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Strength and Durability Test of Fly Ash and GGBS Based Geopolymer Concrete

Ajay Kumar Singh
(Department Of Civil Engineering, Government Engg. College, Jagdalpur)

ABSTRACT
Geopolymer concrete is a environment friendly which has less carbon emission than the Portland cement. The production of Portland cement contributes 13.5 billion ton carbon dioxide per year (0.87ton carbon dioxide for each ton of Portland cement). Geopolymer is combination of waste material like flyash, ggbs therefore does not have an industry which could cause carbon dioxide emission. When Portland cement was produced a mixture of raw materials required heating more than 1400° C to obtain cement powder and its corresponding high use of fuels. For preserving our natural resources it can be used. I have performed following test such as compressive strength, split tensile strength and acid resistance by replacing flyash and ggbs over cement. Low calcium ClassF flyash has been used.
Keywords: Acid durability factor, Compressive strength, Geopolymer Concrete, Fly Ash, GGBS, Split Tensile Strength

I. INTRODUCTION

Nowadays concrete plays a major role in the development of the world. It has become in such a way that the usage of concrete became second only to water around the world. In the last two decades environmental issues in the concrete industry are paying a lot of attention, aiming To reduce the total environmental impact of concrete structures to a minimum, without compromising on their performance. It was estimated that 7% of the world' s greenhouse gas is being emitted in the atmosphere annually on account of production of OPC. It is necessary to reduce the emission of CO2 into the atmosphere by reducing the cement production and consumption. It is suggested that consumption of cement could be reduced by replacing cement with supplementary cementations materials like fly ash, slag.

Geopolymer is inorganic alumina-silicate polymer synthesized from predominantly silicon and aluminium material such as fly ash and ggbs. The binders could be produced by a polymeric reaction of alkaline solutions with materials containing silicon and aluminium by geological origin or by-product materials such as fly ash and GGBS.

The aims of this study were:To develop a mix proportion to manufacture (ASTM Class F) Fly ash-GGBS based geopolymer concrete.the effect of replacing cement with other supplementary cementatious materials like Flyash and G.G.B.S that affects on properties of low-calcium fly ash-based geo polymer concrete. Fresh and hardened properties of fly ash and GGBS based geopolymer concrete, .Water penetrability property for the low calcium fly ash and GGBS based Geopolymer concrete.

The durability characteristics of fly ash and GGBS based Geopolymer concrete.

II. CONCRETE MIX DESIGN

Mix design of geopolymer concrete is calculated from IS 10262:2009.the design of geopolymer concrete the aggregates takes 75% of entire mix by mass.The design of geopolymer concrete the coarse aggregates take 50% of entire mix by mass.The fine aggregates takes 25.75%.the average density of flyash and ggbs based geopolymer concrete is similar to the opc 2400kg/m3.

The following parameters for various trial mixes:
The following parameters has taken into account:
Alkaline liquid to flyash ratio =0.45,0.40,0.35,0.30
Fly ash= 60%
GGBS=40%
Mix design of flyash and ggbs=426.50kg/m3
Alkaline soln to flyash=0.45
Alkaline soln =0.45*(flyash + ggbs)
Mass of alkaline soln=191.92
Mass of fine aggregates = 609.90 kg/m3
Mass of coarse aggregates = 1168.61 kg/m3
Admixture =1.8%,2.8%,3.8%,4.68% for different cubes
Sun curing = 28days
Similary,for the different alkaline soln to flyash ratio mass of the materials calculated.

Table1: Mix design of M30 grade of concrete for alkaline to binder ratio 0.45

S No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Fly ash +GGBS	426.50	8.636
2	Fine Aggregate	609.90	12.35
3	Coarse Aggregate	1164.34	23.58
4	Binder	191.92	3.89
5	Fly ash	255.90	5.18
6	GGBS	170.6	3.454
7	SP	8	0.69
	Density	**2400**	

Table2: Mix design of M30 grade of concrete for alkaline to binder ratio 0.40

S No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Fly ash +GGBS	426.50	8.636
2	Fine Aggregate	609.90	12.35
3	Coarse Aggregate	1164.34	23.57
4	Binder	170.6	3.454
5	Fly ash	255.90	5.18
6	GGBS	170.6	3.454
7	SP	12	1.040
	Density	**2383**	

Table3: Mix design of M30 grade of concrete for alkaline to binder ratio 0.35

S No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Fly ash +GGBS	426.50	8.636
2	Fine Aggregate	609.90	12.35
3	Coarse Aggregate	1164.34	23.57
4	Binder	149.27	3.022
5	Fly ash	255.90	5.18
6	GGBS	170.6	3.454
7	SP	16	1.389
	Density	**2366**	

Table4: Mix design of M30 grade of concrete for alkaline to binder ratio 0.30

S No.	Material	Quantity kg/m^3	Quantity for 6 cubes in Kg
1	Fly ash +GGBS	426.50	8.636
2	Fine Aggregate	609.90	12.35
3	Coarse Aggregate	1164.34	23.57
4	Binder	127.95	2.59
5	Fly ash	255.90	5.18
6	GGBS	170.6	3.454
7	SP	20	1.82
	Density	**2383**	

III. TESTING

3.1. Compressive Strength

The compressive strength is an essential property for all concrete where it depends on the curing time and type of the curing. The Geopolymer cubes were cured at the sun for 28 days. As the curing time and temperature increases, the compressive strength of the geopolymer cubes increases. After 28 days the cubes attains compressive strength of 47.40 MPa.

3.2. Split Tensile Strength

For testing the split tensile strength cylindrical specimen was used. The load was increased at constant rate until the specimen was failed.

The split tensile strength can be calculated by:

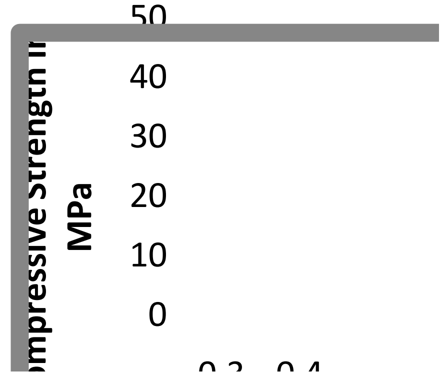
$F_{st}=2P/(\pi LD)$

P=Maximum load carried by the specimen

L= length of the cylindrical specimen

D=Diameter of the specimen

Fig1: Compressive strength of geopolymer cubes



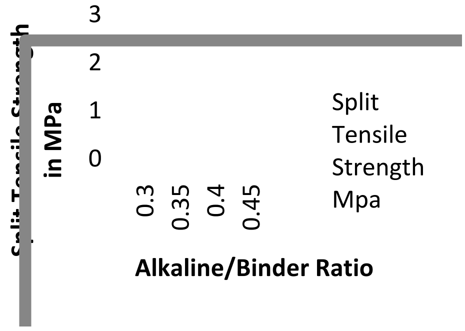


Fig2: Split tensile strength of geopolymer concrete cubes

3.3 Durability test:

The specimen were taken to test after the 28 days of curing in the sun. The specimen were immersed in the 3% HCL,3% H_2SO_4 and 3% HNO_3 and it is tested in compression testing machine.

3.4 Acid attack study

The acid attack study was done by immersing the specimen in acid solution. 2 specimen of each batch. The initial mass and body dimensions were measured. The mass and diagonal measurement were again taken at 3,7,14 and 28 days. The compressive strength is measured after 28 days of immersion.

The Acid Durability Factor can be Calculated as follows

ADF=SrN/M

Sr - Relative Strength at N days, (%)

N - Number of days at which the durability factor is needed.

M - Number of days at which the exposure is to be terminated.

So M is 28 in this case

Table5: Geopolymer cube Durability against HCL

S No.	Alkaline/Binder ratio	Initial strength	Final Strength	ADF
1	0.30	15.75	12.537	79.60
2	0.35	27.01	23.26	86.15
3	0.40	36.98	33.34	90.18
4	0.45	47.40	44.98	94.90

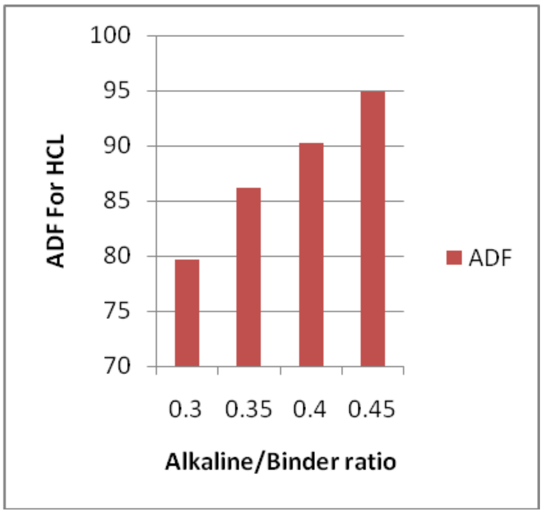


Fig 3: ADF against HCL

Table6: Geopolymer cube durability against H_2SO_4

S No.	Alkaline/Binder ratio	Initial strength	Final Strength	ADF
1	0.30	15.75	12.537	79.60
2	0.35	27.01	23.26	86.15
3	0.40	36.98	33.34	90.18
4	0.45	47.40	44.98	94.90

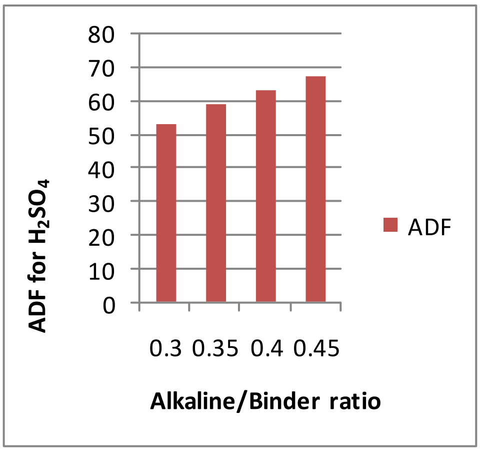


Fig 4: ADF against H_2SO_4

Table 7: Geopolymer cube durability against HNO_3

S No.	Alkaline/Binder ratio	Initial strength	Final Strength	ADF
1	0.30	15.75	12.00	76.16
2	0.35	27.01	22.42	83.02
3	0.40	36.98	32.26	87.25
4	0.45	47.40	42.27	90.25

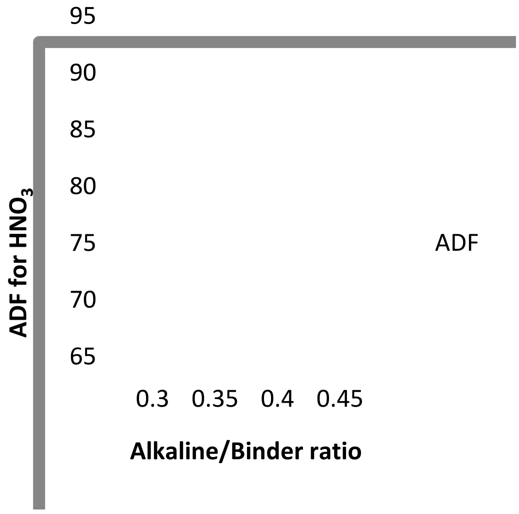


Fig 5: ADF against HNO_3

IV. RESULT

- The initial and final setting time of the Geo Polymer concrete is low.
- The Specific gravity of Geopolymer concrete is low as compared to ordinary Portland cement.
- Compressive strength of GGBS added geopolymer concrete is high with increase in alkaline to binder ratio.
- Geopolymer concrete shows greater resistance to acid environment as compared to ordinary Portland cement.
- The addition of Geopolymer gives good result in compressive strength.

V. CONCLUSION

- The geopolymer concrete is light in colour and surface are more smooth than ordinary Portland cement.
- Curing temperature and method of curing influences the compressive strength of the specimens.
- With the addition of 40% GGBS there is increase in compressive strength of geopolymer concrete.
- there is no mix-design code is available so it is needed to review on the results which had come out up to till date work done all over the world.

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