AN EXPERIMENTAL STUDY ON THE BEHAVIOR OF GEOPOLYMER CONCRETE BY USING GGBS AND ALKALINE SOLUTION

Patel Jigar[1], Patel Monika[2]
Department of Civil Engineering(structure)
[1]PG Student, Sankalchand Patel engineering college, Visnagar, Gujarat, India
[2] Assistant Professor, Sankalchand Patel engineering college, Visnagar, Gujarat, India

Abstract- *In this dissertation work the effect of concentration of NaOH solution on mechanical properties of geopolymer concrete is analyzed by varying the molarity of NaOH in ground granulated blast furnace slag based geopolymer concrete. It is found that ground granulated blast furnace slag based geopolymer concrete has very low workability.*

Keywords- GGBS, GPC, Sodium hydroxide, Sodium silicate.

I. INTRODUCTION

In present time after water most used material is cement concrete. OPC is used as binding material in concrete. Two major problems are associated with the production of cement. First is that in the manufacturing of OPC fresh material such as lime stone, clay and other natural resources are required and other is the production of OPC enormous amount of Carbon di Oxide (CO2) released. On the other side, the abundance and availability of waste materials such as fly ash (FA), ground granulated blast furnace slag (GGBS), red mud and rice husk ash (RHA) worldwide create opportunity to utilize these by product of different industries, as partial replacement of OPC in concrete. The utilization of industrial and agricultural by products as the replacement or as the additional cementitious material has had a constructive effect in minimizing greenhouse gas emissions. GGBS had used in OPC concrete from long period to replace cement.

II. METHODS AND MATERIAL

GGBS (Ground Granulated Blast Furnace Slag): GGBS comprises mainly of calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has the same chief chemical elements as ordinary Portland cement but in different proportions and the addition of GGBS in geopolymer concrete (GPC) increases the strength of the concrete and also curing of Geo-Polymer concrete at room temperature is possible.

Physical properties of GGBS:

Specific gravity: 2.88

Fine aggregates:

Table: 2.1 Physical properties of fine aggregate

Characteristics	Result
Aggregate type	Natural
Specific gravity	2.62
Fineness modulus	3.19

Coarse aggregate:

Table: 2.2 Physical properties of 10 mm aggregate

Characteristics	Result
Aggregate type	Crushed Stone
Maximum size of aggregate	10 mm
Specific gravity	2.67
Fineness modulus	1.244

Table: 2.3 Physical properties of 20 mm aggregate

Characteristics	Result
Aggregate type	Crushed stone
Maximum size of aggregate	20
Specific gravity	2.71
Fineness modulus	1.945

Sodium Hydroxide:

Table: 2.4 Specification of Sodium Hydroxide (NaOH)

Characteristics	value
Sodium hydroxide as NaOH % by mass	99.62
Chlorides as NaCl % by mass	0.10
Sodium carbonate as Na_2CO_3	0.35

Sodium Silicate:

Sodium Silicate is the common name for a compound sodium meta-silicate (Na_2SiO_3) also known as water glass or liquid glass.

III. METHODOLOGY

Experimental Investigation:

Cube specimens of size 150 mm x 150 mm x 150 mm, beam specimens of size 700 mm x 150 mm x 150 mm and cylinder specimens of size 300 mm x 150 mm was casted

Preparation of Alkaline Activator Solution

In this study 8 molarity solution was taken to make AAS so to prepare NaOH solution of 8M molarity, 8*40=320 gram of NaOH in flakes form was added to water to prepare one liter of solution, where 40 is the molecular weight of NaOH. When 320gm NaOH pellets were added to 1 liter water then total prepared solution 1.32 kg. Pellets required to make 1 kg NaOH solution = 320/1.32 = 242.42gm

TEST RESULT:

Slump cone test:

Table: 2.5 Test result of slump test

Molarity	Slump(cm)
8M	21
10M	18
12M	15
14M	11
16M	9

Compressive Strength Test:

Table: 2.6 Average Compressive strength of GPC mixes at different ages

Age of specimens (Days)	Avg. Compressive strength (MPa)				
	Mix-A (8M)	Mix-B (10M)	Mix-C (12M)	Mix-D (14M)	Mix-E (16M)
3	49.31	52.56	57.67	59.79	62.31
7	55.78	58.42	63.16	65.08	66.38
28	58.31	61.45	65.26	68.24	71.12

Flexural Strength Test:

Table: 2.7 Average flexural strength of GPC mixes at different age

Age of specimens (Days)	Avg. flexural strength (MPa)				
	Mix-A (8M)	Mix-B (10M)	Mix-C (12M)	Mix-D (14M)	Mix-E (16M)
3	0.52	0.61	0.73	0.81	0.87
7	0.60	0.69	0.80	0.87	0.93
28	0.67	0.81	0.97	1.09	1.15

Split Tensile Strength Test:

Table: 2.8 Average split tensile strength of GPC mixes at different ages

Age of specimens (Days)	Avg. Split tensile strength (MPa)				
	Mix-A (8M)	Mix-B (10M)	Mix-C (12M)	Mix-D (14M)	Mix-E (16M)
3	3.46	3.85	4.52	4.73	5.08
7	3.89	4.17	4.98	5.21	5.46
28	4.28	4.67	5.37	5.56	5.87

Durability test for Acid Attack:

Table: 2.9 Result of weight loss after acid attack test

Mix Design	Chemical	Molarity (M)	Weight Of Specimens (kg)	Weight Of Specimens After 28 Days (kg)	Loss In Weight (%)
A	H_2SO_4	8	7.87	7.57	3.81
B		10	7.95	7.65	3.90
C		12	8.4	8.09	3.67
D		14	7.85	7.45	5.09
E		16	8.63	8.21	4.79

IV. CONCLUSION

- GGBS based geopolymer concrete is very less workable. Workability of GPC mix decreased with increase of molarity of NaOH.
- Compressive strength of GGBS based GPC increased with increase of molarity of NaOH solution. The GGBS based GPC mixes developed compressive strength in the range of 49.31MPa to 62.31MPa in 3 days, for molarity varying from 8M to 16M respectively. It achieved strength ranging from 55.78MPa to 66.38MPa at the age of 7 days; at the age of 28 days strength obtained is 58.31MPa to 71.12Mpa.
- Although maximum compressive strength comes at 16M but 12M molarity solution give significant strength for practical purpose. From economic point it is better to use 12M molarity solution to produce GPC.
- GGBS based GPC mixes developed split tensile strength in the range of 3.46MPa to 5.87MPa in 3 to 28 days for molarity variation from 8M to 16M. Maximum strength is achieved at 28 days for 16 M molarity.
- GGBS based GPC mixes developed flexural strength in the range of 0.52MPa to 1.15MPa in 3 to 28 days for molarity

variation from 8M to 16M. Maximum strength is achieved at 28 days for 16 M molarity.

- Weight loss due acid test is varies 3 to 5.5% of specimens.
- GGBS based concrete can be replaced conventional concrete for practical purpose as it give higher compressive strength and comparable split tensile strength.
- Alkaline activator solution should be prepared very carefully, and the chemicals used should be handled carefully and mixed deliberately to avoid any threat, since the process of addition of water to NaOH pellets is exothermic in nature so lot of heat generated at the time of mixing. It can be prepared 3-4 hours before casting

REFERENCES

[1] Alwis Deva Kirupa J. P. and Sakthieswaran N. (Nov 2015), “Strength and stability characteristics of GGBS and red mud based geopolymer concrete incorporated with hybrid fibers” ICJ pp 66-72.

[2] Cheng, T. W. and J. P. Chiu, “Fire-resistant Geopolymer Produced by Granulated Blast Furnace Slag” Minerals Engineering 16(3), 2003, pp. 205-210.

[3] Davidovits J. (1994), “Properties of Geopolymer Concrete” published in proceedings first International Conferemnce on Alkaline Cements and Concretes, Scientific, Research Institute on Binder and Materials, Kiev state university, Kiev, Ukraine, pp 131-149.

[4] Fernandez-Jimenez A., Garcia-Lodeiro, I. and Palomo A. (2007), “Durability of Alkali- Activated Fly Ash Cementitious Materials”, J Mater Sci, 42, pp 3055-3065.

[5] Gokulanathan V., Prasanna Venkatesan R. and Pazhani K.C., (Nov 2013), “Effect of NaOH Concentration on Strength of GGBS and BRHA Based Geopolymer Concrete” RECENT SCIENCE PUBLICATIONS ARCHIVES

[6] Islam Azizul, Johnson Alengaram U., Zamit Jumaat Mohd., Ibnul Bashar Iftekhair, Alamgir Kabir S. M. (Dec 2013)), “The development of compressive strength of ground granulated blast furnace slag-palm oil fuel ash-fly ash based geopolymer mortar” Materials and Design 56, pp 833-841.

[7] Khale, Divya, Chaudhary and Rubina (2007), “Mechanism of Geopolymerization and Factors Influencing Its Development: A Review” J Mater Sci 42, pp.729-746.

[8] Naidu Ganapati P, Prassad A.S.S.N, Adiseshen S. and Satyanarayan P.V.V (July 2012), “A Study on Strength Properties of Geopolymer Concrete with addition of GGBS” IJERD, vol 2, pp 19-28.

[9] Oner A. and Akyuz S. (Jan 2007), “An Experimental Study on Optimum usage of GGBS for the Compressive Strength of Concrete” ELSEVIER, pp 505-514.

[10] Indian standard code of practice, Method of sampling and analysis of concrete IS: 1199- 1959, Reaffirmed 2004, BIS New Delhi, India.

[11] Indian standard code of practice, Methods of Test for strength of concrete, IS: 516-1959, Reaffirmed 2004, BIS New Delhi, India.