56.80	23.40	5.40	5.20	0.91	0.10	-	--	1.10

Specimens for Testing

NaOH (10M) & Na2SO4 solutions were mixed alone, twenty hours before to the manufacturing of GC mixed thoroughly. First, constituents are mixed after drying for 180 to 300 seconds. Later, the solution which was prepared, is being mixed to the dry mix. The mixing is done for 5 minutes. The samples were then cast in to the moulds. The samples are casted in the steel moulds of size 100 x 100 x 100 mm, (Fig.1) with three layers of concrete. To get full compacted, compaction is done on a vibrating table for 25 seconds. The cubes, are de moulded one day and curing has been done at a room temperature of 25 ̊C. Sufficient number of specimens for each proportion has been produced and the results indicated are the average of the triplicate samples.

Table 2. Sample Ids and Composition

Mix Design	Binder Composition in %			Constituents in kg/Cum.						
	Cement	Fly ash	GGBS	Cement	Fly ash	GGBS	Coarse Aggregate	Fine Aggregate	NaOH solution	Na2SO4 Solution
CC	100	0	0	420	0	0	1176	707	0	0
GCA	0	100	0	0	514	0	1176	504	74.5	149
GCB	0	90	10	0	463	51	1176	504	74.5	149
GCC	0	80	20	0	412	102	1176	504	74.5	149
GPD	0	70	30	0	361	153	1176	504	74.5	149
GPE	0	60	40	0	310	204	1176	504	74.5	149
GPF	0	50	50	0	257	257	1176	504	74.5	149

Test Methodology

Crushing strength for cubes is conducted for determining the strength properties. The test was carried out on cubes according to IS: 516-2004. The samples were tested at three days, seven days, twenty-eight days and sixty days in the compression testing machine to test the maximum load of 2000kN.Maximum load causing failure was noted. The investigation is done for the seven different mixes and it has been compared. The Water absorption test is carried out by the guidelines in ASTM C642 after twenty-eight days. The sorptivity test is done by the norms as per ASTM C 1585 after 28 days.

Fig1: Casting of CC&GC

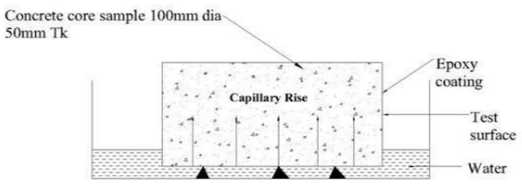


Fig2: Schematic Diagram of Sorptivity Test

Fig3: Equipment Set Up and Progress of the RCPT Test.

III. Results and Discussion

Strength characteristics of GC

The Fig.4 shows test results of crushing strength for various period under natural curing. The compressive strength increased with reference to duration for proportions studied. The strength of GC in blending of Fly ash and GGBS (GCF Both 50%) shows a maximum crushing strength of 79 MPa at two months of duration. Its value has varied from 53 MPa initially and had reached 79 MPa at two months duration. The percentage increase for initial days strength to two-month days strength is approximately 100%, is in par with the researchers [16-18]. Partial substitution of 50% GS to Fly ash geopolymer concrete gave better values when correlated to conventional concrete. The partial substitution to GS to Fly ash from 10 – 50% shows the same results of 100% hike of compressive strength.

IV.

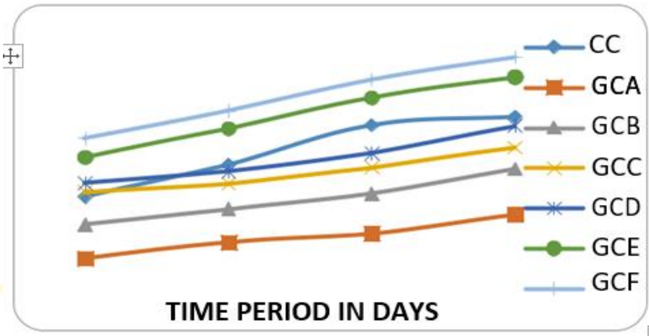
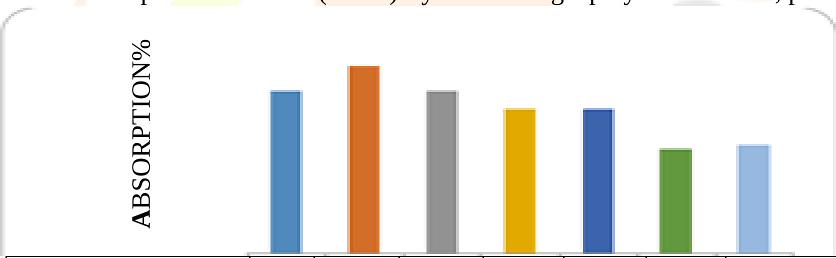


Fig4: Compressive Strength of GC and Conventional Concrete

Absorption of Water

Comparative study on water absorption of geopolymer concrete for different combination of the constituent materials at twenty-eight days have been shown in Fig.5 FAF based geopolymer concrete (GCF FAF & GS (50%)) performed the least absorption of the volume in par with the other mixes. The percentage of absorption is varied from 2.9 to 5.2 at twenty-eight days. Among the all the mixes except the mix GCA (100%) fly ash based geopolymer concrete, performs well.



WATER	CC	GCA	GCB	GPC	GPD	GPE	GPF
28 DAYS	4.5	5.2	4.5	4	4.01	2.88	2.99

Fig5: Water Absorption in % with different mix proportions at 28 days

Capillary Sorptivity

Testing on samples in twenty-eight days (Fig.6) indicates that the absorption between Square of root time in seconds for various alumina silicate proportions. It indicated that the sorptivity rate of GC with (FAF) and GC produced in the combination of FAF and GS reduces with the partial replacement of GS. The development of sorptivity varies from 21.7 μ m / √ sec to 13.9 μ m / √ sec respectively in all the samples of GCA to GCF. Sorptivity and √ sec curves are straight line and the coefficients varied between 0.91 to 0.98. Partly substitution of Granulated Slag decreased its value The absorption outcomes indicated that, it is in same line with the normal concrete of five to thirty µm/ Square root of time in sec and the readings are within the stipulated readings of normal concrete. The readings of sorptivity is more in the lower crushing strength samples, indicated that the hardened and strong polymerization of the samples.

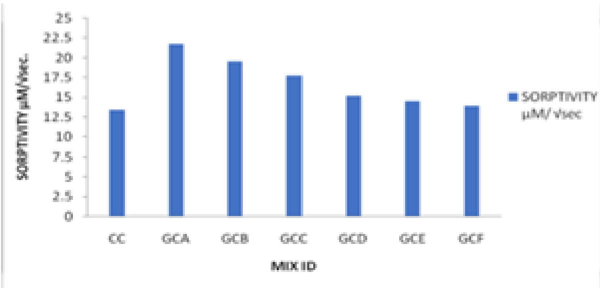


Fig6: Sorptivity with different mix proportions

Resistance against Chloride ion penetration (Rapid Chloride Permeability Test)

Fig.3 shows the arrangement of test set up and testing progress of RCPT. The test result has been shown in Fig.7.According to ASTM 1202 the samples were tested with the electrical charges passed over the samples and results of electrical charges were measured for the 28 days. GC produced with FAF and GS (GCF- 50% partial substitution) indicated the lower value which showed the resistance against chloride intrusion. Samples taken for the test, shown good results and characterized between low to moderate, but the sample (GCA) shown more results (Moderate), indicating that it had the low resistance against chloride penetration among all mixes.

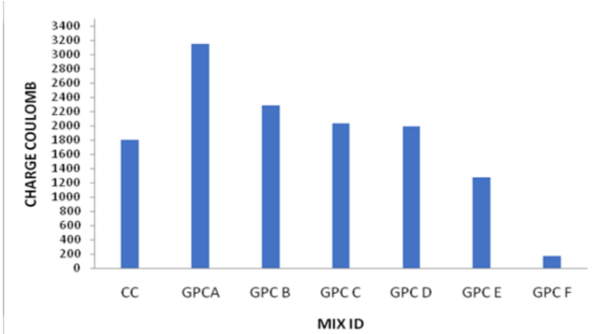


Fig7: RCPT results of Charges passed with different mix proportions

IV. Conclusion:

In the above research work, under the points are arrived and concluded.

The Absorption of water in Geopolymer Concrete are within the allowable limits and also in par with the conventional concrete. The partial replacement of 50% GS to Fly ash has the low sorptivity compared to other geopolymer concrete mixes. In the partial substitution of GS to FAF, geopolymer concrete mix GCF (50% GS and %0% FA) shows better performance in different properties like, absorption of water, water penetration & resistance against chloride environment as such it can be replaced. In summary, it can be finally concluded that GC with 50% partial substitution of GS to Fly ash was the suitable limit of substitution, as it have the good strength characteristics and performing all the durability parameters. The results obtained from this research, suitable for ready-mix concrete plants for selecting the particular proportion for the particular work in practical applications.

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